

Deployment Cost Analysis - Shift Schedule Manager with OR-Tools

Executive Summary

AWS Free Tier: ❌ TIDAK CUKUP - Aplikasi membutuhkan minimal 9.5GB RAM, Free Tier hanya 1GB
Biaya Minimum AWS: \$50-70/bulan (EC2 t3.xlarge) **Alternatif Terbaik:** Railway.app atau Render.com (\$20-30/bulan) **Rekomendasi:** Railway.app dengan Hobby Plan (\$5/bulan per service)

Resource Requirements Analysis

Production Architecture (docker-compose.yml)

Service	Memory Limit	CPU Limit	Critical?
nginx	512MB	1.0 core	<input checked="" type="checkbox"/> Yes
ai-server (2 replicas)	4GB × 2 = 8GB	2.0 × 2 = 4.0 cores	⚠ Optional (legacy TensorFlow.js)
ortools-optimizer	1GB	2.0 cores	<input checked="" type="checkbox"/> Yes
go-websocket-server (3 replicas)	512MB × 3 = 1.5GB	1.0 × 3 = 3.0 cores	<input checked="" type="checkbox"/> Yes
redis	512MB	0.5 core	<input checked="" type="checkbox"/> Yes
postgres	1GB	1.0 core	⚠ Optional (using Supabase)

Total Requirements (Full Stack)

Scenario 1: Full Production (All Services)

- **Total RAM:** 11.5GB
- **Total CPU:** 11.5 cores
- **Storage:** ~5GB (Docker images + data)
- **Network:** ~10GB/month outbound

Scenario 2: Minimal Production (Without AI Server)

- **Total RAM:** 3.5GB (nginx + Go + OR-Tools + Redis)
- **Total CPU:** 4.5 cores
- **Storage:** ~3GB
- **Network:** ~5GB/month outbound

Scenario 3: Ultra Minimal (Go + OR-Tools only, external Supabase)

- **Total RAM:** 2.5GB (nginx + Go + OR-Tools)
- **Total CPU:** 4.0 cores
- **Storage:** ~2GB
- **Network:** ~3GB/month outbound

AWS Free Tier Limitations

What's Available FREE (12 months)

Service	Free Tier Limit	Your Need	Gap
EC2 t2.micro	750 hours/month, 1GB RAM, 1 vCPU	3.5GB RAM, 4.5 CPU	✗ -2.5GB RAM, -3.5 CPU
RDS db.t3.micro	750 hours/month, 1GB RAM	Not needed (Supabase)	✓ N/A
EBS Storage	30GB	5GB	✓ Enough
Data Transfer	15GB outbound/month	~5-10GB	✓ Enough
Elastic Load Balancer	Not free	Needed for 3 Go replicas	✗ +\$16/month

Conclusion: AWS Free Tier ✗ TIDAK CUKUP

Free Tier hanya menyediakan 1GB RAM, aplikasi Anda minimal butuh **3.5GB RAM** (tanpa AI server).

AWS Paid Options

Option 1: Single EC2 Instance (Minimal Production)

Instance Type: `t3.xlarge` (4 vCPU, 16GB RAM)

Cost Component	Monthly Cost
EC2 t3.xlarge (us-east-1)	\$121.76
EBS 30GB gp3	\$2.40
Elastic IP	\$3.65
Data Transfer (10GB)	\$0.90
Total	~\$128.71/month

Pros: Cukup untuk semua services + monitoring **Cons:** Terlalu mahal untuk fresh graduate portfolio

Option 2: Multiple Small Instances (NOT RECOMMENDED)

Split services ke multiple t3.small/t3.medium instances.

Estimated Cost: \$80-120/month **Why Not:** Kompleksitas tinggi, biaya hampir sama dengan single xlarge

Option 3: AWS Lightsail

Instance: \$40/month (8GB RAM, 2 vCPU, 4TB transfer)

Cost Component	Monthly Cost
Lightsail 8GB	\$40
Additional storage	\$0-5
Total	~\$40-45/month

Pros: Lebih murah dari EC2, UI sederhana **Cons:** RAM cukup tapi CPU kurang (2 vCPU vs need 4.5), tidak ada load balancer

Better Alternatives (RECOMMENDED)

🏆 Option A: Railway.app (BEST FOR PORTFOLIO)

Pricing: Pay-per-use, \$5/month per service (Hobby Plan)

Minimal Deployment (3 services)

Service	RAM	Cost/Month
nginx + React static	512MB	\$5
go-websocket-server	1GB	\$5
ortools-optimizer	1GB	\$5
Redis	Included free	\$0
Supabase	External (already have)	\$0
Total	2.5GB	\$15/month

Full Deployment (with AI server)

Service	RAM	Cost/Month
nginx + React static	512MB	\$5
go-websocket-server	1GB	\$5
ortools-optimizer	1GB	\$5
ai-server	2GB	\$10 (2 units)
Redis	512MB	\$5
Total	5GB	\$30/month

Why Railway?

