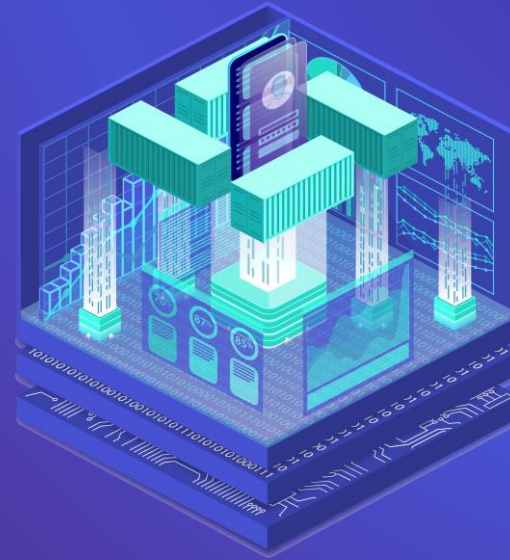




Perspective

Accelerate Healthcare Technology Modernization with **Containerization** and **DevOps**



As the healthcare industry evolves, healthcare organizations and technology companies need to address key issues around quality, consistency, and speed-to-market of new products. DevOps with containerization gives them a strategic advantage as they build scale and accelerate modernization.

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About CitiusTech

With over 4,000 professionals worldwide, CitiusTech enables healthcare organizations to drive clinical value chain excellence, across product engineering, integration & interoperability, data management (EDW, Big Data), performance management (BI / analytics), data science (predictive analytics, Machine Learning, AI) and digital engagement (mobile, IoT).

CitiusTech helps customers accelerate innovation in healthcare through specialized solutions, healthcare technology platforms, proficiencies and accelerators. With cutting-edge technology expertise, world-class service quality and a global resource base, CitiusTech consistently delivers best-in-class solutions and an unmatched cost advantage to healthcare organizations worldwide.

Worldwide Offices

- **US:** Princeton, Dallas, Rochester, Boston, New York, Philadelphia
- **India:** Mumbai, Airoli, Bangalore, Chennai
- **Rest of the world:** Dubai, Singapore, London

\$205+ Mn
in revenue



4,000+
healthcare IT professionals

40 Mn+
lives touched

69
NPS - highest in the industry!

110+
healthcare customers

Key Factors Shaping Healthcare Technology Modernization

In healthcare organizations, the need for change is apparent like never before, bringing with it a combination of expectations and trepidation.

Healthcare providers, payers, medical technology and life-sciences companies are now focused on re-designing their business operations due to cost pressures, regulatory changes, or to leverage digital innovations for competitive advantages.

As organizations adopt digital architectures to meet changing needs, software development and management capabilities take center-stage.

Digitalization and Cloud Adoption

Healthcare applications have witnessed increasing digitalization and cloud adoption to enable **real-time data processing, health information exchange and a seamless user experience.**

Cloud-based digital architectures can also help build more scalable systems, enable faster deployments, and provide better visibility into hosting and maintenance costs.

The current pandemic has accelerated digitalization as companies try to adopt to the new normal, with a shifting attitude towards cloud-based healthcare technology.

Rise of Microservices

The move to cloud-native and serverless technologies for existing applications, as well as the need for modernization of legacy systems have given rise to microservices.

Organizations are using microservices to **break up legacy applications** into smaller, workable components which can be managed independently.

Microservices are also being adopted to overcome the challenges of monolithic architectures, and to provide **consistent user experience** across a range of platforms such as web, mobile, wearables, consumer applications, etc.

