Introduction & Motivation

Lecture: "Deploying Containerized Application to the Cloud in Practice"

Why Containerized Cloud Deployments? (1/2)

- The "traditional" deployment has... challenges.
    - Deployment inconsistencies
    - Manual setup
    - Scaling issues
    - Resource waste

IT WORKED OK ON MY MACHINE!
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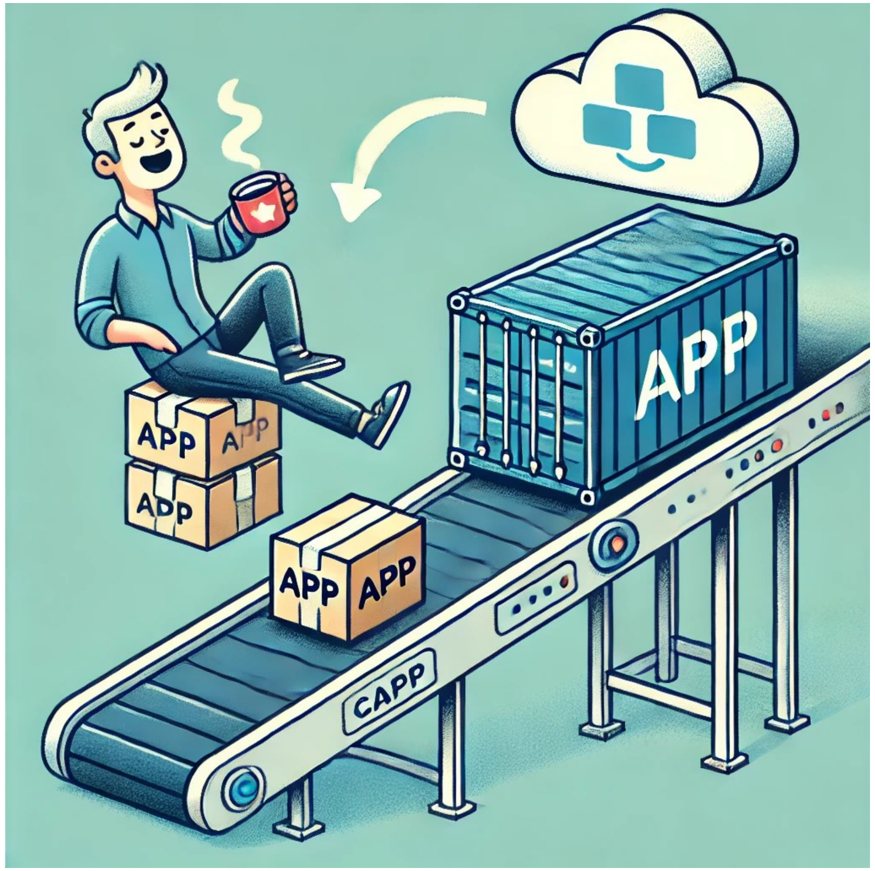
Why Containerized Cloud Deployments? (2/2)

- Thus, by utilizing containters and cloud(s), the goal is to achieve:
  - Portalibility
  - Automation
  - Scalability
  - Cost-effectiviness



References and More to Read

- M. Narasimhulu, et al., "Investigating the Impact of Containerization on the Deployment Process in DevOps," 2023 2nd International Conference on Edge Computing and Applications (ICECAA), Namakkal, India, 2023, pp. 679-685, doi: 10.1109/ICECAA58104.2023.10212240. https://ieeexplore.ieee.org/document/10212240
- Microsoft, "Get started with cloud native apps and containerized deployments", https://learn.microsoft.com/en-us/training/modules/get-started-cloud-native-apps-containerized-deployments/
- Google Cloud, "Best practices for continuous integration and delivery to Google Kubernetes Engine", https://cloud.google.com/kubernetes-engine/docs/concepts/best-practices-continuous-integration-delivery-kubernetes

Automating Deployment (CI/CD)

