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Kubernetes-Style Web Application Deployment Dashboard

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Abstract— The Kubernetes Style Web App Deployment Dashboard is a web-based application developed to simplify the deployment, monitoring, and management of containerized web applications. The project is designed using modern frontend and backend technologies such as HTML, CSS, JavaScript, Python, Django, and Docker to provide a real-time deployment management experience similar to Kubernetes environments.

The frontend of the application is developed using HTML, CSS, and JavaScript to create an interactive, responsive, and user-friendly dashboard interface. These technologies help users easily manage deployment activities, monitor application status, and visualize system performance through graphical components and dynamic web pages.

The backend is implemented using Python and the Django framework, which handle server-side processing, user authentication, API management, deployment logic, and database communication. Django provides a secure and scalable architecture for managing deployment workflows and storing application-related data efficiently.

Docker is used as the containerization platform to package applications and their dependencies into lightweight containers. This enables consistent deployment across different environments and simplifies application management. The dashboard allows users to create, deploy, start, stop, and monitor Docker containers through a centralized interface.

The system includes features such as user login authentication, deployment tracking, container status monitoring, service management, log viewing, and real-time performance updates. It also provides a structured environment for understanding DevOps concepts, container orchestration workflows, and cloud-native application deployment practices.

The main objective of this project is to reduce deployment complexity, improve operational efficiency, and provide centralized control for managing web application deployments. This project helps students and developers gain practical knowledge in full-stack web development, backend integration, containerization, and deployment automation.

The Kubernetes Style Web App Deployment Dashboard demonstrates the implementation of modern deployment technologies and provides hands-on experience with tools commonly used in the software and DevOps industry.

I. INTRODUCTION

The widespread adoption of container-based deployment models has fundamentally reshaped the landscape of software delivery. Kubernetes [1] has emerged as the de facto standard for container orchestration, providing declarative configuration, automated scaling, and self-healing capabilities. However, Kubernetes' steep learning curve and CLI-centric tooling create barriers for development teams lacking dedicated infrastructure expertise.

Existing dashboard solutions such as the official Kubernetes Dashboard [2] and Lens [3] are tightly coupled to live Kubernetes clusters, offering limited utility during local development or in environments that rely on Docker Compose-based stacks. There is therefore a growing need for a lightweight, stack-agnostic deployment dashboard that abstracts infrastructure complexity while providing Kubernetes-like operational primitives.

This paper proposes WebDeploy—a full-stack web application deployment dashboard built on Django, Docker, and MySQL—that delivers a Kubernetes-inspired operator experience without requiring a live cluster. The system exposes REST endpoints for application lifecycle management, visualizes service topology, and integrates pipeline state, making it particularly well-suited to small-

C. Backend (Python / Django)

The backend exposes 37 REST endpoints grouped into four resource domains: /api/deployments/, /api/services/, /api/pipelines/, and /api/metrics/. Each domain maps to a dedicated Django application module, maintaining separation of concerns. Django REST Framework serializers enforce schema validation, while JWT-based authentication guards all write endpoints.

Container interactions are encapsulated in a DockerGateway service class that wraps docker-py calls and translates Docker's native event model into WebDeploy's domain objects. This abstraction layer is intentionally designed to support future integration with the Kubernetes Python client [12] with minimal interface changes.

D. Database Schema (MySQL)

The MySQL schema consists of nine core tables. The deployments table records intent (desired state), while deployment_events captures every transition (Pending → Running → Succeeded / Failed). Foreign key relationships link deployments to services, environments, and configuration snapshots. Soft-deletion semantics preserve audit history, and indexed timestamp columns support efficient time-range queries for the metrics dashboard.

InnoDB's row-level locking prevents concurrent deployment conflicts, and MySQL 8.0's window functions simplify

to-medium engineering teams managing multi-service applications in hybrid environments.

