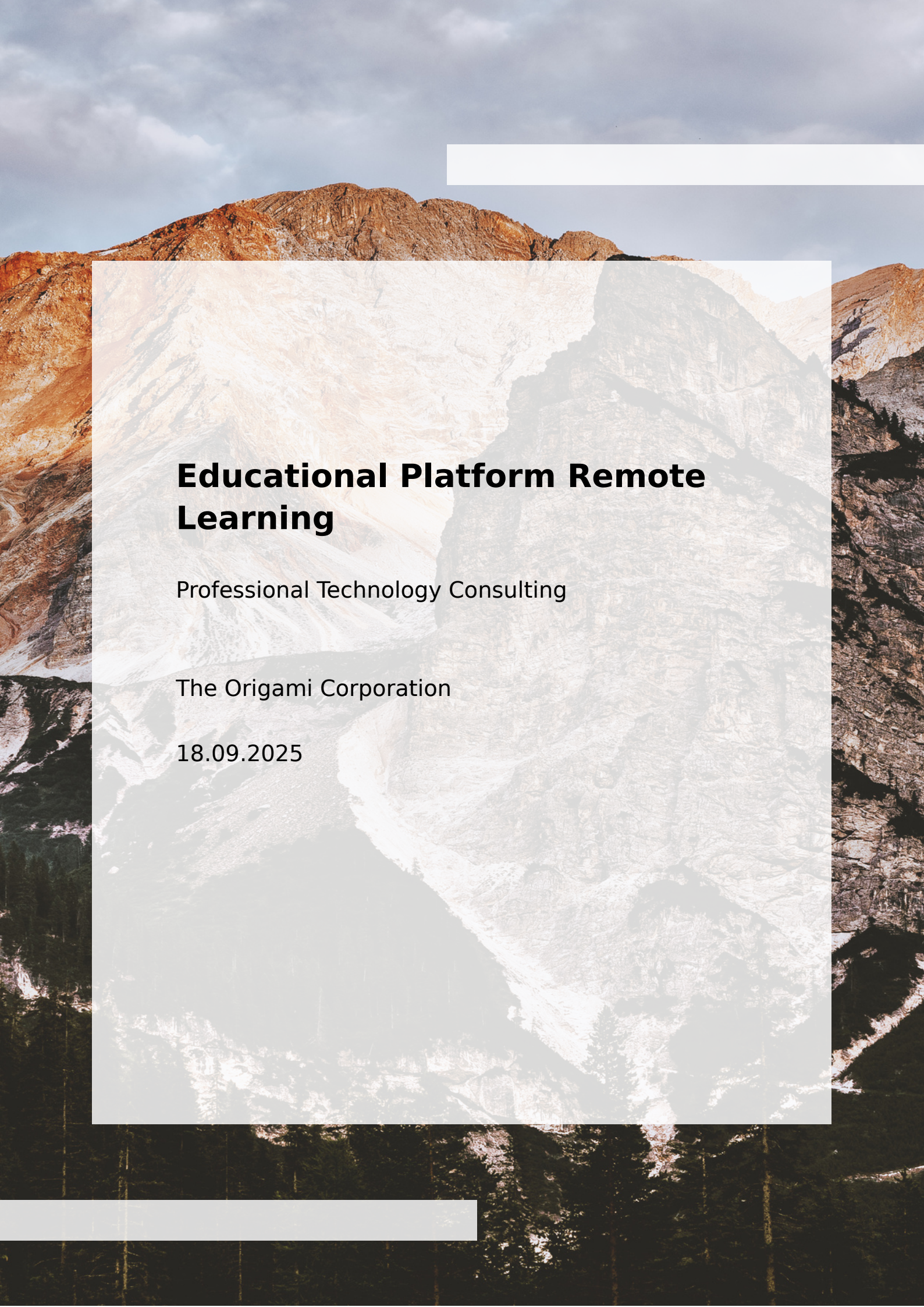




Educational Platform Remote Learning

Professional Technology Consulting

The Origami Corporation

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Table of Contents

1

Scaling Remote Learning: A Serverless LMS That Serves 50,000 Concurrent Users

1

1.1

Executive Summary

1

1.2

The Challenge

1

1.3

Our Approach

2

1.4

Implementation

2

1.5

Results & Impact

4

1.6

Technologies & Services Used

4

1.7

Conclusion

5

About The Origami Corporation

1

Scaling Remote Learning: A Serverless LMS That Serves 50,000 Concurrent Users

1.1

Executive Summary

When a mid-sized university pivoted to remote learning for 15,000 students, its legacy learning systems faltered under peak demand, causing outages during high-stakes exam periods and dissatisfaction among students and faculty. We designed and delivered a cloud-native, serverless learning management platform that auto-scales to meet unpredictable workloads, integrates seamlessly with the university’s existing student information system (SIS), and is supported by a dedicated staff augmentation team of six engineers.