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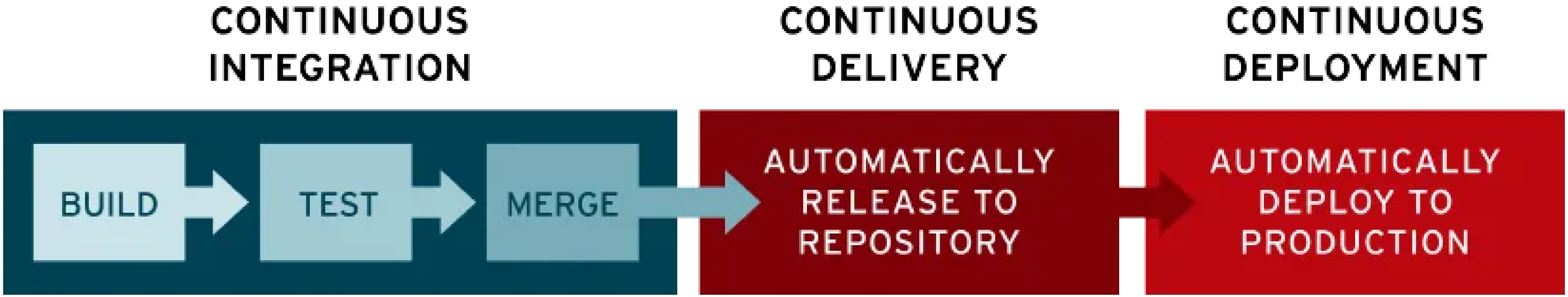
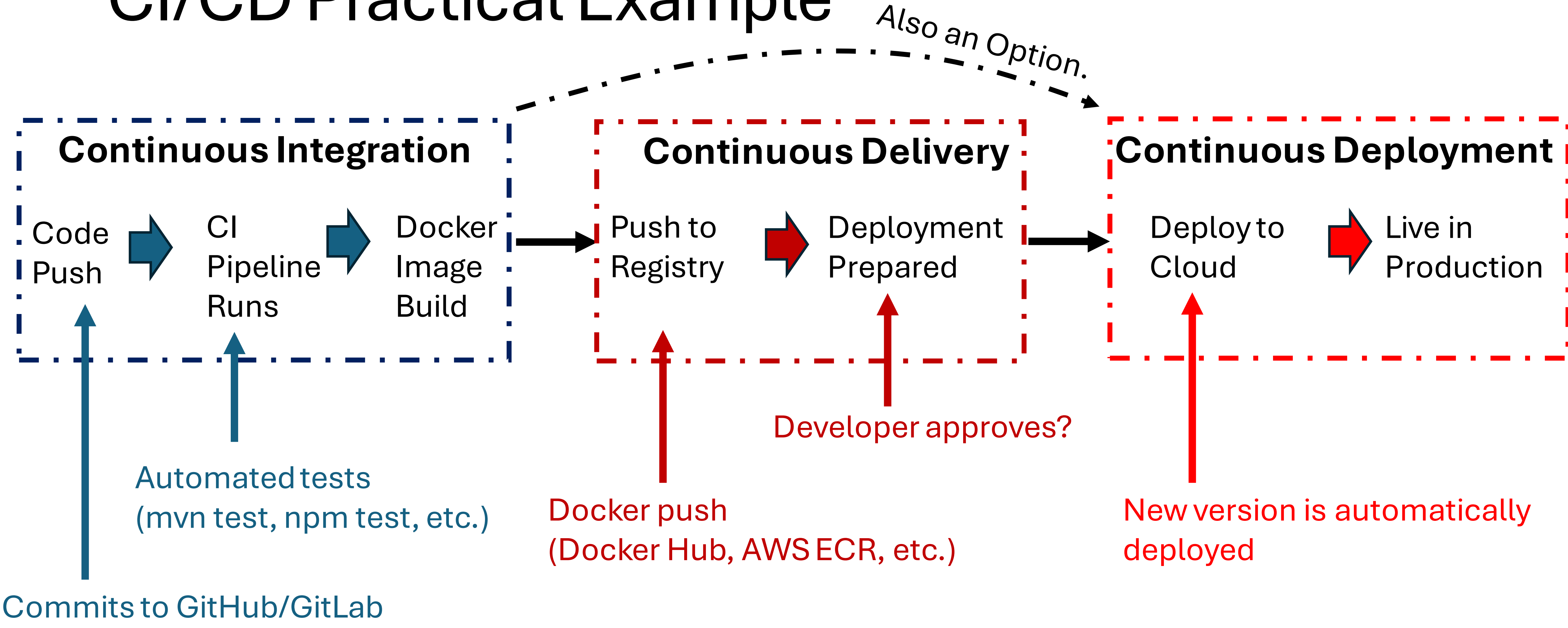
What is CI/CD?

- CI/CD, Continuous Integration (/ Continuous Delivery) / Continuous Development, aims to automate the process of building, testing and deploying software



https://www.redhat.com/en/topics/devops/what-is-ci-cd

CI/CD Practical Example



Also an Option.

