THE LINUX FOUNDATION MEMBER SUMMIT

PyTorch

Collaborative Infrastructure at Scale: PyTorch's Multi-Cloud CI Model

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Contents

The Infrastructure Challenge

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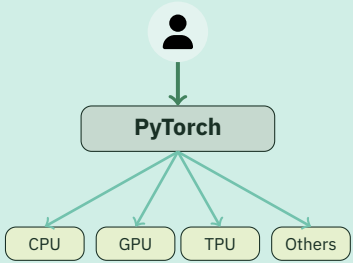
What is PyTorch?

A Leading Open Source ML Framework:

- Researchers, data scientists, ML engineers
- Research and production ML workloads
- (Distributed) Training, LLM, RL, Inference
- Python API, C++ Core (libtorch)
- Eager and Graph Mode (Inductor)
- Rapid growth and adoption across industry



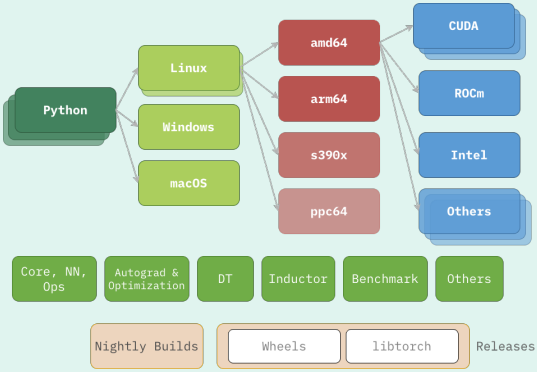
CI/CD Infrastructure Today

- ~1M$ monthly infrastructure costs
- ~1M hours of compute per month
- ~100 distinct PRs/day

- ~1.3k Compute-intensive Workflows/day
- Growing year over year

`pytorch/pytorch` repo only, numbers are estimated

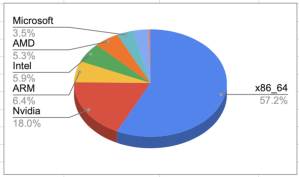
An Expanding Test Matrix



Combined Hardware Runtime by Hardware Vendor September 2025

Combined Runtime By Hardware Vendor

Vendor	Total
x86_64	834,085 hours
Nvidia	262,878 hours
ARM	93,000 hours
Intel	86,090 hours
AMD	77,517 hours
Microsoft	51,515 hours
Apple	46,812 hours
IBM	6,245 hours
N/A	0 hours
	1,458,142 hours



* Data from PT Foundation AWS Account + PyTorch HUD. This does not include self-hosted runner costs by member provided runners.

The Challenges

Community Challenges:

- Maintain high-quality end-user experience
- Preserve contributor workflow
- Provide clear path for vendor engagement

Scale Challenges:

- **Engineering:** Managing a Diverse Fleet, Access to Platforms
- **Financial:** Reconcile Community Wishes with Budget Constraints

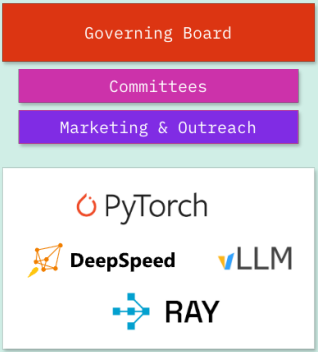
Security Challenges:

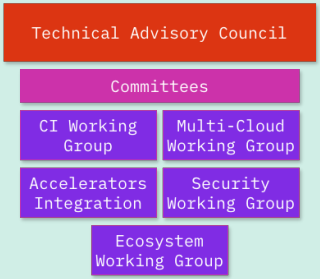
- Trust and Consistency in a diverse environment
- Central Administration
- Trusted Builds

PyTorch Foundation & Working Groups

The PyTorch Foundation

- Part of the Linux Foundation
- Neutral home for PyTorch project
- Hosts multiple projects
- Thought Leadership (GB)
- Technical Leadership (TAC)
- Marketing & Outreach





Working Groups

Multi-Cloud CI

Cloud Agnostic Infrastructure:

- CI/CD jobs and Supporting Infra
- Metrics and Monitoring
- Fleet Management

Vendor-managed Runner Pools

Accelerator Integration

Software Integration:

- Developer Guide
- Framework Improvement

Reference Test Framework

CI Event Relay Infrastructure

CI Infra

Responsible for the CI/CD infra:

- Develop and maintain tools
- Operate the AWS/GitHub fleet
- Execute Releases

Security

- PyTorch Security Triage
- Tools and reports
- CI/CD Security

Governance Model

Photo by Khampha Phimmachak, CC0

Personas: A Balancing Act

End Users

- Stable software
- Available on my dev platform
- Available on my prod platform
- Following the industry at speed