DevOps as an Enabler

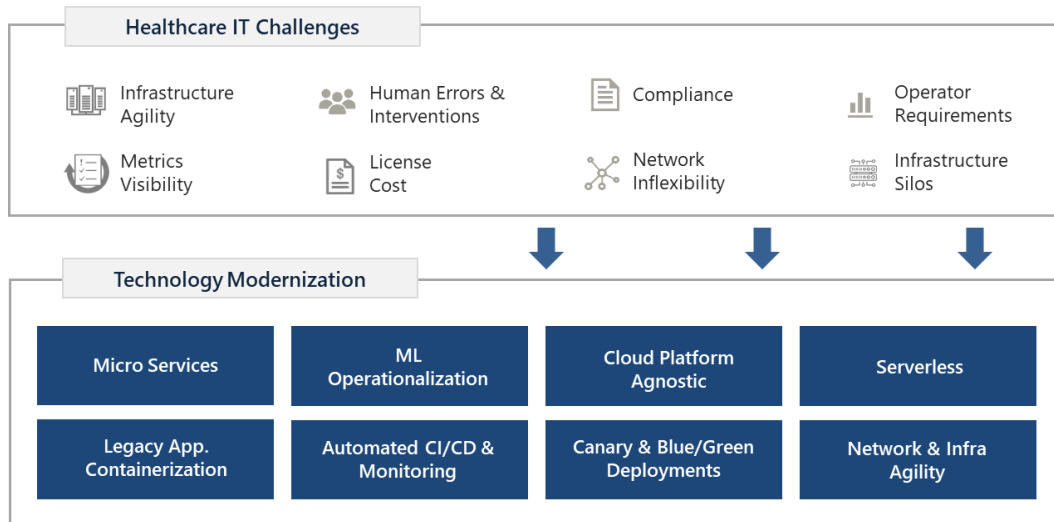
Healthcare organizations working on microservices are embracing DevOps as an enabler for-

- Better team collaboration
- Continuous feedback loops
- Faster deployments and experimentations

DevOps promises to be the silver bullet to help scale-up technology modernizations efforts and provide better deployment and management of microservices.

Role of DevOps in Healthcare Technology Modernization

As healthcare applications adopt digital trends, DevOps methods are shifting from CI pipelines to assembly lines. This allows enterprise IT-infrastructure management teams to deliver better business intelligence, provide native integration support, and leverage containerization for scalability and infrastructure management.



Healthcare Enterprise Focus	
Enterprise CloudOps	Move legacy apps to the cloud and monitor key performance metrics, and provide better user experience
DevSecOps	Meet the security challenges resulting from changes in software development practices, and address healthcare regulations like HIPAA
Operationalization of ML Models (MLOps)	Ensure optimized ML model operations, as an enabler for the healthcare organization's ML adoption journey

Containerization : The Need of the Hour for Healthcare

DevOps-based implementations for cloud-native microservices have a lot to gain from the use of containerized applications, a form of operating system virtualization. Containerization can help reduce overheads, improve portability, scalability, and the overall quality of application development.

Consequently, over the past few years, containerized environments have become the go-to standard for deploying microservices-based applications and powering the DevOps model.

Role of Containerization Orchestration

Information technology in the healthcare domain is complex, and requires multiple containers and services to perform optimally, for even straightforward functional workflows.

To operate healthcare applications at scale, container orchestration is required for automating deployment, management, networking, and availability of containers.

