Go + Flutter Course

CI/CD & Deployment

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Lecture 07: **CI/CD & Deployment**

From code to production: Automated delivery pipelines

Block 7: CI/CD & Deployment

Lecture 07 Overview

- **Build Fundamentals**: Understanding compilation and build processes
- **CI/CD Pipelines**: Automated testing, building, and deployment
- **Containerization**: Docker for Go and Flutter applications
- **Orchestration**: Kubernetes deployment and management
- **Store Deployment**: Publishing to app stores and web platforms

What we'll learn

- **Build processes for Go binaries and Flutter apps**
- **Setting up comprehensive CI/CD pipelines**
- **Container best practices and multi-stage builds**
- **Kubernetes deployment strategies and configurations**
- **App store publishing and web deployment**
- **Monitoring and rollback strategies**

Learning path

```
Build & Deployment Fundamentals
       │
       ├── Go Build Process ───────────┐
       │                               │
       ├── Flutter Build Process ──────┤
       │                               │
       ├── CI/CD Pipeline Setup ───────┤
       │                               │
       ├── Containerization ───────────┤
       │                               │
       └── Orchestration & Monitoring ─┤
                                       │
                                       ▼
                        Production-Ready Deployment
```

- **Foundation**: Understanding build processes and artifacts
- **Automation**: CI/CD pipelines for consistent delivery
- **Containerization**: Packaging applications for deployment
- **Orchestration**: Managing applications at scale

Part I: Build Fundamentals

> ***Build processes*** *transform source code into executable artifacts that can run on target platforms.*

Build pipeline stages

1. **Source Code**: Version-controlled application code
2. **Dependencies**: Package management and dependency resolution
3. **Compilation**: Transform source to binary/bytecode
4. **Testing**: Automated quality assurance
5. **Packaging**: Bundle into deployable artifacts
6. **Distribution**: Deliver to target environments

Key concepts

- **Cross-compilation**: Building for different platforms
- **Build artifacts**: Output files from build process
- **Build tools**: Compilers, bundlers, package managers
- **Environment consistency**: Reproducible builds

Go build fundamentals

Basic Go compilation

```
# Build for current platform
go build -o myapp ./cmd/server

# Build with specific module
go build -o myapp github.com/user/repo/cmd/server

# Build with version information
go build -ldflags "-X main.version=1.0.0" -o myapp

# Optimize for production
go build -ldflags "-s -w" -o myapp
# -s: strip symbol table
# -w: strip debug information
```

Cross-platform compilation

```
# Build for Linux
GOOS=linux GOARCH=amd64 go build -o myapp-linux

# Build for Windows
GOOS=windows GOARCH=amd64 go build -o myapp.exe

# Build for macOS (Intel)
GOOS=darwin GOARCH=amd64 go build -o myapp-darwin

# Build for macOS (Apple Silicon)
GOOS=darwin GOARCH=arm64 go build -o myapp-darwin-arm64

# List all supported platforms
go tool dist list
```

Go build optimization

Build script example (build.sh)

```bash
#!/bin/bash
VERSION=$(git describe --tags --always)
BUILD_TIME=$(date -u '+%Y-%m-%d_%H:%M:%S')
COMMIT_HASH=$(git rev-parse HEAD)
LDFLAGS="-s -w \
  -X main.version=${VERSION} \
  -X main.buildTime=${BUILD_TIME} \
  -X main.commitHash=${COMMIT_HASH}"
echo "Building version: ${VERSION}"

# Build for multiple platforms
platforms=("linux/amd64" "darwin/amd64" "windows/amd64") # can have more
for platform in "${platforms[@]}"; do
  GOOS=${platform%/*}
  GOARCH=${platform#*/}
  output="dist/myapp-${GOOS}-${GOARCH}"
  if [ "$GOOS" = "windows" ]; then
    output+=".exe"
  fi
  GOOS=$GOOS GOARCH=$GOARCH go build \
    -ldflags "${LDFLAGS}" \
    -o "$output" ./cmd/server
  echo "Built: $output"
done
```

Version information injection

```go
// cmd/server/main.go
package main
import (
    "fmt"
    "log"
    "runtime"
)
var (
    version    string = "dev"
    buildTime  string = "unknown"
    commitHash string = "unknown"
)
func main() {
    fmt.Printf("App Version: %s\n", version)
    fmt.Printf("Build Time: %s\n", buildTime)
    fmt.Printf("Commit: %s\n", commitHash)
    fmt.Printf("Go Version: %s\n", runtime.Version())
    fmt.Printf("Platform: %s/%s\n", runtime.GOOS, runtime.GOARCH)
    // Start your application
    startServer()
}
```

