CNCF Platforms Working Group

PLATFORMS FOR CLOUD-NATIVE COMPUTING

White paper

CLOUD NATIVE COMPUTING FOUNDATION

Introduction

Inspired by the cross-functional cooperation promised by DevOps, platform engineering has begun to emerge in enterprises as an explicit form of that cooperation. Platforms curate and present foundational capabilities, frameworks and experiences to facilitate and accelerate the work of internal customers such as application developers, data scientists and information workers. Particularly in cloud computing, platforms have helped enterprises realize values long promised by the cloud like fast product releases, portability across infrastructures, more secure and resilient products, and greater developer productivity.

This paper intends to support enterprise leaders, enterprise architects and platform team leaders to advocate for, investigate and plan internal platforms for cloud computing. We believe platforms significantly impact enterprises' actual value streams, but only indirectly, so leadership consensus and support is vital to the long-term sustainability and success of platform teams. In this paper we'll enable that support by discussing what the value of platforms is, how to measure that value, and how to implement platform teams that maximize it.

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Why platforms?

Platforms and platform engineering are a popular topic in today's cloud computing world. Before diving into definitions, techniques, and measurements for platform building, it is important to first explore the value platforms provide that's driving this well-deserved attention.

Process improvements over the past 2-3 decades have significantly increased the agility of software application and product teams, offering them flexible services for both infrastructure like compute, network and storage as well as developer services like builds, tests, delivery and observability. This autonomy and process improvement has also had the effect of gradually shifting more and more responsibility for supporting services to product teams, forcing them to spend more and more time and cognitive energy on infrastructure concerns and reducing their time to produce value relevant to their organization.

The desire to refocus delivery teams on their core focus and reduce duplication of effort across the organization has motivated enterprises to implement platforms for cloud-native computing. By investing in platforms, enterprises can:

1. Reduce the cognitive load on product teams and thereby accelerate product development and delivery
2. Improve reliability and resiliency of products relying on platform capabilities by dedicating experts to configure and manage them
3. Accelerate product development and delivery by reusing and sharing platform tools and knowledge across many teams in an enterprise
4. Reduce risk of security, regulatory and functional issues in products and services by governing platform capabilities and the users, tools and processes surrounding them
5. Enable cost-effective and productive use of services from public clouds and other managed offerings by enabling delegation of implementations to those providers while maintaining control over user experience

These benefits accrue in part because just a few platform teams serve many product teams, multiplying their impact; in part because platform teams consolidate management of common functionality, facilitating governance; and in part because platform teams emphasize user interfaces and experiences above all else.

A team of platform experts not only reduces common work demanded of product teams but also optimizes platform capabilities used in those products. A platform team also maintains a set of conventional patterns, knowledge and tools used broadly across the enterprise; enabling developers to quickly contribute to other teams and products built on the same foundations. The shared platform patterns also allow embedding governance and controls in templates, patterns and capabilities. Finally, because platform teams corral providers and provide consistent experiences over their offerings, they enable efficient use of public clouds and service providers for foundational but undifferentiated capabilities such as databases, identity access, infrastructure operations, and app lifecycle.

What is a platform

A platform for cloud-native computing is an integrated collection of capabilities defined and presented according to the needs of the platform's users. It is a cross-cutting layer that ensures a consistent experience for acquiring and integrating typical capabilities and services for a broad set of applications and use cases. A good platform provides consistent user experiences for using and managing its capabilities and services, such as Web portals, project templates, and self-service APIs.

According to Atlassian [1], "platform teams create capabilities that can be used by numerous stream-aligned [product] teams with little overhead.... platform teams minimize resources and cognitive load of the stream-aligned [product] team... platform teams can create a cohesive experience that spans across different user experiences or products."

According to Martin Fowler and Evan Bottcher [2], "a digital platform is a foundation of self-service APIs, tools, services, knowledge and support which are arranged as a compelling internal product. Autonomous delivery teams can make use of the platform to deliver product features at a higher pace, with reduced coordination."

The specific set of capabilities and scenarios supported by a platform should be determined by the needs of stakeholders and users. And while platforms provide these required capabilities, it's critical to note that platform teams should not always implement them themselves. Managed service providers or dedicated internal teams can maintain backing implementations while platforms are the thinnest reasonable layer that provides consistency across provided implementations and meets an organization's requirements. For example, a very simple "platform" could be a wiki page with links to standard operating procedures to provision capabilities from providers, as described in [3].