Industry Highlights*

250+ containers

in production grew by 28%, crossing the 50% threshold for the first time in 2019

84%

rise in production container usage, up 15% from last year

91,680

commits made to date to the Kubernetes repository on GitHub

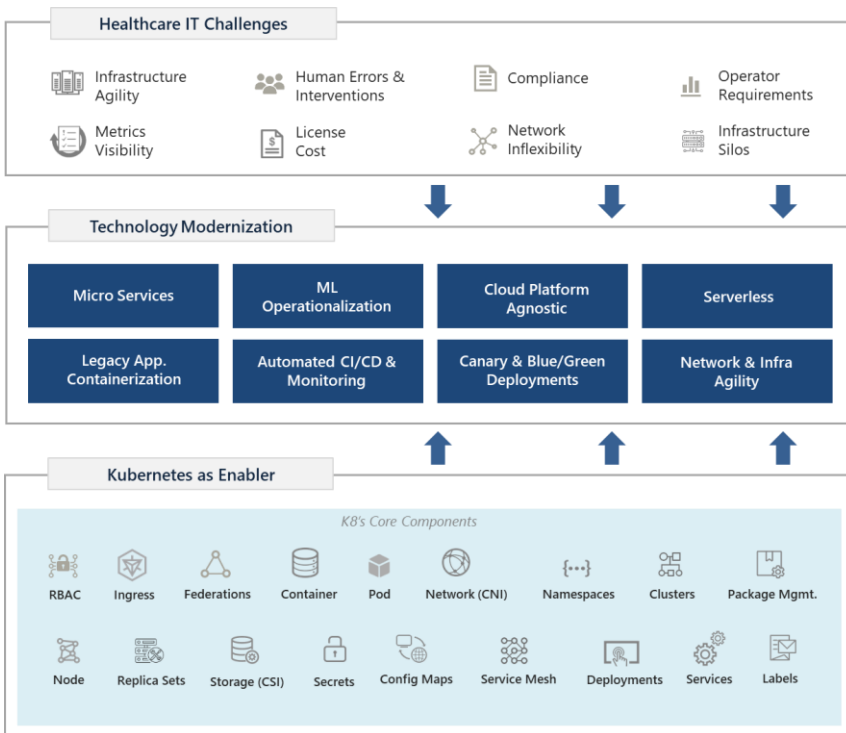


*Source: [2019 CNCF Survey](#), [The Enterprisers Project](#)

Healthcare organizations across the board are leveraging
Containerization Orchestration with DevOps for technology modernization initiatives

Leveraging Kubernetes with DevOps for Healthcare Technology Modernization

Kubernetes is now a de-facto standard for containerized orchestration, offering multiple advantages for healthcare application development. It is the flagship project of the **Cloud Native Computing Foundation (CNCF)**, backed by key technology players such as Google, AWS, Microsoft, IBM, Intel, Cisco, and Red Hat.



Kubernetes for Healthcare

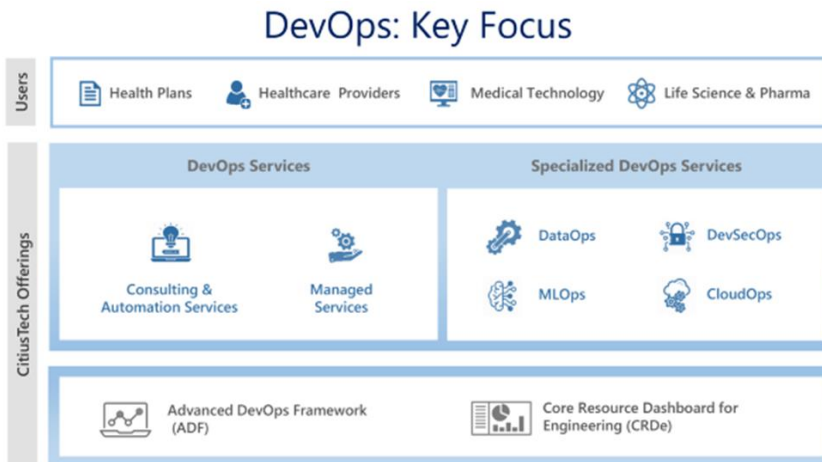
Kubernetes is steadily growing to become a key enabler for healthcare digitalization, driven by:

- **Developed Ecosystem** of supporting applications for Kubernetes
- **Open-source acceptance** as a part of enterprise roadmap strategy for healthcare
- Open-source platforms like **Kubeflow** to make deployments of machine learning workflows on Kubernetes portable and scalable

CitiuTech Experience in Leveraging Containerization and DevOps (1/2)

CitiuTech has a mature DevOps practice which provides end-to-end solutions and support for healthcare organizations in their enterprise transformation journey.