Continuous Integration

Code Push → CI Pipeline Runs → Docker Image Build

Automated tests (mvn test, npm test, etc.)

Commits to GitHub/GitLab

Continuous Delivery

Push to Registry → Deployment Prepared

Docker push (Docker Hub, AWS ECR, etc.)

Developer approves?

Continuous Deployment

Deploy to Cloud → Live in Production

New version is automatically deployed

Tools: Jenkins, GitHub Actions / Gitlab CD/CD, Travis CI /CircleCI, Docker, etc.

Tools: Jenkins, GitHub Actions/ GitLab CI/CD, ArgoCD, Docker, etc.

Tools: ArgoCD/FluxCD, Kubernetes, Spinnaker, GitHub Actions / GitLab CI/CD, etc.

Microservices, briefly.

- Microservices are an architectural pattern that aims ot organize application into a collection of loose-coupled services
  - Advantages: e.g., services can be deployed independently (modularity, scalability, adaptibility), distributed development
  - Disadvantages: e.g., increased complexity (service management, communication), latency (network vs. in-process calls in monolithic services)
- Microservices != containers
  - Containers can be used without using microservices pattern
  - Containers are one architectural option for implementing microservices

Options for Cloud Deployment

	Scalability	Control	Cost-efficiency	Ease of Use	Performance	Use Cases	Examples
Serverless	High, automatic	Limited	Pay-per-use	Less operational management	Variable, possible cold starts	Event-driven applications, IoT, real-time data, unpredictable/fluctuating workloads	AWS Lambda, Azure Functions, Google Cloud Functions
Platform-as-a-Service (PaaS)	Moderate to high	Moderate	Generally cost-effective / pay-per-use	Simplified deployment	Depends on the service (generally good)	Rapid development, small to medium-sizez applications	AWS Elastic Beanstalk, Azure App Service, Google App Engine
Containers	Hih, manual	Full	Steady cost, more for reserved resources	Orchestration required for complex applications	High	Complex, scalable applications, when environmental control is required, multi-cloud/hybrid environments	Docker, Kubernetes (also on, e.g., AWS, Azure)

Adapted from Alok Mishra Blog, Journal of Distributed Software Engineering, Architecture and Design: https://alok-mishra.com/2024/01/02/choosing-the-right-architecture-comparing-serverless-containers-and-platform-as-a-service-paas-for-microservices-applications/

References and More to Read

- Wikipedia, "Microservices", https://en.wikipedia.org/wiki/Microservices
- Alok Mishra, Journal of Distributed Software Engineering, Architecture and Design, "Choosing the Right Architecture: Comparing Serverless, Containers, and Platform-as-a-Service (PaaS) for Microservices Applications", https://alok-mishra.com/2024/01/02/choosing-the-right-architecture-comparing-serverless-containers-and-platform-as-a-service-paas-for-microservices-applications/
- DigitalOcean, "Serverless vs Containers: Which is best for your needs?", https://www.digitalocean.com/resources/articles/serverless-vs-containers
- Red Hat, ”What is CI/CD?”, https://www.redhat.com/en/topics/devops/what-is-ci-cd
- Visual Studio Code, ”Developing inside a Container”, https://code.visualstudio.com/docs/devcontainers/containers

- **Simple CI/CD pipeline to try-out**
  - GitHub Docs, ”Quickstart for GitHub Actions”, https://learn.microsoft.com/en-us/azure/container-instances/container-instances-quickstart