Because these platforms target no more and no less than an enterprise's internal users we often refer to them as internal platforms.

Platforms are particularly relevant for cloud-native architectures because they separate supporting capabilities from application-specific logic more than previous paradigms. In cloud-like environments resources and capabilities are often managed independently and integrated with custom business components; such resources may include databases and object stores, message queues and brokers, observability collectors and dashboards, user directories and authentication systems, task runners and reconcilers and more. An internal platform provides these to enterprise teams in ways that make them easy to integrate in their applications and systems.

Platform maturity

At their most basic, internal platforms provide consistent experiences for acquiring and using individual services such as a pipeline runner, a database system or a secret store. As they mature internal platforms also offer compositions of such services as self-serviceable templates for key scenarios like web application development or data analysis, aka MLOps.

Use cases an enterprise could meet with platforms might progress through the following:

1. Product developers can provision capabilities on demand and immediately use them to run systems, such as compute, storage, databases or identities.
2. Product developers can provision service spaces on demand and use them to run pipelines and tasks, to store artifacts and configuration, and/or to collect telemetry.
3. Administrators of third-party software can provision required dependencies like databases on demand and easily install and run that software.
4. Product developers can provision complete environments from templates combining run-time and development-time services required for specific scenarios, such as web development or MLOps.
5. Product developers and managers can observe functionality, performance, and cost of deployed services through automatic instrumentation and standard dashboards.

By offering consistent, compliant experiences for individual capabilities or sets of them, internal platforms ultimately make it easier and more efficient for their users to deliver valuable products.

Attributes of platforms

After defining what a platform is and why an organization might want to build one, let's identify some key attributes that affect the success of a platform.

1. **Platform as a product**. A platform exists to serve the requirements of its users and it should be designed and evolved based on those requirements, similar to any other software products. Platforms should provide the necessary capabilities to support the most common use cases across product teams, and prioritize those over more specific capabilities that are only used by a single team to maximize the value delivered.
2. **User experience**. A platform should offer its capabilities through consistent interfaces and focus on the user experience. Platforms should endeavor to meet their users where they are, which may mean a combination of GUIs, APIs, command-line tools, IDEs, and portals. For example, a platform typically offers the capability of deploying an application. Developers might consume such a capability via the IDE, testers might use a command-line tool, whereas a product owner might use a GUI-based web portal.
3. **Documentation and onboarding**. Documentation is a key aspect of a successful software product. To be able to use a platform's offerings, users require documentation and examples. A platform should be delivered with proper documentation addressing the needs of its users. It should also provide tools to accelerate the onboarding of new projects that can help users consume the necessary platform services in a quick and simple way. For example, the platform could offer a reusable supply chain workflow for building, scanning, testing, deploying, and observing a web application on Kubernetes. Such a workflow could be offered with an initial project template and documentation, a bundle often described as a golden path.
4. **Self-service**. A platform should be self-serviceable. Users must be able to request and receive capabilities autonomously and automatically. This property is key to allowing a platform team to enable multiple product teams and scale as needed. The platform capabilities should be available on demand and with minimal manual intervention via the interfaces described above. For example, it should be possible for a user to request a database and receive its locator and credentials by running a command-line tool or filling out a form on a web portal.
5. **Reduced cognitive load for users**. An essential goal of a platform is to reduce the cognitive load on product teams. A platform should encapsulate implementation details and hide any complexity that might arise from its architecture. For example, a platform might delegate certain services to a cloud provider, but users should not be exposed to such details. At the same time, the platform should allow users to configure and observe certain services as needed. Users must not be responsible for operating the services offered by the platform. For example, users may often require a database, but they shouldn't have to manage the database server.
6. **Optional and composable**. Platforms are intended to make product development more efficient, so they must not be an impediment. A platform should be composable and enable product teams to use only parts of its offerings. It should also enable product teams to provide and manage their own capabilities outside of the platform's offerings when necessary. For example, if a platform doesn't provide a graph database and it's required for a product, it should be possible for the product team to provision and operate a graph database themselves.
7. **Secure by default**. A platform should be secure by default and offer capabilities to ensure compliance and validation based on rules and standards defined by the organization.