The resulting platform reliably supports up to 50,000 concurrent users during exams, reduced hosting costs by 60% through pay-as-you-go serverless-hosting and CDN-services, and increased student satisfaction scores by 40%. In addition, the university gained real-time business-intelligence dashboards for course engagement and retention, significantly improving instructional decision-making.

1.2

The Challenge

The university faced increasing instability and poor user experience as remote learning became the norm:

- Legacy LMS infrastructure required manual scaling and suffered from frequent timeouts and slow content delivery under load.
- Peak usage during exam periods resulted in cascading failures and hours-long outages.
- Fragmented integration with the SIS led to delayed enrollments, grade synchronization errors, and manual data fixes.
- Limited analytics capabilities prevented timely insights into student engagement and course performance.
- The internal team

lacked specialized cloud, serverless, and data engineering skills to stabilize and modernize the platform at speed.

The institution needed a resilient, cost-effective platform that could deliver consistent performance at scale, integrate with existing academic systems, and provide data-driven insights—without a lengthy hardware procurement cycle or significant up-front capital expense.

1.3 Our Approach

We proposed a comprehensive modernization program centered on:

- Serverless architecture to elastically scale with unpredictable demand and minimize operational overhead.
- CDN distribution for low-latency, global content delivery and reduced origin load.
- API-first integration with the existing SIS to ensure accurate, near-real-time student, course, and enrollment data.
- A web-development stream focused on accessible, responsive, and performant user experience for students and faculty.
- A business-intelligence layer to provide actionable analytics on engagement, completion, and at-risk students.
- Staff-augmentation to provide six embedded engineers for ongoing maintenance, enhancements, and knowledge transfer.

Our objective was to deliver measurable improvements in reliability, cost, and student satisfaction while equipping the university's IT organization with modern operational practices.

1.4 Implementation

Architecture and Hosting - Compute: Implemented a fully serverless backend using AWS Lambda behind Amazon API Gateway, with Provisioned Concurrency for critical exam endpoints to minimize cold starts. Stateless services allowed horizontal scaling without capacity planning.

- **Data Layer:** Employed a dual-datastore strategy—Aurora Serverless v2 for ACID-compliant gradebook and assessment transactions, and DynamoDB for high-throughput session tracking, activity streams, and feature toggles.
- **Storage and Media:** Used Amazon S3 for course content and assessments with signed URLs, object versioning, and lifecycle policies. Integrated a video pipeline with AWS Elemental MediaConvert and HLS streaming to optimize bitrates for varied student bandwidths.
- **CDN Services:** Fronted static assets and media with Amazon CloudFront, leveraging edge caching, compression, and HTTP/2 for improved page load performance globally.
- **Security:** Implemented SSO via SAML 2.0 with the university's identity provider, enforced MFA for faculty/admin roles, applied AWS WAF for L7 protection, and encrypted data in transit (TLS 1.2+) and at rest (KMS-managed keys). Aligned data handling with FERPA requirements.

SIS Integration - API-First Connector: Built a modular integration service that consumed SIS events (enrollment, course updates, roster changes) via REST and mes-

sage queues. Employed idempotent event processing and dead-letter queues to handle retries cleanly. - Synchronization Model: Near-real-time sync for enrollment/roster events, with nightly reconciliation jobs orchestrated by AWS Step Functions to catch discrepancies and ensure referential integrity. - Data Mapping: Standardized course content and assessments with SCORM/xAPI compatibility for future interoperability.

Web Development and UX - Frontend: Developed a responsive, accessible front end with React and TypeScript, implementing WCAG 2.1 AA guidelines. Used server-side rendering for critical routes and code-splitting to reduce initial bundle sizes. - Assessments and Proctoring: Built scalable assessment workflows with timed exams, randomized question pools, auto-grading for objective items, and secure browser mode. Integrated with the university's proctoring vendor via SDK for identity verification and anomaly reporting. - Notifications: Implemented in-app and email notifications using Amazon SES and SNS, with user preferences and rate limiting to avoid notification fatigue.