Flutter build fundamentals

Build modes

```
# Debug mode (development)
flutter run  # Hot reload enabled
flutter build apk --debug

# Profile mode (performance testing)
flutter build apk --profile
flutter run --profile

# Release mode (production)
flutter build apk --release
flutter build appbundle --release  # For Play Store
flutter build ios --release
flutter build web --release
```

Platform-specific builds

```
# Android
flutter build apk --split-per-abi  # Multiple APKs
flutter build appbundle           # App Bundle (recommended)

# iOS
flutter build ios --release --no-codesign
flutter build ipa                 # For App Store

# Web
flutter build web --web-renderer html  # HTML renderer
flutter build web --web-renderer canvaskit  # CanvasKit
```

Flutter build flavors

Build configuration

```yaml
# pubspec.yaml
flutter:
  uses-material-design: true
  assets:
    - assets/images/
    - assets/configs/
# Build flavors
flutter:
  flavors:
    development:
      android:
        applicationId: "com.example.app.dev"
      ios:
        bundleId: "com.example.app.dev"
    production:
      android:
        applicationId: "com.example.app"
      ios:
        bundleId: "com.example.app"
```

Build flavors

```
# Build with flavor
flutter build apk --flavor development
flutter build apk --flavor production --release
```

Go build artifacts and versioning

Go build artifacts

```
dist/
├── myapp-linux-amd64           # Linux binary
├── myapp-darwin-amd64          # macOS Intel binary
├── myapp-darwin-arm64          # macOS ARM binary
├── myapp-windows-amd64.exe     # Windows binary
├── checksums.sha256            # Integrity verification
└── release-notes.md            # Version information
```

Makefile for consistent builds

```
VERSION := $(shell git describe --tags --always)
LDFLAGS := -s -w -X main.version=$(VERSION)

.PHONY: build
build:
        go build -ldflags "$(LDFLAGS)" -o bin/myapp ./cmd/server
.PHONY: build-all
build-all:
        GOOS=linux GOARCH=amd64 go build -ldflags "$(LDFLAGS)"
    -o dist/myapp-linux ./cmd/server
        GOOS=darwin GOARCH=amd64 go build -ldflags "$(LDFLAGS)"
    -o dist/myapp-darwin ./cmd/server
        GOOS=windows GOARCH=amd64 go build -ldflags "$(LDFLAGS)"
    -o dist/myapp.exe ./cmd/server
.PHONY: test
test:
        go test -v ./...
.PHONY: clean
clean:
        rm -rf dist/ bin/
```

Flutter version management

```yaml
# pubspec.yaml
name: myapp
description: My Flutter application
version: 1.2.3+4  # semantic version + build number

environment:
  sdk: ">=3.0.0 <4.0.0"
  flutter: ">=3.10.0"
```

```dart
// lib/config/app_config.dart
class AppConfig {
  static const String appName = 'MyApp';
  static const String version = String.fromEnvironment(
    'APP_VERSION',
    defaultValue: '1.0.0',
  );
  static const String buildNumber = String.fromEnvironment(
    'BUILD_NUMBER',
    defaultValue: '1',
  );
  static const String environment = String.fromEnvironment(
    'ENVIRONMENT',
    defaultValue: 'development',
  );
}
```

Part II: CI/CD Pipeline Setup

> ***Continuous Integration/Continuous Deployment*** *automates the software delivery process, ensuring quality and enabling rapid, reliable releases.*

CI/CD benefits

- **Automated testing**: Catch bugs early and consistently
- **Consistent builds**: Same process every time
- **Fast feedback**: Quick detection of issues
- **Reduced manual work**: Less human error
- **Faster releases**: Deploy frequently with confidence

Popular CI/CD platforms

- **GitHub Actions**: Integrated with GitHub repositories
- **GitLab CI/CD**: Built into GitLab platform
- **Jenkins**: Self-hosted, highly customizable
- **Azure DevOps**: Microsoft's complete DevOps platform

