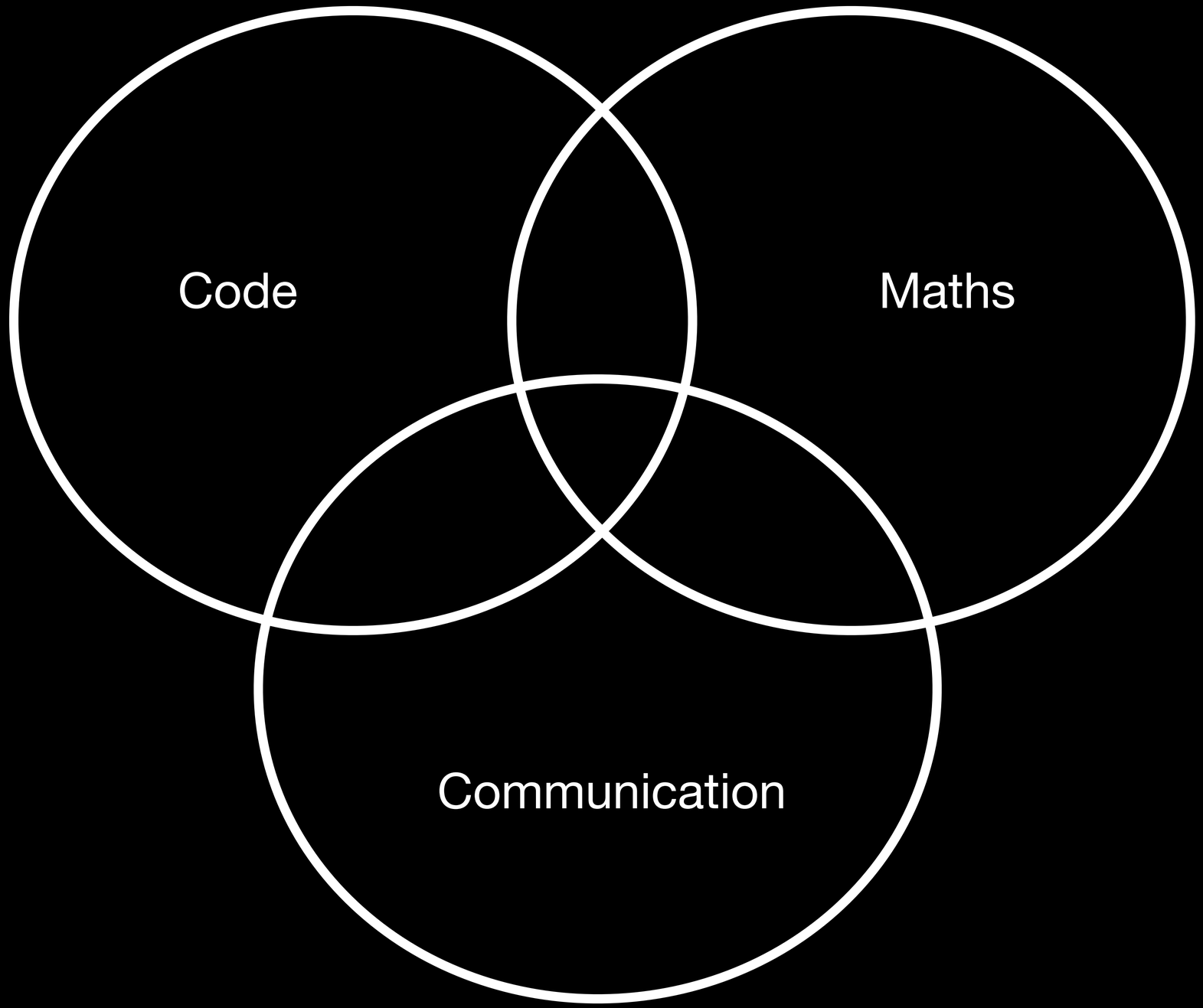