Platform Vendors

- PyTorch for my platform
- Demonstrate platform compatibility
- Low bar to contribution of infrastructure
- Clear guidance and processes

Project Maintainers

- Project Success
- Stay relevant for end-users
- High quality secure builds
- Manageable CI/CD System (scale)
- Smooth CI/CD experience for contributors

PyTorch Foundation

- Ensure Vendor Neutrality
- Vendor participation encouraged
- Fair representation
- Financial sustainability

Integration Models

Three Ways to Contribute Infrastructure:

- **Public Cloud Credits:** Financial contribution for shared infrastructure
- **Vendor-Managed Runner Pools:** Tightly integrated with GitHub Actions
- **Vendor-Managed Test Infrastructure:** Loosely integrated with GitHub

	Community	Scale	Security
Advantages	Flexible models accommodate different vendor capabilities	Outsourcing engineering with vendor-managed setups	More loosely coupled systems cannot compromise core CI system
Challenges	Hide the underlying infra complexity to contributors	Consistent tech stack required for public cloud credits. Consistent metrics and monitoring across the board.	Ensure security best practices on vendor managed infrastructure

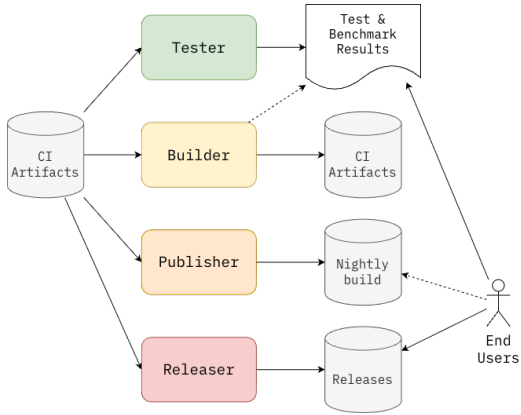
Roles & Requirements

Least privilege access to cloud resources:

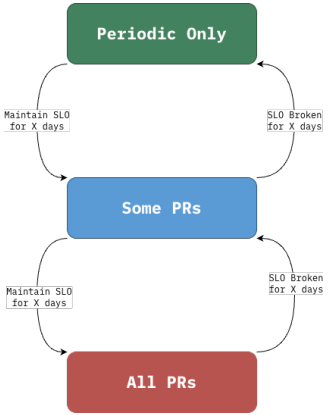
- Jobs specify nodes access level required
- Runners are assigned a role
- Roles define the level of access to resources

Requirements for Runners:

- Configuration
- Provisioning
- Monitoring
- Security



Triggers & SLOs



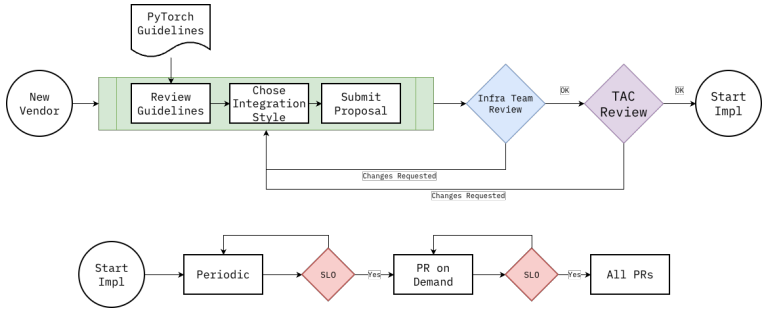
Trigger levels for CI/CD jobs:

- On-demand only
- Periodic nightly
- Periodic multi-times per day
- Specific PRs only
- All PRs

Service Level Objectives:

- Availability %
- Reliability (Num of infra failures)
- Average Job Queue Time (p95/3 months)
- Engineering Commitment (on-call, slack, meetings)

Contribution Process



- Working Group provides guidance and recommendations
- Infra team verify checks for compliance
- TAC Community for final approval
- Transparent process with clear requirements
- Monitoring for SLOs

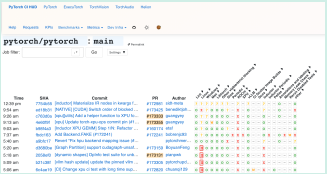
Central Administration & Visibility

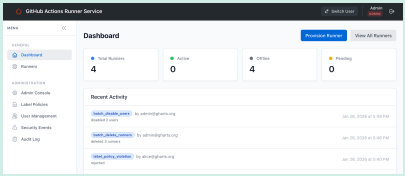
Maintaining Manageability at Scale:

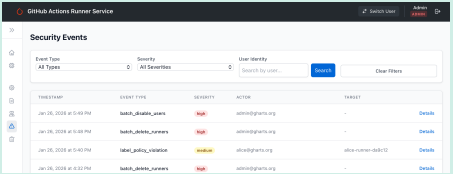
- Common software stack across clouds
  Reusable by vendors too
- Self-service Tools with Central Admin Override
- Vendor playbooks, reusable IaaC

Visibility & Control:

- Public Dashboards: Transparency for community and vendors
- Cost Tracking: Attribution per vendor and workload type
- Performance Metrics: Build times, success rates, SLA compliance



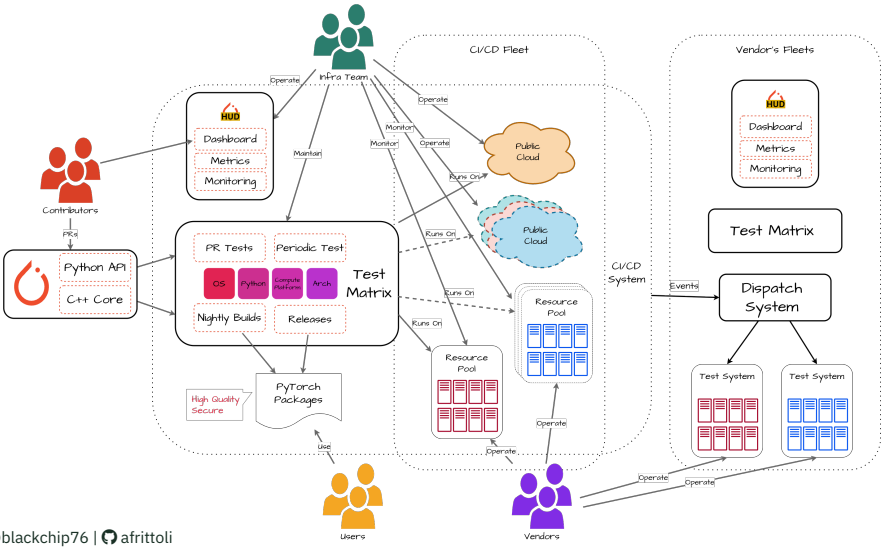




Technical Architecture

Photo by Nadi Whatisdelirium, CC0

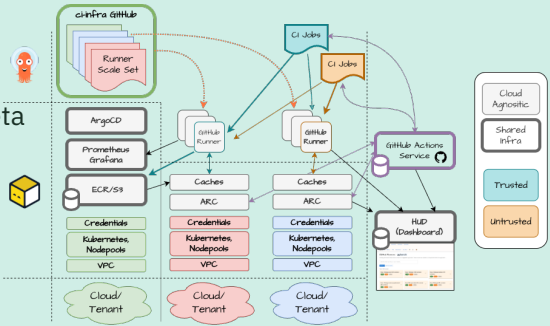
High Level Architecture



Public Cloud Infrastructure

Current AWS Setup:

- Primary infrastructure hosted on AWS
- Two accounts, funded by AWS Credits and Meta
- Self-hosted GitHub Actions runners
- Managed by PyTorch Infra team
- Autoscaling based on workload demand



Multi-Cloud & Infra Working Group Initiatives:

- **Portable CI Jobs:** Run in a container, remove cloud-specific assumptions
- **Reusable Autoscaler:** Developing portable autoscale based on ARC
- **Infrastructure as Code:** Reusable OpenTofu modules

Vendor-Managed Runner Pools

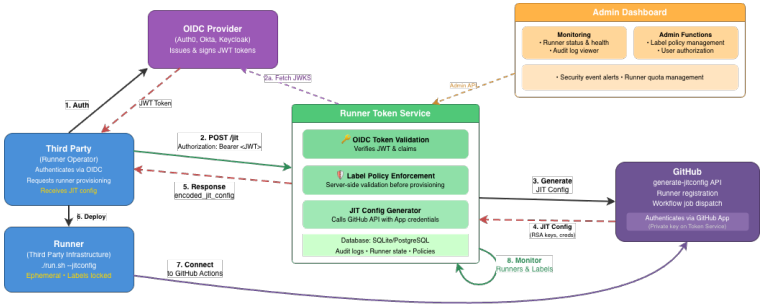
Challenges:

- Long lived admin credentials
- Runner metadata cannot be enforced
- Lack of central administration
- Lack of auditability

Proposed Solution:

- GHA Runner Token Service (GHARTS)
- Use LFID for authentication
- No Admin Credentials to vendors
- Ephemeral, non reusable credentials
- Enforcement of metadata and quota
- Centralized administration
- Auditability

GHARTS Provisioning Flow



- Vendor authenticates using existing credentials (LFID)
- Vendor requests a JIT config using the JWT
- GHARTS verifies AuthN and AuthZ for vendor
- GHARTS requests JIT config from GitHub
- Vendor uses JIT config to provision a runner
- JIT lasts 1h, and can only be used Once

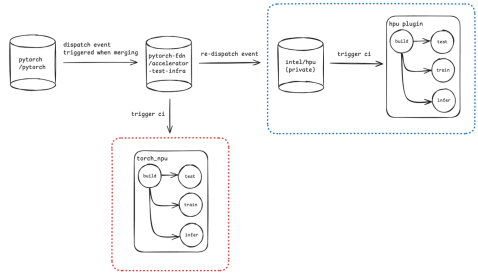
Vendor-Managed Test Systems

Accelerator Integration Working Group Initiative:

- Loosely coupled with PyTorch CI
- Events relayed to external repository
- Vendors provide test infrastructure and environments
- Out-of-tree test workflows

Use Cases:

- Specialized hardware testing (TPUs, custom accelerators)
- Produce test results only



Test System Visibility

Challenges:

- Loosely coupled systems harder to monitor
- Results come from external systems
- Need consistent reporting format
- Debugging failures more complex

Ongoing Work:

- Standardized result reporting via GitHub workflow_run events
- Exploring alternatives: OpenTelemetry for metrics, CDEvents for event streaming
- Unified dashboard for cross-vendor visibility
- Real-time event relay for debugging

Results & Lessons Learned

Platform Coverage Expansion

Achievements:

- **Public Cloud Credits:** AWS, Meta funding
- **Runner Pools:** IBM (via GHARTS), additional vendors onboarding
- **Vendor Systems:** AMD, Intel, NVIDIA, ARM for specialized accelerator testing
- Significant increase in platform coverage across CPU architectures and accelerators
- Reduced time-to-market for new platform support
- Improved test reliability through dedicated infrastructure

Vendor Onboarding Experience

Positive Feedback:

- Clear expectations and requirements documentation
- Reasonable onboarding timeline with good support
- Responsive technical support from maintainers
- Fair and transparent governance model

Ongoing Initiatives:

- IBM trialing GHARTS for runner pool integration
- Red Hat collaborating on vendor system visibility improvements
- Vendors actively sharing experiences and best practices

Key Lessons Learned

Principles for Collaborative Infrastructure:

- **Fair Governance:** Protect everyone's interests, vendors can't veto but have voice
- **Engage Vendors Early:** Let them help build solutions, not just consume them
- **Empower Maintainers:** Give infra team authority and tools to manage at scale
- **Security First:** Build security in from day one, not as afterthought
- **Flexible Models:** Multiple contribution paths reduce friction and attrition

Challenges:

- Balancing vendor needs with project sustainability
- Standardization across diverse platforms and requirements

Applicability to Other LF Projects

Shared Challenges:

- Accepting vendor infrastructure
- Maintaining project neutrality
- Ensuring transparency
- Achieving financial sustainability

This Model Can Help:

- Proven governance framework
- Technical architecture patterns
- Onboarding playbook

Future Directions

Ongoing Activities:

- Complete GHARTS rollout with IBM and additional vendors
- Enhance monitoring and observability across all integration models
- Expand portable CI/CD tooling for multi-cloud deployments
- Standardize event streaming with OpenTelemetry/CDEvents

Long-term Goals:

- Share governance and technical patterns with other LF projects
- Build community of practice around collaborative infrastructure
- Continuously refine based on vendor and maintainer feedback

Key Takeaways

- **Sustainable Scaling:** Distribute infrastructure costs while maintaining project control
- **Governance Matters:** Fair rules enable vendor participation without compromising autonomy
- **Security & Transparency:** Non-negotiable foundations that build trust
- **Flexible Models:** Multiple contribution paths reduce friction and increase adoption
- **Reusable Pattern:** This model can help other Linux Foundation projects

Questions?

Brecon Beacons, Wales, Photo by Carl Jorgensen, CC0

References & Contact

Resources:

- PyTorch Foundation: `https://pytorch.org/foundation`
- PyTorch CI/CD: `https://github.com/pytorch/pytorch/wiki/CI`
- GitHub: `https://github.com/pytorch/pytorch`
- Multi-Cloud Infrastructure WG: PyTorch Slack #infra-wg

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