Typical steps for Go

1. **Checkout code**: Retrieve source from version control
2. **Set up Go environment**: Install Go toolchain and dependencies
3. **Dependency caching**: Speed up builds by caching modules
4. **Static analysis**: Run `go vet`, `golint`, or similar tools
5. **Run tests**: Execute unit/integration tests with coverage
6. **Build binaries**: Compile for target platforms (cross-compile if needed)
7. **Security checks**: Scan for vulnerabilities (e.g., `gosec`)
8. **Build Docker image**: Package app for deployment
9. **Publish artifacts**: Upload binaries/images to registry or storage
10. **Deploy**: Roll out to staging/production environments

Typical steps for Flutter

1. **Checkout code**: Retrieve source from version control
2. **Set up Flutter environment**: Install Flutter SDK and dependencies
3. **Dependency caching**: Cache `pub` packages
4. **Static analysis**: Run `flutter analyze` for code quality
5. **Run tests**: Execute widget/unit/integration tests with coverage
6. **Build artifacts**: Generate APK, AAB, IPA, or web assets
7. **Code signing**: Apply signing keys/certificates for release builds
8. **Build Docker image** (for web): Package static assets with Nginx
9. **Publish artifacts**: Upload to Play Store, App Store, or web/CDN
10. **Deploy**: Release to users or hosting platforms

Part III: Containerization

> ***Docker containers*** *provide consistent, portable deployment environments by packaging applications with their dependencies.*

Container benefits

- **Consistency**: Same environment everywhere
- **Isolation**: Applications don't interfere with each other
- **Portability**: Run anywhere Docker is supported
- **Scalability**: Easy to scale up/down
- **Resource efficiency**: Lower overhead than VMs

Docker concepts

- **Image**: Read-only template for creating containers
- **Container**: Running instance of an image
- **Dockerfile**: Instructions for building images
- **Registry**: Repository for storing and sharing images

Docker for Go applications

Basic Dockerfile

```
# Dockerfile
FROM golang:1.21-alpine AS builder
WORKDIR /app
COPY go.mod go.sum ./
RUN go mod download
COPY . .
RUN CGO_ENABLED=0 GOOS=linux go build \
    -ldflags "-s -w" \
    -o main ./cmd/server

FROM alpine:latest
RUN apk --no-cache add ca-certificates tzdata
WORKDIR /root/
COPY --from=builder /app/main .
EXPOSE 8080
CMD ["./main"]
```

Multi-stage optimized build

```
# Dockerfile.optimized
FROM golang:1.21-alpine AS builder
# Install git for private modules
RUN apk add --no-cache git
WORKDIR /app
# Copy dependency files first for better caching
COPY go.mod go.sum ./
RUN go mod download
# Copy source code
COPY . .
# Build the binary
RUN CGO_ENABLED=0 GOOS=linux GOARCH=amd64 go build \
    -ldflags="-w -s -X main.version=${VERSION}" -a -installsuffix cgo -o \
    main ./cmd/server
# Final stage
FROM scratch
# Add CA certificates for HTTPS
COPY --from=builder /etc/ssl/certs/ca-certificates.crt /etc/ssl/certs/
# Add timezone data
COPY --from=builder /usr/share/zoneinfo /usr/share/zoneinfo
# Add binary
COPY --from=builder /app/main /main
EXPOSE 8080
ENTRYPOINT ["/main"]
```

Docker for Flutter Web

Flutter web Dockerfile

```
# Dockerfile.flutter-web
FROM cirrusci/flutter:stable AS builder

WORKDIR /app
COPY pubspec.* ./
RUN flutter pub get

COPY . .
RUN flutter build web --release

FROM nginx:alpine
COPY --from=builder /app/build/web /usr/share/nginx/html

# Custom nginx configuration
COPY nginx.conf /etc/nginx/nginx.conf

EXPOSE 80
CMD ["nginx", "-g", "daemon off;"]
```

Nginx configuration

```
# nginx.conf
events {
    worker_connections 1024;
}

http {
    include       /etc/nginx/mime.types;
    default_type  application/octet-stream;

    gzip on;
    gzip_vary on;
    gzip_min_length 1024;
    gzip_types text/plain text/css application/json application/javascript text/xml application/xml
      application/xml+rss text/javascript;

    server {
        listen 80;
        server_name localhost;
        root /usr/share/nginx/html;
        index index.html;

        # Handle Flutter routing
        location / {
            try_files $uri $uri/ /index.html;
        }

        # Cache static assets
        location ~* \.(js|css|png|jpg|jpeg|gif|ico|svg|woff|woff2)$ {
            expires 1y;
            add_header Cache-Control "public, immutable";
        }
    }
}
```