- Automatic Docker deployment from GitHub
- Zero-config PostgreSQL/Redis/MySQL
- Built-in CI/CD and previews
- Free tier: \$5 credit/month (enough for testing)
- Easy WebSocket support
- Custom domains + SSL free
- No credit card required for trial

Railway vs AWS:

- Railway \$15/month vs AWS \$128/month
- **Savings: \$113/month (88% cheaper)**

Option B: Render.com

Pricing: Fixed pricing per service

Service Type	Specs	Cost/Month
Web Service	512MB RAM	\$7
Web Service	2GB RAM	\$25
PostgreSQL	1GB RAM	\$7 (not needed)
Redis	1GB RAM	\$10 (not needed)

Minimal Deployment

Service	Plan	Cost/Month
React + nginx	Static site	\$0 (free tier)
go-websocket-server	Starter (512MB)	\$7
ortools-optimizer	Starter (512MB)	\$7
Total		\$14/month

Notes:

- ⚠️ Free tier has 750h/month limit (same as AWS Free Tier)
- ⚠️ Services sleep after 15 mins inactivity (not good for WebSocket)
- ✓ Upgrade to Starter (\$7/month) for always-on

Why Render?

- ✓ Even cheaper than Railway for minimal setup
- ✓ Free static site hosting (React build)
- ✓ Automatic SSL + CDN
- ✓ Docker support
- ✗ No built-in Redis (must use external)

Option C: Fly.io

Pricing: Pay-per-use, generous free tier

Free Tier (Permanent)

- 3 shared-cpu-1x VMs (256MB RAM each) = 768MB total
- 3GB persistent volume storage

- 160GB outbound data transfer

Minimal Deployment (Free Tier)

Service	RAM	Cost/Month
go-websocket-server	256MB	\$0
ortools-optimizer	512MB	\$0 (scale down)
Static site	256MB	\$0
Total	1GB	\$0/month (Free!)

With Paid Scaling:

Service	RAM	Cost/Month
go-websocket-server (3 replicas)	256MB × 3	~\$5
ortools-optimizer	1GB	~\$10
nginx + React	512MB	~\$3
Total	2.5GB	\$18/month

Why Fly.io?

- **FREE TIER yang generous** (256MB × 3 VMs)
- Global edge network (low latency)
- Built-in load balancing
- PostgreSQL included free (not needed, have Supabase)
- Learning curve lebih tinggi (Fly.toml config)

Option D: DigitalOcean App Platform

Pricing: Similar to Render

Service	Plan	Cost/Month
Basic (512MB)	Static + 1 service	\$5
Professional (1GB)	Per service	\$12

Minimal Deployment

Service	Plan	Cost/Month
React static site	Static	\$0
go-websocket-server	Basic (512MB)	\$5
ortools-optimizer	Basic (512MB)	\$5
Total		\$10/month

Why DigitalOcean?

- ✓ Cheapest for basic deployment
- ✓ Simple UI and documentation
- ✓ Good for beginners
- ⚠ Limited to 1 region (no global CDN)

Option E: Heroku (NOT RECOMMENDED)

Pricing: Eco Dynos \$5/month, Basic \$7/month

Why Not?:

- ✗ No free tier anymore (sejak Nov 2022)
- ✗ More expensive than Railway/Render
- ✗ Limited memory (512MB max for Eco)
- ⚠ Better alternatives available

Comparison Table: All Options

Platform	Minimal Cost	Full Cost	Free Tier?	Docker?	CI/CD?	Ease of Use	Best For
AWS EC2	\$128/month	\$200+/month	⚠ 12 months, insufficient	✓	⚠ Manual	★★	Enterprise
AWS Lightsail	\$40/month	\$80/month	✗	✓	⚠ Manual	★★★	Simple apps
Railway	\$15/month	\$30/month	✓ \$5 credit	✓	✓	★★★★★	Portfolio (BEST)
Render	\$14/month	\$40/month	✓ 750h	✓	✓	★★★★★	Budget

Platform	Minimal Cost	Full Cost	Free Tier?	Docker?	CI/CD?	Ease of Use	Best For
Fly.io	\$0/month	\$18/month	Generous				Free tier (BEST)
DigitalOcean	\$10/month	\$30/month	\$200 credit				Beginners
Heroku	\$12/month	\$40/month					Legacy apps

Recommended Deployment Strategy

Phase 1: Portfolio Demo (FREE)

Platform: Fly.io Free Tier

Services:

1. **Go WebSocket Server** (256MB × 3 replicas) - FREE
2. **OR-Tools Optimizer** (256MB, scaled down) - FREE
3. **React Static Build** (nginx) - FREE
4. **Supabase** (external, already have)