Attributes of platform teams

Platform teams are responsible for the interfaces to and experiences with platform capabilities - like Web portals, custom APIs, and golden path templates. On one hand, platform teams work with those teams implementing infrastructure and supporting services to define consistent experiences; on the other, they work with product and user teams to gather feedback and ensure those experiences meet requirements.

Following are jobs a platform team should be responsible for:

1. Research platform user requirements and plan feature roadmap
2. Market, evangelize and advocate for the platform's proposed values
3. Manage and develop interfaces for using and observing capabilities and services, including portals, APIs, documentation and templates, and CLI tools

Most importantly, platform teams must learn about the requirements of platform users to inform and continuously improve capabilities and interfaces offered by their platform. Ways to learn about user requirements include user interviews, interactive hackathons, issue trackers and surveys, and direct observation of usage through observability tools. For example, a platform team could publish a form for users to submit feature requests, lead roadmap meetings to share upcoming features and review users' usage patterns to set priorities.

Inbound feedback and thoughtful design is one side of product delivery; the other side is outbound marketing and advocacy. If the platform is truly built to user requirements those users will be excited to use the provided capabilities. Some ways a platform team can enable user adoption is through internal marketing activities including broad announcements, engaging demos, and regular feedback and communication sessions. The key here is to meet users where they are and bring them on a journey to engage with and benefit from the platform.

A platform team doesn't necessarily run compute, network, storage or other services. In fact an internal platform should rely on externally-provided services and capabilities as much as possible; platform teams should build and maintain their own capabilities only when they're not available elsewhere from managed providers or internal infrastructure teams. Instead, platform teams are most responsible for the interfaces (i.e., GUI, CLI, and API) and user experiences for the services and capabilities their platform makes available.

For example, a Web page in a platform might describe and even offer a button to provision an identity for an app; while the implementation of that capability might be via a cloud-hosted identity service. An internal platform team may manage the web page and an API, but not the actual service implementation. Platform teams should usually consider creating and maintaining their own capabilities only when a required capability is not available elsewhere.

Challenges with platforms

While platforms promise lots of value, they also bring challenges like the following which implementers should keep in mind.

1. Platform teams must treat their platforms like products and develop them together with users
2. Platform teams must carefully choose their priorities and initial partner application teams
3. Platform teams must seek support of enterprise leadership and show impact on value streams

Perhaps most important is to treat the platform as a customer-facing product and recognize that its success is directly dependent on the success of its users and products; and as such it's vital that platform teams partner with app teams and other users to prioritize, plan, implement and iterate on the platform's capabilities and user experiences. Platform teams that release features and experiences without feedback or that rely on top-down mandates to achieve adoption are almost certain to find resistance and resentment from their users and miss a lot of the promised value. To counter this, platform teams should include product managers from the start to share roadmaps, gather feedback and generally understand and represent the needs of platform users.

When adopting platforms, choosing the right capabilities and experiences to enable first, can be crucial. Capabilities that are frequently required and undifferentiated, like pipelines, databases and observability, may be a good place to start. Platform teams may also choose to focus first on a limited number of engaged and skillful app teams. Detailed feedback from such teams improves the first platform experiences; and people from those teams help champion and evangelize the platform to later adopters.

Finally, it's vital in large enterprises to quickly gain leadership support for platform teams. Many enterprise leaders perceive IT infrastructure as an expense quite disconnected from their primary value streams and may try to constrain costs and resources allocated to IT platforms, leading to a poor implementation, unrealized promises and frustration. To mitigate this, platform teams need to demonstrate their direct impact on and relationships with product and value stream teams (see the previous two paragraphs), presenting the platform team as a strategic partner of product teams in delivering value to customers.

Enabling platform teams

It is clear from these challenges that platform teams are faced with a number of diverse responsibilities which lead to cognitive load. Just as with their application team counterparts, this challenge grows with the number and diversity of users and teams they need to support.