Docker Compose for development

Frontend service

```yaml
# docker-compose.yml
version: '3.8'

services:
  frontend:
    build:
      context: ./frontend
      dockerfile: Dockerfile.dev
    ports:
      - "3000:3000"
    volumes:
      - ./frontend:/app
      - node_modules:/app/node_modules
    environment:
      - API_URL=http://backend:8080
    restart: unless-stopped
```

Backend service

```yaml
backend:
  build:
    context: ./backend
    dockerfile: Dockerfile.dev
  ports:
    - "8080:8080"
  environment:
    - DB_HOST=postgres
    - DB_NAME=myapp_dev
    - DB_USER=postgres
    - DB_PASSWORD=password
    - REDIS_URL=redis:6379
  volumes:
    - ./backend:/app
    - go_modules:/go/pkg/mod
  depends_on:
    - postgres
    - redis
  restart: unless-stopped
```

Docker Compose for development

Database and cache

```yaml
postgres:
  image: postgres:15-alpine
  environment:
    - POSTGRES_DB=myapp_dev
    - POSTGRES_USER=postgres
    - POSTGRES_PASSWORD=password
  volumes:
    - postgres_data:/var/lib/postgresql/data
    - ./backend/migrations:/docker-entrypoint-initdb.d
  ports:
    - "5432:5432"
  restart: unless-stopped

redis:
  image: redis:7-alpine
  ports:
    - "6379:6379"
  volumes:
    - redis_data:/data
  restart: unless-stopped
```

Nginx and volumes

```yaml
    nginx:
      image: nginx:alpine
      ports:
        - "80:80"
      volumes:
        - ./nginx.conf:/etc/nginx/nginx.conf
      depends_on:
        - backend
        - frontend
      restart: unless-stopped

  volumes:
    postgres_data:
    redis_data:
    go_modules:
    node_modules:
```

Container best practices

Security best practices

```
# Use specific version tags
FROM golang:1.21.4-alpine3.18

# Create non-root user
RUN addgroup -g 1001 -S appgroup && \
    adduser -u 1001 -S appuser -G appgroup

# Install only necessary packages
RUN apk add --no-cache ca-certificates tzdata

# Use non-root user
USER appuser

# Set read-only filesystem
COPY --chown=appuser:appgroup --from=builder /app/main /main

# Health check
HEALTHCHECK --interval=30s --timeout=3s --start-period=5s --retries=3 \
  CMD wget --no-verbose --tries=1 \
    --spider http://localhost:8080/health || exit 1
```

Performance optimization

```
# Minimize layers
RUN apk add --no-cache \
    ca-certificates \
    tzdata \
    && rm -rf /var/cache/apk/*

# Use .dockerignore
.git
.gitignore
Dockerfile*
docker-compose*
.dockerignore
.env*
coverage.txt
*.md
tests/
.github/
```