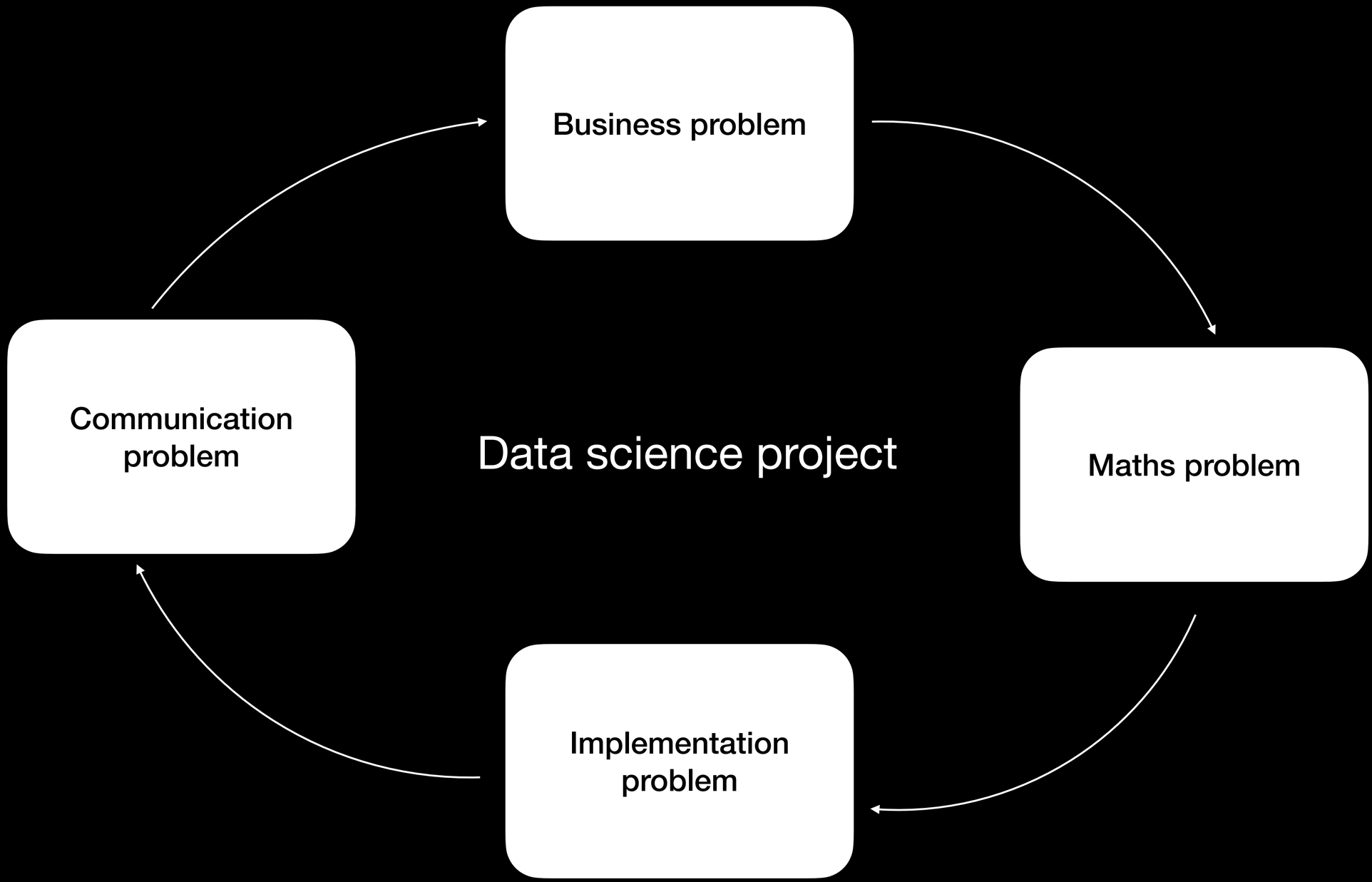
MADS - Deployment