Containerizing an Application

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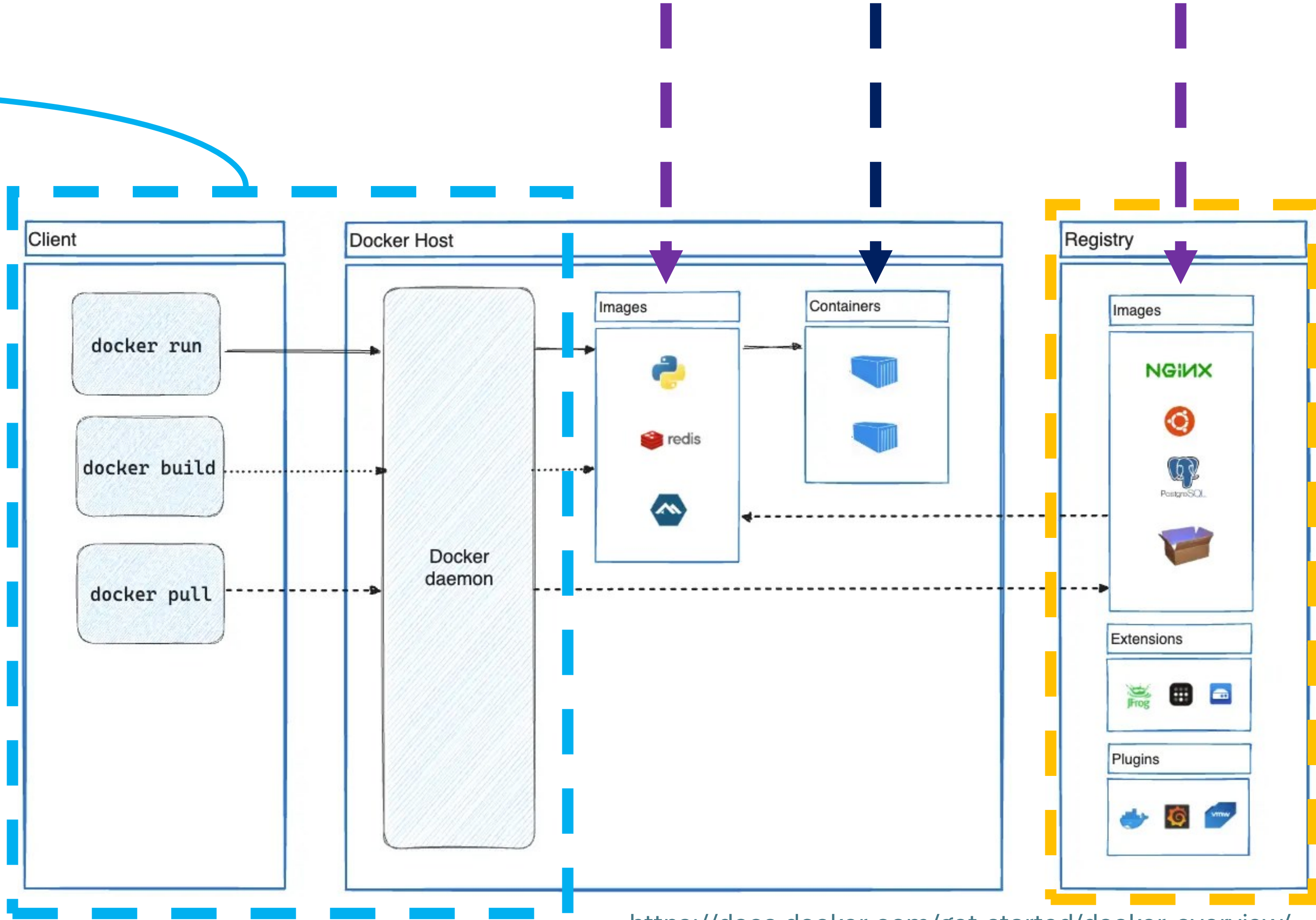
Docker – the Basics

- Docker is a platform for developing, shipping, and running applications in lightweight, portable containers.

- Key Components
  - **Docker Engine**, core runtime for building and running containers.
  - **Docker Image**, a snapshot containing the application, dependencies and OS environment.
  - **Dockerfile**, a script defining how a Docker image is built.
  - **Docker Container**, a running instance of a Docker image.
  - **Docker Hub / Registry**, a repository for storing and sharing images.



https://docs.docker.com/get-started/docker-overview/

Docker

Pros

- Portability
  - Local, cloud, on-premises
- Isolation
  - Generally, no dependency conflicts with the host system
- Scalability
- Efficiency
  - Better than, e.g. VMs

Cons

- Learning curve
  - Understanding images, networking, volumes
- Performance overhead
  - Slightly slower than native
- Security concerns
  - Not as well isolated as VMs

Docker – in Practice

Example with Quarkus

1. Install requirements
    1. Docker, Maven, Java 21+
2. Create example application
    1. mvn io.quarkus.platform:quarkus-maven-plugin:3.18.2:create -DprojectGroupId=com.example -DprojectArtifactId=example-app -Dextensions="resteasy”
3. Test your application works
    1. cd example-app && mvn quarkus:dev
    2. Web browser: http://localhost:8080/hello
4. Compile native binaries
    1. mvn package –Pnative (downloads images from Docker, docker/root (user) permissions required)
5. Create Docker image
    1. Create file named ”Dockerfile” in the application root file:
    2. docker build -t example-app .
6. Done!
    1. docker run -p 8080:8080 questions-app
    2. Web browser: http://localhost:8080/hello

```
FROM quay.io/quarkus/quarkus-distroless-image:2.0
WORKDIR /app
COPY target/*-runner /app/app
CMD ["/app/app"]
EXPOSE 8080
```