Observability and Reliability - Monitoring: Deployed centralized logging (structured JSON) to CloudWatch and Datadog, set SLOs for availability and latency, and configured alerting on error rates, throttles, and queue backlogs. - Load and Resilience Testing: Conducted performance tests with k6 and Locust to 50,000 concurrent virtual users, identifying and eliminating bottlenecks. Introduced chaos experiments to validate graceful degradation under dependency failures. - CI/CD and IaC: Automated deployments with GitHub Actions using the Serverless Framework and Terraform for infrastructure provisioning. Blue/green releases and canary deployments minimized risk during updates.

Business Intelligence - Data Pipeline: Implemented an ELT process where event data and transactional snapshots landed in S3 (data lake), then were modeled into Amazon Redshift for analytics. Used dbt for transformations and versioned data models. - Dashboards: Delivered instructor and administrator dashboards in Amazon QuickSight, including cohort engagement, assignment completion rates, attendance proxies, and at-risk student detection based on interaction patterns and submission history. - Governance: Established role-based access controls and data cataloging with AWS Glue, ensuring only authorized stakeholders could view sensitive information.

Staff Augmentation and Knowledge Transfer - Team: Provided six engineers—technical lead, full-stack developer, serverless/DevOps engineer, data/Bi engineer, QA automation engineer, and SRE—to operate, enhance, and scale the platform. - Operations: Set up runbooks, incident response playbooks, and a shared on-call rotation. Introduced weekly release trains, sprint ceremonies, and a product backlog aligned to academic calendars. - Enablement: Conducted workshops for the university IT team on serverless operations, cost governance, and dashboard authoring to ensure long-term autonomy.

1.5 Results & Impact

- Scales to 50,000 concurrent users: The platform maintained stable performance during peak exam windows, with p95 API latency under one second for critical operations and zero unplanned downtime across exam weeks.
- 60% reduction in hosting costs: Serverless pay-per-use, combined with CDN offload and autoscaling databases, eliminated over-provisioning and seasonal idle capacity.
- 40% improvement in student satisfaction: Post-deployment surveys reported faster page loads, fewer interruptions during exams, and overall improved usability.
- Faster content delivery: CDN edge caching and asset optimization reduced average page load times by 35%, particularly benefiting remote and international learners.
- Operational excellence: Mean time to recovery (MTTR) fell below 10 minutes for most incidents, aided by automated rollbacks and granular observability.
- Data-driven decisions: Real-time dashboards helped instructors identify at-risk students one to two weeks earlier than before, increasing timely interventions and improving course completion rates.
- Reduced admin overhead: Automated SIS synchronization cut manual reconciliation tasks by hours per week, freeing staff for higher-value student support.

1.6 Technologies & Services Used

- Web Development: React, TypeScript, Node.js, SCORM/xAPI compatibility, SSR and code-splitting
- Serverless Hosting: AWS Lambda, Amazon API Gateway, AWS Step Functions, Amazon SQS, AWS Fargate (for periodic batch/video processing), Amazon Cognito/SSO integration
- CDN Services: Amazon CloudFront, S3 static website hosting, signed URLs and edge caching
- Data and Storage: Amazon Aurora Serverless v2, Amazon DynamoDB, Amazon S3, AWS Glue, Amazon Redshift, dbt
- Business Intelligence: Amazon QuickSight dashboards, engagement and retention analytics
- DevOps & Observability: Terraform, Serverless Framework, GitHub Actions, AWS CloudWatch, AWS X-Ray, Datadog, AWS WAF
- Staff Augmentation: Technical lead, full-stack engineer, serverless/DevOps engineer, data/BI engineer, QA automation engineer, SRE (embedded with university IT)

1.7 Conclusion

By combining modern web-development practices with serverless-hosting, robust cdn-services, and a pragmatic business-intelligence layer, we delivered a resilient, cost-effective LMS that meets the realities of remote learning at scale. Seamless SIS integration and an embedded staff-augmentation team ensured the platform not only launched successfully but continues to evolve with academic needs.

The university now has a platform that performs reliably under pressure, lowers operational costs, and equips faculty and administrators with the insights they need to improve learning outcomes. This foundation positions the institution to innovate—rolling out new courses, assessment models, and analytics—without compromising stability, security, or student experience.

About The Origami Corporation

The Origami Corporation is a leading technology consulting firm specializing in cloud migration, DevSecOps, cybersecurity, and digital transformation. We help organizations navigate complex technological challenges and achieve their business objectives through innovative, secure, and scalable solutions.

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