It works on my machine

Raoul Grouls, 2 December 2024


Code
Maths
Communication


Business problem
Maths problem
Implementation problem
Communication problem
Data science project

Docker for Data Scientists: Getting Started

Why containerization matters for ML/AI projects

Promise of reproducibility across different machines

- Same environment
- Same dependencies
- Same behavior
- Isolation of dependencies from your personal workflow

Easy sharing of complete project setups

- Less "it works on my machine"
- Quick onboarding of new team members (if they have enough RAM for Docker…)

Simplified deployment process

- From local to production with minimal changes

Docker for Data Scientists: Getting Started

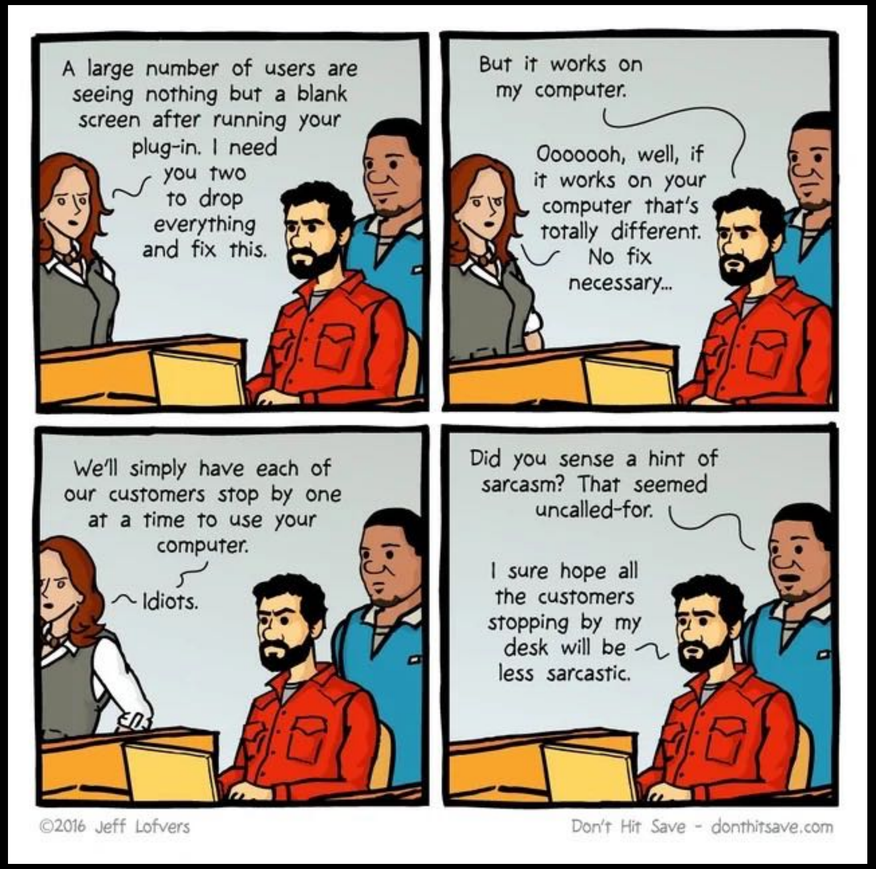
Why containerization matters for ML/AI projects

Easy sharing of complete project setups

- Less "it works on my machine"
- Quick onboarding of new team members (if they have enough RAM for Docker…)

Simplified deployment process

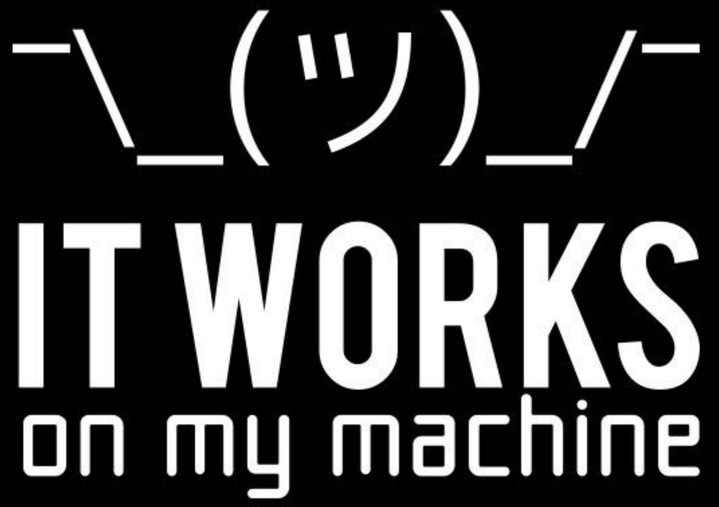
- From local to production with minimal changes