Total Cost: \$0/month

Limitations:

- OR-Tools might be slow with 256MB RAM (reduce to single-staff optimization)
- No AI server (not critical, TensorFlow.js is legacy)
- Shared CPU (slower than dedicated)

Perfect For:

- Portfolio showcase
- Thesis demonstration
- Employer demo during interview

Phase 2: Job Application Period (LOW COST)

Platform: Railway.app Hobby Plan

Services:

1. **nginx + React static** (512MB) - \$5/month
2. **go-websocket-server** (1GB) - \$5/month
3. **ortools-optimizer** (1GB) - \$5/month
4. **Redis** (included free)
5. **Supabase** (external)

Total Cost: \$15/month ✓

Benefits:

- Always-on (no cold starts)
- Full 1GB RAM for OR-Tools (fast optimization)
- Custom domain + SSL
- GitHub auto-deploy

Perfect For:

- Active job search (3-6 months)
- Employer live testing
- Interview technical demos

Phase 3: If Hired (SCALE UP)

Platform: Railway.app or AWS Lightsail

Option A: Railway Full Stack - \$30/month

- Add AI server (2GB) + monitoring

Option B: AWS Lightsail 8GB - \$40/month

- More resources, professional setup
- Good impression for employer

Architecture Optimization for Cost Reduction

1. Remove AI Server (TensorFlow.js)

Current: AI server uses 8GB RAM (2 replicas × 4GB) **Status:** Legacy system, replaced by OR-Tools

Action: Remove from docker-compose.yml

Savings: -8GB RAM, -\$20/month on Railway

2. Reduce Go Server Replicas

Current: 3 replicas × 512MB = 1.5GB **Minimal:** 1 replica × 1GB = 1GB **Action:** Change `replicas: 3` to `replicas: 1` in docker-compose.yml

Savings: -512MB RAM, not critical for portfolio (1000+ users testing not needed)

3. Use Supabase (Already Implemented)

Current: postgres service in docker-compose (optional) **Status:** Already using external Supabase

Action: Don't deploy postgres container

Savings: -1GB RAM, -\$7/month

4. Optimize OR-Tools Memory

Current: 1GB RAM limit **Optimization:**

```
# In scheduler.py, reduce solver workers  
solver.parameters.num_search_workers = 2 # Instead of 4
```

Potential: Run on 512MB for small datasets (15-20 staff)

Ultra-Minimal Deployment (Recommended for Portfolio)

Configuration

File: docker-compose.minimal.yml (create new)

```
version: '3.8'  
  
services:  
  db:  
    image: postgres:13-alpine  
    environment:  
      - POSTGRES_PASSWORD=postgres  
      - POSTGRES_USER=postgres  
      - POSTGRES_DB=postgres  
    ports:  
      - 5432:5432  
    volumes:  
      - db_data:/var/lib/postgresql/data  
  app:  
    build: ./app  
    command: gunicorn app:app  
    volumes:  
      - db_data:/var/lib/postgresql/data  
    depends_on:  
      - db  
    environment:  
      - DB_HOST=db  
      - DB_PORT=5432  
      - DB_NAME=postgres  
      - DB_USER=postgres  
      - DB_PASSWORD=postgres  
  redis:  
    image: redis:5-alpine  
    ports:  
      - 6379:6379  
    volumes:  
      - redis_data:/var/lib/redis  
  memcached:  
    image: memcached:1.6-alpine  
    ports:  
      - 11211:11211  
    volumes:  
      - memcached_data:/var/lib/memcached  
  or-tools:  
    image: google/or-tools:9.1.1  
    command: python3 setup.py install  
    volumes:  
      - .:/src  
    depends_on:  
      - redis  
      - memcached  
    environment:  
      - MEMCACHED_HOST=memcached  
      - MEMCACHED_PORT=11211  
      - REDIS_HOST=redis  
      - REDIS_PORT=6379  
  web:  
    build: ./web  
    command: gunicorn web:app  
    volumes:  
      - .:/src  
    depends_on:  
      - app  
    environment:  
      - APP_HOST=0.0.0.0  
      - APP_PORT=8000  
      - APP_DEBUG=True  
      - APP_ENV=development  
      - APP_KEY=base64:...  
      - APP_URL=http://localhost:8000  
      - APP_DATABASE_URL=pgsql://postgres:postgres@db:5432/postgres  
      - APP_REDIS_HOST=redis  
      - APP_REDIS_PORT=6379  
      - APP_MEMCACHED_HOST=memcached  
      - APP_MEMCACHED_PORT=11211
```

```
# Remove: pg-server, postgres
# External: Supabase, no Redis needed for demo
```

Total Requirements:

- RAM: 1.3GB (nginx 256MB + Go 512MB + OR-Tools 512MB)
- CPU: 2.0 cores
- Storage: 2GB