CitiuTech has rich experience of creating state-of-the-art architectures for DevOps, across diverse projects and applications for leading healthcare organizations and ISVs.



Recent Client Engagements on DevOps with Containerization

- **Cloud Lift and Shift:** Developed .NET microservices on Azure and introduced Docker and Kubernetes for a leading RCM company
- **Serverless:** Developed platform to aggregate data from IoT devices for a Fortune 500 company. Performed advanced analytics with Big Data and Machine Learning, and leveraged a serverless architecture using Knative
- **MLOps:** Leveraged Kubeflow – a Kubernetes framework to operationalize data models with MLOps-specific processes and pipeline for a leading bio-tech company
- **Microservices:** Developed microservices on AWS for a multinational biopharmaceutical company



CitiusTech Experience in Leveraging Containerization and DevOps (2/2)



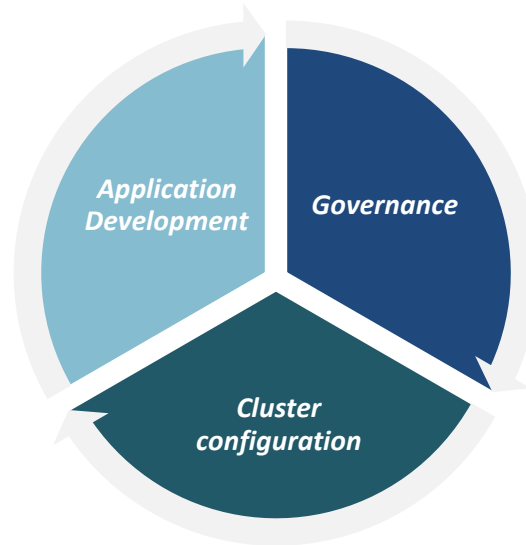
CitiusTech DevOps practice leverages in-house accelerators and frameworks developed on Kubernetes (K8s), to fast-track CloudOps and DevOps adoption, and gain long- term technology advantages.

CitiusTech Accelerators for Containerization and DevOps	
Automated CI/CD Framework	K8s-native automated CI/CD framework to deploy applications with zero downtime and to provide script less end-to-end automation
Real-time Monitoring Framework	CRDe dashboard for monitoring clusters and pods metrics like pod CPU / memory usage, cores info. network packets sent / transmitted, etc.
Serverless Deployments	Structured practices to deploy serverless applications to minimize bugs and maintain security (handling secrets, restricting deploy times and allowed regions)
Microservices Starter Kit	K8s-native platform comprising of industry best practices to jumpstart greenfield healthcare microservice projects
MLOps Framework	K8s based machine learning (ML) operationalization platform to track ML metrics like data drift, predictability, etc.
Infrastructure Provisioning	Reusable scripts for launching K8s clusters and installation of environments on Kubernetes
Application Containerization	Migration of legacy applications into containerization and for automatic deployments on K8s clusters
Reference Architectures	Provides template solutions for all architectures, including microservices, serverless, etc.

CitiusTech Experience in Leveraging Containerization and DevOps: Best Practices

CitiusTech DevOps practice leverages its depth of experience in healthcare technology in the form of **Best Practices for Kubernetes and DevOps** implementations, to help organizations get the best value from their modernization efforts.

- Add health checks with readiness and liveness probes
- Embrace graceful shutdown
- Design for fault tolerance
- Architect for acceptable resources utilization
- Tag resources and add logs
- Design for scaling via Autoscaler



- Namespaces must have LimitRange & ResourceQuota
- Enable pod security policies
- Disable privileged containers and prevent privilege escalation
- Add Role-Based Access Control (RBAC) policies
- Only use approved domain names in the ingress hostnames

- Ensure cluster passes the CIS benchmark
- Use OpenID (OIDC) tokens as a user authentication strategy
- Ensure Service Account tokens for applications and controllers only
- Make provision for a log aggregation tool

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