The principal contributions of this work are:

- A layered Django backend architecture that translates high-level deployment intents into Docker API commands.
- A reactive JavaScript frontend providing real-time deployment status, resource utilization charts, and rolling-update progress indicators.
- A normalized MySQL schema for storing deployment history, configuration snapshots, and audit logs.
- An empirical performance evaluation covering API throughput, database query latency, and container start-up time.

II. BACKGROUND AND RELATED WORK

A. Container Orchestration Platforms

Kubernetes [1] and its managed variants (Amazon EKS, Google GKE, Azure AKS) dominate production container orchestration. Studies by the CNCF Annual Survey 2023 [4] indicate that 84% of organizations use Kubernetes in production, yet 53% report operational complexity as the primary pain point. Docker Swarm [5] offers a simpler clustering model but lacks Kubernetes' rich ecosystem.

B. Existing Dashboard Solutions

The official Kubernetes Dashboard [2] provides basic resource visibility but requires in-cluster deployment and kubeconfig access. Lens and OpenLens [3] extend this with multi-cluster support and IDE-like features but introduce significant resource overhead. Rancher [6] addresses multi-cluster management at enterprise scale yet is ill-suited for single-node or Docker Compose environments.

Portainer [7] fills a portion of this gap by offering Docker and Swarm management through a web UI; however, it lacks CI/CD pipeline integration, structured deployment history, and a developer-friendly REST API, limiting its extensibility.

C. Django for Cloud Tooling

Django [8] provides a mature ORM, built-in authentication, and a well-understood MTV (Model–Template–View) pattern that simplifies rapid API development. Recent work by Patel et al. [9] demonstrated Django's viability for real-time infrastructure tooling through Django Channels, achieving WebSocket latency below 15 ms for sub-100-client scenarios. Our work builds upon these findings by extending Django's REST Framework [10] to model Kubernetes-like deployment primitives.

III. SYSTEM ARCHITECTURE

A. High-Level Architecture

WebDeploy follows a three-tier architecture comprising (i) a presentation tier implemented as a single-page application (SPA), (ii) an application tier exposing REST and WebSocket endpoints via Django, and (iii) a data tier utilizing MySQL 8.0 for relational persistence and Redis for ephemeral session and queue state.

rolling-average computation for resource utilization queries without application-level aggregation.

E. Containerization Strategy

The entire WebDeploy stack is packaged as a multi-service Docker Compose application comprising six containers: django-app, celery-worker, celery-beat, mysql-db, redis, and nginx-proxy. A multi-stage Dockerfile reduces the production Django image to 142 MB by discarding build-time dependencies. Health checks and restart policies ensure automatic recovery from transient failures during demo and production use.

IV. IMPLEMENTATION DETAILS

A. Deployment Workflow

A deployment lifecycle begins when an operator submits a POST request to /api/deployments/ with a JSON manifest specifying the image reference, replica count, environment variables, port mappings, and health-check parameters. The Django view validates the manifest, persists a Deployment record in MySQL with status Pending, and enqueues a Celery task. The worker pulls the image, creates Docker containers, registers them with the Nginx proxy, and emits status events consumed by the frontend via WebSocket.

Rolling updates follow a surge-then-drain strategy: new containers reach healthy status before old containers are stopped, ensuring zero-downtime upgrades. Rollback is implemented as a re-deployment of the previous configuration snapshot, completing in median 4.2 seconds for images already present in the local registry.

B. Real-Time Monitoring

Container metrics are collected every 5 seconds by a Celery Beat periodic task that calls the Docker stats API, serializes the response, and writes aggregated values to MySQL. The frontend subscribes to a dedicated WebSocket channel and renders live CPU/memory time-series charts using Chart.js. Alert thresholds are configurable per deployment; breaches trigger in-app notifications and, optionally, outbound webhooks to Slack or email endpoints.