Part IV: Kubernetes Deployment

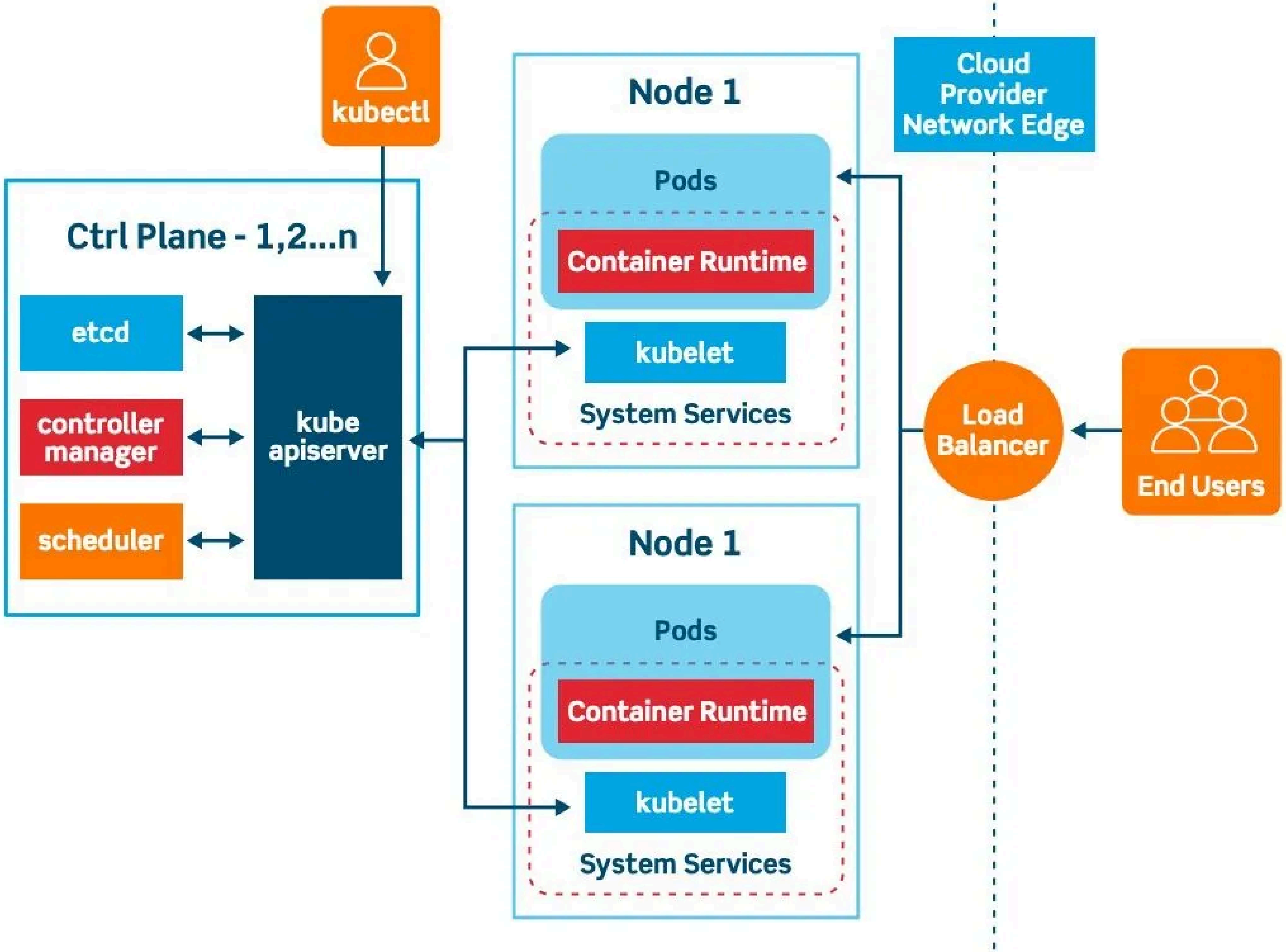
> ***Kubernetes** orchestrates containerized applications at scale, providing automated deployment, scaling, and management.*