References and More to Read

- Platforms/tools for container management (orchestration)
  - o Docker, "What is Docker?", https://docs.docker.com/get-started/docker-overview/
  - o Kubernetes, "Why you need Kubernetes and what it can do", https://kubernetes.io/docs/concepts/overview/

o dockerdocs, ”Build and push your first image”, https://docs.docker.com/get-started/introduction/build-and-push-first-image/

o **Cloud deployment:**

  - o Amazon AWS, ”Deploy Docker Containers on Amazon ECS”, https://aws.amazon.com/getting-started/hands-on/deploy-docker-containers/
  - o Microsoft, ”Quickstart: Deploy a container instance in Azure using the Azure CLI”, https://learn.microsoft.com/en-us/azure/container-instances/container-instances-quickstart

Deploying to the Cloud

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Key Takeaways

(summary)

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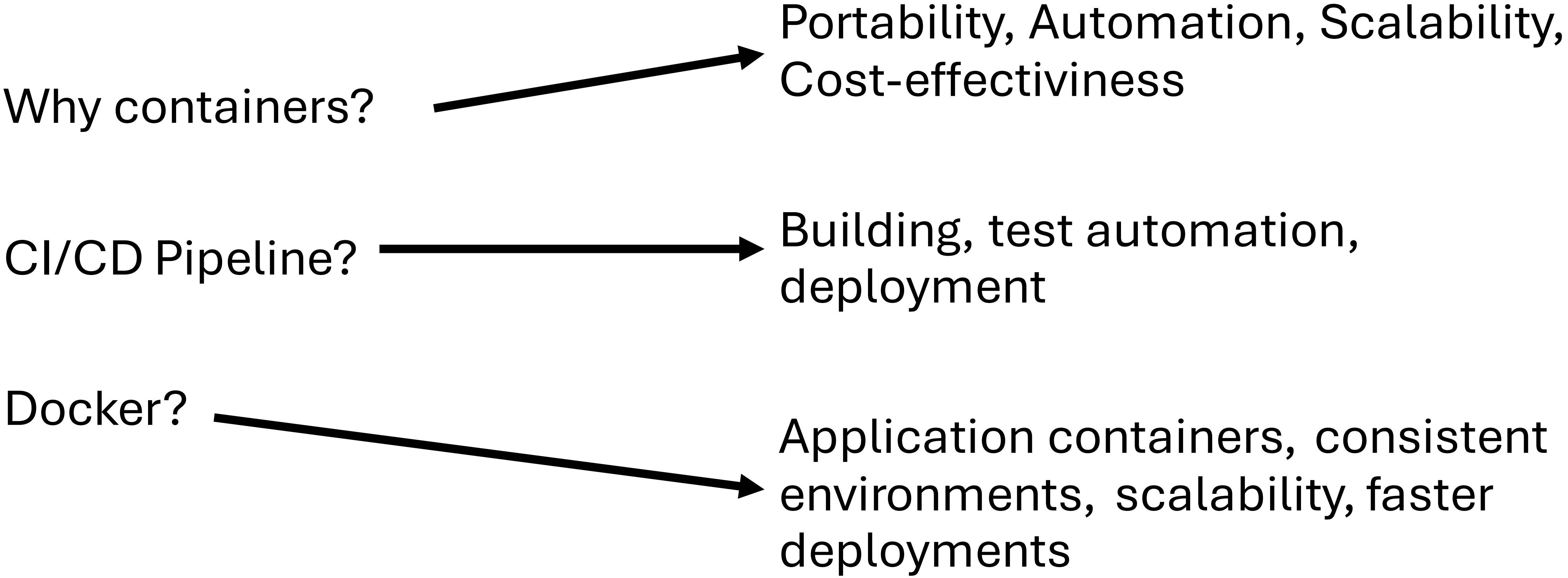
Summary



Why containers? → Portability, Automation, Scalability, Cost-effectiviness

CI/CD Pipeline? → Building, test automation, deployment

Docker? → Application containers, consistent environments, scalability, faster deployments

And, a bonus: Consider multi-stage builds, scan for vulnerabilities, test your tests, and secure your secrets!