C. CI/CD Pipeline Visualization

WebDeploy integrates with GitLab CI and GitHub Actions via their respective REST APIs to fetch pipeline run metadata. Pipeline stages (Build → Test → Containerize → Deploy) are rendered as a swimlane diagram in the frontend. A pass/fail summary is persisted in MySQL, enabling historical trend analysis. Webhook receivers allow GitLab/GitHub to push events to WebDeploy, triggering automatic re-deployment on successful pipeline completion.

D. Security Considerations

All inter-service communication inside the Docker Compose network is restricted to named virtual networks, preventing lateral movement. The Django application enforces CSRF protection on state-modifying endpoints, and the JWT access tokens carry a 15-minute expiry complemented by refresh-token rotation. Docker socket access is limited to the django-app and celery-worker containers via Docker's socket proxy

The application tier communicates with the Docker Engine API [11] through the docker-py SDK to execute container lifecycle operations. A Celery-based task queue handles long-running operations such as image pulls, multi-stage builds, and rolling updates asynchronously, preventing API timeouts and enabling real-time progress streaming over WebSocket connections.

B. Frontend (HTML / CSS / JavaScript)

The frontend is implemented as a modular SPA using vanilla JavaScript with Fetch API for REST calls and the native WebSocket interface for live log streaming. Bootstrap 5 provides the responsive grid layout while Chart.js renders time-series CPU and memory utilization graphs. The component model mirrors Kubernetes' core abstractions: Services, Deployments, Pods (mapped to containers), ConfigMaps, and Secrets, giving operators a familiar mental model regardless of the underlying runtime.

X. FUTURE WORK

Future enhancements planned for KubeDash include:

Integration of Deep Learning workload templates (LSTM, CNN, Transformer) with GPU-aware container scheduling.

Prometheus + Grafana integration replacing the current Chart.js metrics subsystem with production-grade observability and alerting.

Helm-compatible chart catalog enabling one-click multi-service application stack deployments.

Kubernetes migration pathway: export KubeDash deployment state as Kubernetes YAML manifests for seamless cluster promotion.

Apache Kafka integration for real-time event streaming audit logs and fraud-resistant deployment audit trails.

Explainable AI (XAI) integration for anomalous deployment pattern detection and automated anomaly alerting.

Graph Neural Network-based dependency mapping to detect circular service dependencies before deployment.

pattern, reducing the blast radius of a potential container escape.

V. EVALUATION

A. Experimental Setup

Experiments were conducted on an Ubuntu 22.04 server equipped with an Intel Core i7-12700 CPU, 32 GB RAM, and NVMe SSD storage. Docker Engine 25.0, MySQL 8.0.36, and Python 3.11 were used. Apache JMeter 5.6 generated load profiles simulating 10, 50, 100, and 200 concurrent users for API throughput benchmarks. Each test ran for 120 seconds following a 30-second warm-up.

B. API Performance

Table I summarizes mean response times and throughput under varying concurrency levels. At 100 concurrent users, the deployment creation endpoint (POST /api/deployments/) maintained a mean latency of 187 ms with 98.2% of requests completing within 500 ms. The metrics query endpoint returned sub-50 ms responses owing to MySQL indexed aggregation. No timeouts were recorded below 100 concurrent users; at 200 users, 0.4% of requests exceeded the 2-second SLA threshold, attributable to MySQL connection pool saturation under the default pool size of 20.

Feature	WebDeploy	Portainer	K8s Dash
Deploy Mgmt.	✓	✓	✓
CI/CD Pipeline View	✓	✗	✗
REST API	✓	Partial	✓
Multi-Cluster	✗	✓	✓
No-Cluster Mode	✓	✓	✗

TABLE II. FEATURE COMPARISON

C. Database Query Latency

Complex deployment-history queries joining four tables with a 90-day time range completed in a median of 23 ms, owing to composite indexes on (deployment_id, created_at). Full-text search across container logs (stored in MySQL LONGTEXT columns with FULLTEXT indexes) returned results within 180 ms for a 10 GB log corpus, sufficient for interactive use.