It is important to focus the platform team's energy on the experience and capabilities that are unique to their specific business. Ways to reduce load on the platform team include the following:

1. Seek to build the thinnest viable platform layer over implementations from managed providers
2. Leverage open source frameworks and toolkits for creating docs, templates and compositions for application team use
3. Ensure platform teams are staffed appropriately for their domain and number of customers

How to measure the success of platforms

Enterprises will want to measure whether their platform initiatives are delivering the values and attributes discussed above. Also, throughout this paper we've emphasized the importance of treating internal platforms as products, and good product management depends on quantitative and qualitative measurement of a product's performance. To meet these requirements, internal platform teams should continuously gather user feedback and measure user activities.

As with other aspects of internal platforms, though, platform teams should use the smallest viable effort to gather the feedback they need. We'll suggest metrics here but simple surveys and analysis of user behavior may be most valuable initially.

Categories of metrics that will help enterprises and platform teams understand the impact of their platforms include the following:

User satisfaction and productivity

The first quality sought by many platforms is to improve user experience in order to increase productivity. Metrics that reflect user satisfaction and productivity include the following:

- Active users and retention: includes number of capabilities provisioned and user growth/churn
- "Net Promoter Score" (NPS) or other surveys that measure user satisfaction with a product
- Metrics for developer productivity such as those discussed in the SPACE framework [4]

Organizational efficiency

Another benefit sought from many platforms is to efficiently provide common needs to a large user base. This is often achieved by enabling user self-service and reducing manual steps and required human intervention while implementing policies to guarantee safety and compliance. To measure the efficiency of a platform in reducing common work, consider measures such as these:

- Latency from request to fulfillment of a service or capability, such as a database or test environment
- Latency to build and deploy a brand new service into production
- Time for a new user to submit their first code changes to their product

Product and feature delivery

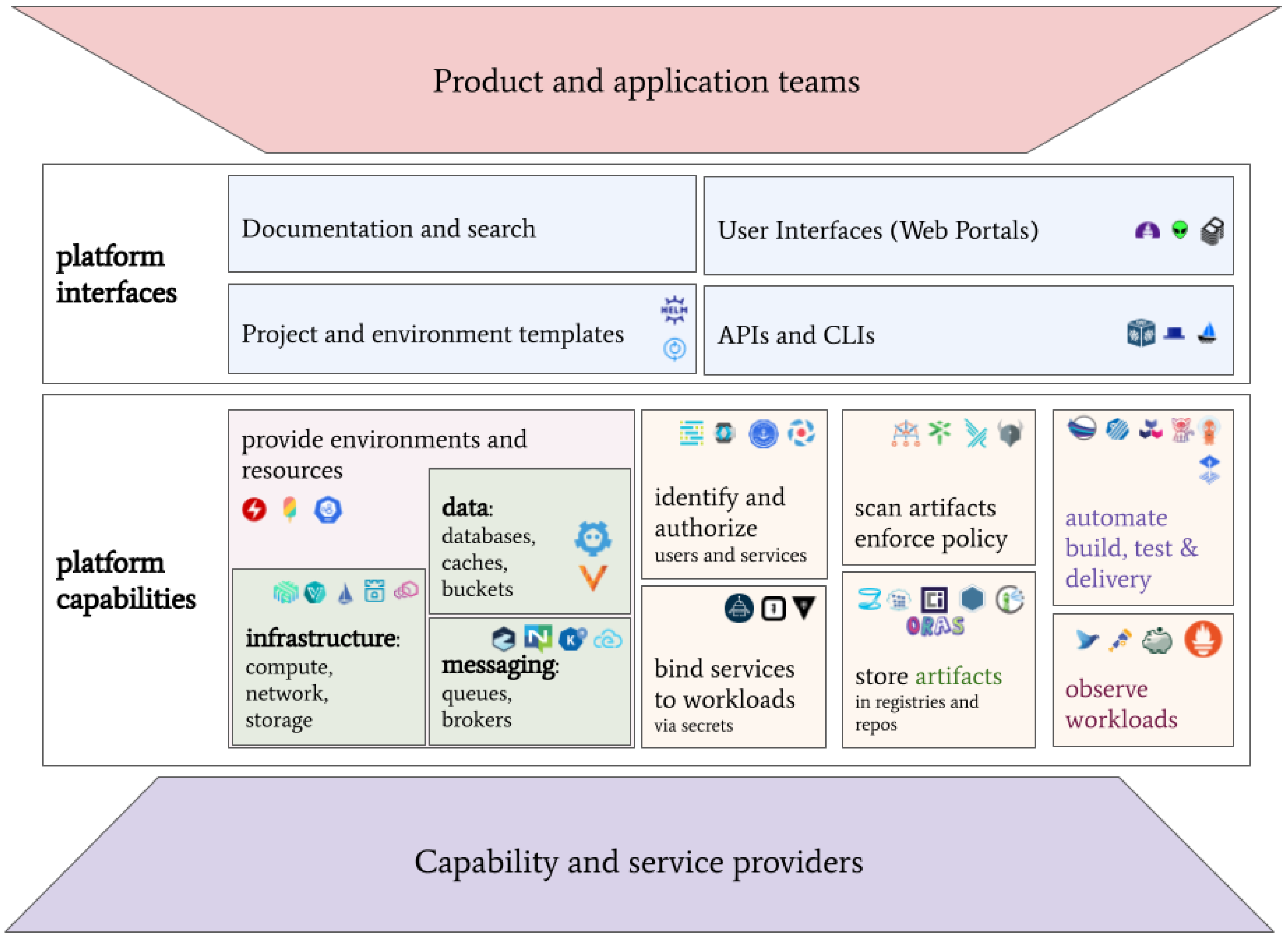
The ultimate objective of internal platforms is to deliver business value to customers faster, so measuring impact on a business's own product and feature releases demonstrates that the objectives of the platform are being met. The DevOps Research and Assessment (DORA) institute at Google suggests [5] tracking the following metrics:

- Deployment frequency
- Lead time for changes
- Time to restore services after failure
- Change failure rate

Generally, a key objective of platform teams is to align infrastructure and other IT capabilities with an enterprise's value streams - its products. And so ultimately the success of an organization's products and applications are the true measure of the success of a platform.

Capabilities of platforms

As we've described, a platform for cloud-native computing offers and composes capabilities and services from many supporting providers. These providers may be other teams within the same enterprise or third parties like cloud service providers. In a nutshell, platforms bridge from underlying capability providers to platform users like application developers; and in the process implement and enforce desired practices for security, performance, cost governance and consistent experience. The following graphic illustrates the relationships between products, platforms, and capability providers.


Product and application teams
platform interfaces
Documentation and search
User Interfaces (Web Portals)
Project and environment templates
APIs and CLIs
platform capabilities
provide environments and resources
data: databases, caches, buckets
infrastructure: compute, network, storage
messaging: queues, brokers
identify and authorize users and services
bind services to workloads via secrets
scan artifacts enforce policy
store artifacts in registries and repos
automate build, test & delivery
observe workloads
Capability and service providers

We've focused in this paper on how to construct a good platform and platform team; now in this last section we'll describe the capabilities a platform may actually offer. This list is intended to guide platform builders and includes capabilities typically required by cloud-native applications. As we've noted throughout though, a good platform reflects its users' needs, so ultimately platform teams should choose and prioritize the capabilities their platform offers together with its users.

Capabilities may comprise several features, meaning aspects or attributes of the parent capability's domain. For example, observability may include features for gathering and publishing metrics, traces and logs as well as for observing costs and energy consumption. Consider the need and priority for each feature or aspect in your organization. Later CNCF publications may expand on each domain further.

Here are capability domains to consider when building platforms for cloud-native computing:

1. **Web portals** for observing and provisioning products and capabilities
2. **APIs (and CLIs)** for automatically provisioning products and capabilities
3. **"Golden path" templates** and docs enabling optimal use of capabilities in products
4. **Automation for building and testing** services and products
5. **Automation for delivering and verifying** services and products
6. **Development environments** such as hosted IDEs and remote connection tools
7. **Observability** for services and products using instrumentation and dashboards, including observation of functionality, performance and costs

8. **Infrastructure** services including compute runtimes, programmable networks, and block and volume storage
9. **Data** services including databases, caches, and object stores
10. **Messaging** and event services including brokers, queues, and event fabrics
11. **Identity and secret** management services such as service and user identity and authorization, certificate and key issuance, and static secret storage
12. **Security** services including static analysis of code and artifacts, runtime analysis, and policy enforcement
13. **Artifact storage** including storage of container image and language-specific packages, custom binaries and libraries, and source code

The following table is intended to help readers grasp each capability by loosely relating it to existing CNCF or CDF projects.