Deployment Cost:

- **Fly.io Free Tier:** \$0/month (fits in 3 × 256MB VMs with scaling)
 - **Railway:** \$10/month (2 services × \$5)
 - **Render:** \$7/month (1 service + free static)
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Cost Breakdown by Use Case

Use Case 1: Thesis Defense Demo (1-2 weeks)

Platform: Fly.io Free Tier **Cost:** \$0 **Setup Time:** 2-3 hours **Justification:** Short-term, free, sufficient for thesis committee demo

Use Case 2: Portfolio for Job Applications (3-6 months)

Platform: Railway.app Hobby Plan **Cost:** \$15/month × 6 months = \$90 total **Setup Time:** 1 hour (GitHub auto-deploy) **Justification:** Always-on, professional domain, fast response, good impression

Use Case 3: Production Use by Hotel (Paid Client)

Platform: AWS Lightsail or DigitalOcean **Cost:** \$40-80/month (billed to client) **Setup Time:** 4-8 hours (full monitoring, backup, SSL) **Justification:** Reliable, scalable, professional SLA

Final Recommendation

For Your Current Situation (Fresh Graduate Portfolio)

Best Choice: Railway.app - \$15/month

Why?

1. **Affordable:** \$15/month vs AWS \$128/month (88% cheaper)
2. **Professional:** Custom domain, SSL, always-on

3. **Zero DevOps**: GitHub push = auto-deploy
4. **Impressive**: Employer can test anytime, no cold starts
5. **Scalable**: Easy to upgrade when needed
6. **Portfolio Ready**: Perfect for job interviews

Alternative Free Option: Fly.io - \$0/month

- Good for thesis demo
- Acceptable for portfolio with caveat ("optimized for cost")
- Upgrade to paid when actively applying

Deployment Timeline

Week 1: Deploy to Fly.io Free Tier (portfolio demo) **When Applying:** Upgrade to Railway \$15/month (professional impression) **If Hired:** Migrate to AWS/DO \$40/month (production-ready)

Action Items

Immediate (This Week)

1. Create Railway.app account (free, no credit card)
2. Test Fly.io free deployment
3. Create `docker-compose.minimal.yml` for cost optimization
4. Update README.md with deployment options

Before Job Applications (Next Month)

1. Deploy to Railway Hobby Plan (\$15/month)
2. Setup custom domain (`portfolio.yourname.com`)
3. Add SSL certificate (Railway provides free)
4. Test with 10+ concurrent users
5. Setup monitoring (Railway dashboard)

Optional (If Budget Allows)

1. Add Sentry error tracking (\$0 - free tier)
 2. Add Google Analytics (\$0)
 3. Setup automated backups (Railway)
 4. Create staging environment (Railway preview)
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Appendix: Detailed Cost Calculations

AWS EC2 t3.xlarge Breakdown (Tokyo Region ap-northeast-1)

Component	Specs	Unit Price	Monthly Cost
EC2 Instance	4 vCPU, 16GB RAM	\$0.1664/hour	\$121.76
EBS Volume	30GB gp3	\$0.08/GB-month	\$2.40
Elastic IP	1 IP	\$3.65/month	\$3.65
Data Transfer	10GB outbound	\$0.09/GB	\$0.90
Application Load Balancer	1 ALB	\$16.20/month	\$16.20
Total			\$144.91/month

With 1-year Reserved Instance: \$86/month (40% cheaper) **With 3-year Reserved Instance:** \$55/month (62% cheaper)

Railway.app Detailed Pricing

Pricing Model: \$0.000231/GB-hour RAM usage

Example: 1GB service running 24/7

- Hours per month: 730 hours
- Usage: $1\text{GB} \times 730\text{ hours} = 730\text{ GB-hours}$
- Cost: $730 \times \$0.000231 = \$0.17/\text{month}$

BUT: Railway charges minimum \$5/month per service (Hobby Plan)

Your Deployment:

- nginx (512MB): \$5/month
- Go server (1GB): \$5/month
- OR-Tools (1GB): \$5/month
- **Total:** \$15/month

If using Pro Plan (\$20/month base + usage):

- Same services: $\$20 + \$0.51 = \$20.51/\text{month}$
- **Not worth it** for minimal deployment

Conclusion

AWS Free Tier: ❌ Tidak cukup untuk production deployment **Minimum AWS Cost:** ~\$128/month (terlalu mahal untuk portfolio)

Recommended Solution:

- **Railway.app** - \$15/month untuk active job search
- **Fly.io** - \$0/month untuk portfolio demo only

Cost Savings: Up to 100% (free) or 88% (Railway vs AWS)

Best Strategy: Start free (Fly.io), upgrade to Railway when applying, scale to AWS/DO if hired.