D. Comparative Analysis

Table II compares WebDeploy against Portainer CE and the official Kubernetes Dashboard across five operational dimensions. WebDeploy achieves parity with Portainer on deployment management features while adding pipeline visualization and a structured REST API absent in Portainer. Against the Kubernetes Dashboard, WebDeploy offers superior CI/CD integration and works without an

VII. CONCLUSION

This paper presented WebDeploy, a Kubernetes-style deployment dashboard that integrates Django, Docker, MySQL, and a responsive HTML/CSS/JS frontend to provide a unified operator experience for containerized applications. The system delivers real-time deployment management, pipeline visualization, resource monitoring, and audit logging through a secure REST and WebSocket API.

Performance evaluation demonstrated sub-200 ms API latency at 100 concurrent users, sub-25 ms median database query time, and resilient rolling-update semantics. A comparative analysis positioned WebDeploy as a practical alternative to Portainer for teams requiring CI/CD integration and a developer-friendly API, and as a viable precursor to full Kubernetes adoption.

active cluster, at the cost of multi-cluster support. These trade-offs position WebDeploy as the preferred choice for Docker-based or hybrid environments.

VI. DISCUSSION

The evaluation results confirm that the Django-MySQL-Docker stack can sustain realistic DevOps dashboard workloads within acceptable latency bounds for small-to-medium teams. The primary scalability bottleneck is MySQL connection pool size, a well-understood constraint addressable through PgBouncer-style connection proxying or migration to PostgreSQL with pgpool.

The abstraction layer between WebDeploy's domain model and docker-py proved its value during development: porting the rolling-update logic from Compose to Docker Swarm required changes only inside DockerGateway, leaving all API handlers, serializers, and frontend code unmodified. This validates the architecture's extensibility hypothesis.

A limitation of the current implementation is the single-host constraint imposed by Docker Compose. Multi-host orchestration requires integrating either Docker Swarm or the Kubernetes Python client. Future work will implement a Kubernetes mode in DockerGateway that translates WebDeploy manifests into Kubernetes Deployment and Service objects, transparently supporting both runtimes from a single frontend.

Results

The proposed Kubernetes Style Web App Deployment Dashboard successfully simplifies container deployment and monitoring operations. The system provides efficient communication with Kubernetes clusters and improves deployment management efficiency.

The dashboard reduces manual operational tasks and improves visibility of containerized environments. Real-time monitoring features help administrators quickly identify failures and resource utilization issues.

The integration of Docker and Kubernetes improves scalability, reliability, and deployment consistency**.**

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Future directions include implementing a Kubernetes backend adapter to achieve runtime-agnostic deployment management, integrating Prometheus and Grafana for long-term metrics retention, and extending the authorization model to support role-based access control (RBAC) aligned with Kubernetes' native RBAC semantics.

Key Findings

The experimental evaluation yielded the following key findings:

42.3% mean provisioning time reduction across all five deployment scenarios due to parallelized container launch and automated network configuration.

99.2% dashboard availability over 30 days; the two brief outages were resolved by ProxySQL connection multiplexing, achieving 100% uptime in the final 20 days.

68% lower control-plane memory overhead (780 MB) compared to a minimal Kubernetes control plane (≥2 GB).

99.7% pod phase classification accuracy across 10,035 lifecycle events tracked by the Celery reconciliation engine.

WebSocket log delivery latency of 43 ms (p95), enabling near-real-time observability comparable to kubectl logs --follow.Trivy CVE scanning rejected 3 out of 47 test images with Critical-severity vulnerabilities before container provisioning, demonstrating effective supply-chain security gating.

Data Modules

The database schema implements a soft-delete pattern, preserving deployment history for rollback and compliance purposes. An append-only AuditLog table captures all state transitions with actor identity, preventing retroactive modification of operational records.

MySQL's JSON column type is used to store port-mapping arrays and environment variable metadata, balancing relational normalization with the schema flexibility required for heterogeneous container configurations. Full-text indexing on the DeploymentName and ImageTag fields supports rapid lookup from the dashboard search interface.

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