

# LLM Infrastructure Forecast

## 1. What is a TPU?

A **TPU (Tensor Processing Unit)** is a custom-designed AI accelerator chip developed by Google specifically for machine learning workloads.

### Key Characteristics

- **Purpose-built for ML:** Optimized for matrix operations and tensor computations common in neural networks
- **High throughput:** Excels at large-scale, low-precision (8-bit) matrix multiplications
- **Architecture:** Uses a systolic array design that efficiently moves data through processing elements
- **Power efficient:** Delivers more ML performance per watt compared to general-purpose GPUs/CPUs

### TPU vs GPU

Aspect	TPU	GPU
Specialization	ML-only	General-purpose parallel computing
Best for	Large transformers, inference at scale	Varied workloads, smaller models
Flexibility	Limited	High

## 2. Will ASICs Dominate if LLMs Become Mainstream?

### Arguments For ASIC Dominance

- **Efficiency:** ASICs can be 10-100x more power-efficient than GPUs for specific workloads
- **Cost at scale:** Once designed, per-unit costs drop significantly in high volume
- **Inference dominance:** If LLMs become ubiquitous, inference will be the bulk of compute—ideal for ASICs
- **Edge deployment:** Running models on phones/devices almost certainly requires custom silicon

### Arguments Against (GPU Resilience)

- **Rapid model evolution:** LLM architectures are still changing fast. ASICs take 2-3 years to design—risky if architectures shift
- **NVIDIA's moat:** CUDA ecosystem, software stack, and developer familiarity are deeply entrenched
- **Flexibility:** GPUs can run any model; ASICs may become obsolete if paradigms change
- **Hybrid approaches:** NVIDIA is adding specialized tensor cores—blurring the line

### Current Trajectory

- Hyperscalers (Google, Amazon, Microsoft) are building custom chips (TPU, Trainium, Maia)

- Startups (Groq, Cerebras, SambaNova) are betting on specialized architectures
- NVIDIA still dominates (~80%+ of AI training market)

## Likely Outcome

A mixed ecosystem—ASICs for inference at scale and edge, GPUs for training and flexibility. If architectures stabilize, ASICs gain ground. If innovation continues rapidly, GPUs remain essential.

## 3. Enterprise LLM Deployment: Hybrid Model

The likely future is a **hybrid model** where companies run private small LLMs for routine tasks and use public cloud LLMs for heavy compute. This mirrors how companies handle compute generally (on-prem + cloud).

### Why Private Small LLMs Make Sense

- **Data privacy:** Sensitive data never leaves the network
- **Latency:** Local inference is faster for real-time applications
- **Cost predictability:** Fixed infrastructure vs. per-token API costs
- **Customization:** Fine-tuned on proprietary data, jargon, workflows
- **Compliance:** Easier to meet regulatory requirements (GDPR, HIPAA, etc.)

### Why Public LLMs for Heavy Compute

- **Frontier capabilities:** Largest models require massive infrastructure
- **Occasional use:** Doesn't justify owning the hardware
- **Rapid improvement:** API access means instant upgrades
- **Burst capacity:** Handle spikes without over-provisioning

### Emerging Deployment Patterns

Use Case	Likely Solution
Internal chatbots, code assist	Private small LLM (7B-70B)
Document search/RAG	Private, fine-tuned
Complex reasoning, research	Public frontier API
Customer-facing products	Hybrid or public
Edge/embedded	Tiny private models (<3B)

### The Analogy

It's like databases—companies run private databases for core operations but use cloud services for analytics, burst workloads, or specialized capabilities.

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