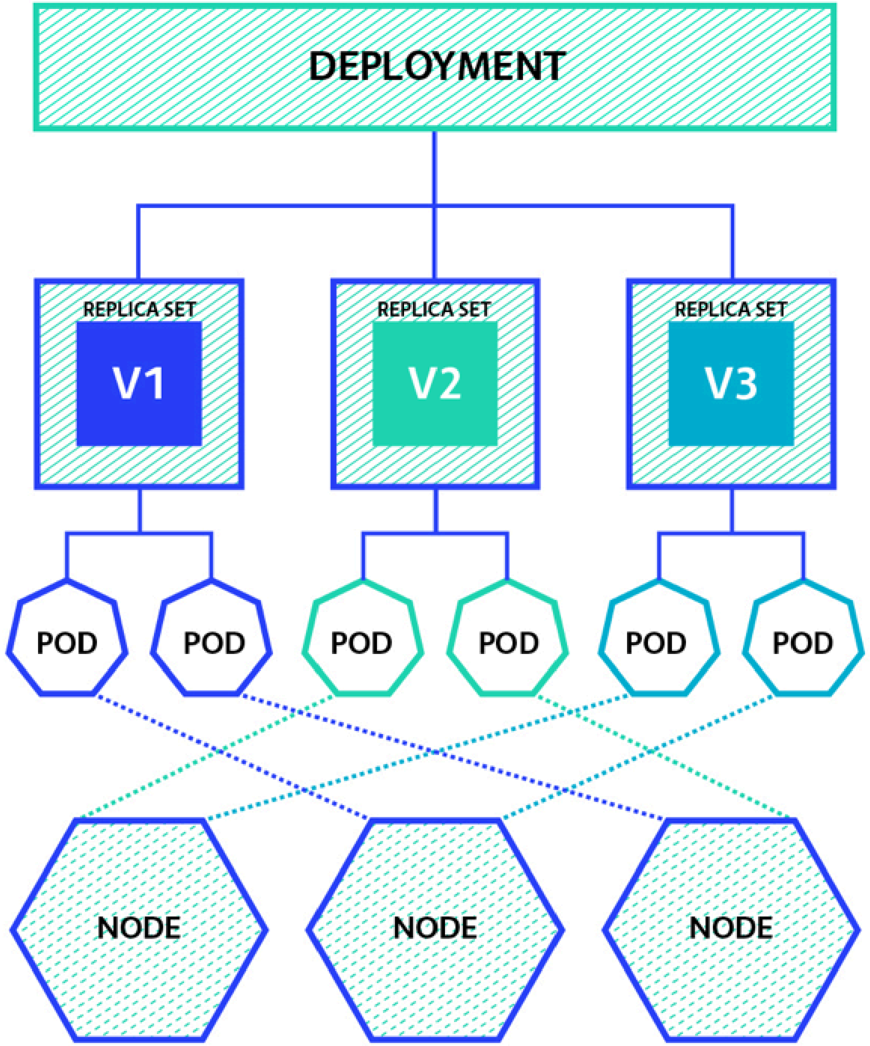
Kubernetes core concepts

- **Pod**: Smallest deployable unit (one or more containers)
- **Deployment**: Manages replica sets and rolling updates
- **Service**: Network endpoint for accessing pods
- **ConfigMap**: Configuration data storage
- **Secret**: Sensitive data storage
- **Ingress**: External access management

Benefits

- **Self-healing**: Automatic pod replacement and health monitoring
- **Scaling**: Horizontal and vertical pod autoscaling
- **Rolling updates**: Zero-downtime deployments
- **Service discovery**: Built-in load balancing and networking


kubectl
Ctrl Plane - 1,2...n
etcd
controller manager
scheduler
kube apiserver
Node 1
Pods
Container Runtime
kubelet
System Services
Node 1
Pods
Container Runtime
kubelet
System Services
Cloud Provider Network Edge
Load Balancer
End Users


DEPLOYMENT
REPLICA SET
V1
REPLICA SET
V2
REPLICA SET
V3
POD
POD
POD
POD
POD
POD
NODE
NODE
NODE

Part V: App Store Deployment

> ***App store deployment*** *involves specific requirements, code signing, and review processes for different platforms.*

Platform requirements

Platform	Format	Requirements
Google Play	AAB/APK	Google Play Console account, signing key
Apple App Store	IPA	Apple Developer account, certificates
Web Hosting	Static files	Domain, SSL certificate
Microsoft Store	MSIX	Microsoft Partner Center account

- **Code signing**: Cryptographic verification of app authenticity
- **App review**: Platform-specific guidelines and approval process
- **Release management**: Staged rollouts and version control
- **Metadata**: App descriptions, screenshots, privacy policy

What we've learned

Build Fundamentals

- **Go compilation**: Cross-platform builds and optimization techniques
- **Flutter builds**: Platform-specific artifacts and build modes
- **Version management**: Embedding build information and semantic versioning
- **Build automation**: Makefiles and scripts for consistent builds

CI/CD Pipelines

- **Plan**: What are popular steps?
- **Platforms**: GitHub Actions, GitLab CI/CD, Jenkins, CircleCI, Azure DevOps
- **Conditional deployment**: Environment-specific release strategies

What we've learned (continued)

Containerization

- **Docker fundamentals**: Images, containers, and multi-stage builds
- **Go containerization**: Optimized Docker images with scratch base
- **Flutter web**: Nginx-based container deployment
- **Best practices**: Security, optimization, and health checks

Kubernetes Orchestration

- **Core concepts**: Pods, Deployments, Services, and Ingress
- **Scaling**: Horizontal Pod Autoscaler and resource management

App Store Deployment

- **Main steps**:What is the flow?

Thank You!

What's Next:

- Lab 07: Implement complete CI/CD pipeline for your project

Resources:

- Docker Best Practices: https://docs.docker.com/develop/dev-best-practices/
- Kubernetes Documentation: https://kubernetes.io/docs/
- GitHub Actions: https://docs.github.com/en/actions
- Flutter Deployment: https://docs.flutter.dev/deployment
- Course Repository: https://github.com/timur-harin/sum25-go-flutter-course

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Next Lecture: Final Project & Wrap-up

Questions?