Capability	**Description**	**Example CNCF/CDF Projects**
Web portals for provisioning and observing capabilities	Publish documentation, service catalogs, and project templates. Publish telemetry about systems and capabilities.	Backstage, Skooner, Ortelius
APIs for automatically provisioning capabilities	Structured formats for automatically creating, updating, deleting and observing capabilities.	Kubernetes, Crossplane, Operator Framework, Helm, KubeVela
Golden path templates and docs	Templated compositions of well-integrated code and capabilities for rapid project development.	ArtifactHub
Automation for building and testing products	Automate build and test of digital products and services.	Tekton, Jenkins, Buildpacks, ko, Carvel
Automation for delivering and verifying services	Automate and observe delivery of services.	Argo, Flux, Keptn, Flagger, OpenFeature
Development environments	Enable research and development of applications and systems.	Devfile, Nocalhost, Telepresence, DevSpace

Capability	Description	Example CNCF/CDF Projects
Application observability	Instrument applications, gather and analyze telemetry and publish info to stakeholders.	OpenTelemetry, Jaeger, Prometheus, Thanos, Fluentd, Grafana, OpenCost
Infrastructure services	Run application code, connect application components and persist data for applications	Kubernetes, Kubevirt, Knative, WasmEdge CNI, Istio, Cilium, Envoy, Linkerd, CoreDNS Rook, Longhorn, Etcd
Data services	Persist structured data for applications	TiKV, Vitess, SchemaHero
Messaging and event services	Enable applications to communicate with each other asynchronously	Strimzi, NATS, gRPC, Knative, Dapr
Identity and secret services	Ensure workloads have locators and secrets to use resources and capabilities. Enable services to identify themselves to other services	Dex, External Secrets, SPIFFE/SPIRE, Teller, cert-manager
Security services	Observe runtime behavior and report/remediate anomalies. Verify builds and artifacts don't contain vulnerabilities. Constrain activities on the platform per enterprise requirements; notify and/or remediate aberrations	Falco, In-toto, KubeArmor, OPA, Kyverno, Cloud Custodian
Artifact storage	Store, publish and secure built artifacts for use in production. Cache and analyze third-party artifacts. Store source code.	ArtifactHub, Harbor, Distribution, Porter

Appendix: Glossary

See also Cloud Native Glossary.

A **platform** aggregates capabilities to serve developers and operators in development and delivery of products, services and apps. In reference to the scenarios it aims to support, a platform may be named a "Developer Platform", a "Delivery Platform", an "App Platform" or even a "Cloud Platform." The connotations of the older term "Platform-as-a-Service", or PaaS, are also influential.

Platforms enable developers and operators to deliver applications and services faster by providing and managing common capabilities. Platforms bridge between platform users and platform capability providers, and are built and maintained by platform teams.

Platform capability providers develop and maintain the capabilities offered by the platform. Providers can be both external organizations or internal teams, and capabilities can be infrastructure, runtime, or other supporting services.

Platform engineers are responsible for developing and maintaining interfaces and tools to enable provisioning and integration of platform capabilities in applications, according to the requirements and instructions provided by platform product managers. Platform developers are usually grouped in platform teams.

Platform product managers are responsible for understanding the experience of platform users, building a roadmap that addresses platform product gaps, requirements, and opportunities, and managing platform teams in their daily work.

Platform teams are responsible for developing and maintaining the interfaces to and experiences with platform capabilities - like Web portals, custom APIs, and golden path templates.
Platform teams are managed by platform product managers and involve platform developers. As the platform evolves and become more advanced, other roles can become part of a platform team, including, but not limited to, operators, QA analysts, UI/UX designers, technical writers, developer advocates.

Platform users include but aren't limited to app developers and operators, data scientists, COTS software operators, and information workers - whoever runs software on the platform or uses platform provided capabilities.

Thinnest viable platform (TVP) is a concept originally defined in the book Team Topologies by Matthew Skelton and Manuel Pais. The definition says: "A TVP is a careful balance between keeping the platform small and ensuring that the platform is helping to accelerate and simplify software delivery for teams building on the platform."

Appendix: Contributors

Thank you to the many members of CNCF WG Platforms who have contributed feedback and insights on this paper, in particular the following:

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