The "Works on My Machine" Paradox

Docker doesn't completely solve architecture differences:

- CPU Architecture Challenges
  - x86_64 (Intel/AMD) vs ARM64 (M1/M2 Macs)
  - Some packages aren't available for all architectures
  - Performance can vary significantly
- Common Issues
  - TensorFlow/PyTorch optimizations differ
  - C++ extensions might not compile
  - Binary dependencies might be architecture-specific
- Possible Solutions
  - Use `--platform` flag when building
  - Build multi-architecture images
  - Document architecture requirements clearly



Cross-Platform Docker: Using Platform Flags

Force x86 build on M1 Mac

- `docker build --platform linux/amd64 -t mymodel:latest .`

Force ARM build on any machine

- `docker build --platform linux/arm64 -t mymodel:latest .`

Run for a speccific platform

- `docker run --platform linux/amd64 my-image`

Docker Fundamentals: Key Concepts

Core Components:

- **Dockerfile :** The build instructions for creating an **Image**. Similar to a recipe with step-by-step instructions
- **Image :** The blueprint/template for **Containers**. Like a snapshot that can create identical containers
- **Container** : A running instance with your application and dependencies. Think of it as a lightweight VM that shares the host OS kernel
- **Registry :** A repository for storing and sharing images. Can be public (Docker Hub) or private

Docker Fundamentals: Key Concepts

Dockerfile -> builds -> **Image** -> runs -> **Container**

Understanding the Dockerfile
FROM

The command FROM:
Docker checks your local machine:

- Looks in local image cache
- If found, uses cached image
- If not found, needs to download

If not found locally:

- Connects to registry (default: Docker Hub)
- Downloads the image in layers
- Saves in local cache for future use

```dockerfile
FROM python:3.12-slim

WORKDIR /app

COPY requirements.txt requirements.txt
COPY src src

RUN pip install --no-cache-dir --upgrade -r requirements.txt

EXPOSE 8000

ENTRYPOINT ["uvicorn", "src.main:app", "--host", "0.0.0.0", "--port", "8000"]
```

Understanding the Dockerfile
FROM python:3.12-slim

There are multiple python images, you can find them on https://hub.docker.com/_/python/tags

- `-alpine`
  - Ultra minimal (50MB)
  - Based on alpine linux
  - Security focused
  - Harder to debug
- `-slim`
  - Minimal image (130MB)
  - Only essentials
  - Good for simple webapps like fastapi when size matters but alpine is too minimal
- `Python:3.x`
  - Full image (920MB)
  - Includes common system libraries
  - Good for complex dependencies
  - Larger deployment size
- `-slim-bullseye / -slim-bookworm`
  - Bullseye = Debian 11
  - Bookworn = Debian 12

Understanding the Dockerfile
WORKDIR

`WORKDIR /app`

- Sets the working directory
- All subsequent commands run here
- Good practice for organization

```dockerfile
FROM python:3.12-slim

WORKDIR /app

COPY requirements.txt requirements.txt
COPY src src

RUN pip install --no-cache-dir --upgrade -r requirements.txt

EXPOSE 8000

ENTRYPOINT ["uvicorn", "src.main:app", "--host", "0.0.0.0", "--port", "8000"]
```

Understanding the Dockerfile
COPY

`COPY requirements.txt .`

- Copies files from host to container
- Best practice: Copy requirements first
- Helps with layer caching

```dockerfile
FROM python:3.12-slim

WORKDIR /app

COPY requirements.txt requirements.txt
COPY src src

RUN pip install --no-cache-dir --upgrade -r requirements.txt

EXPOSE 8000

ENTRYPOINT ["uvicorn", "src.main:app", "--host", "0.0.0.0", "--port", "8000"]
```

Understanding the Dockerfile
RUN

`RUN pip install -r requirements.txt`

- Executes commands during build
- Creates a new layer in the image
- Use && for multiple commands to reduce layers

```dockerfile
FROM python:3.12-slim

WORKDIR /app

COPY requirements.txt requirements.txt
COPY src src

RUN pip install --no-cache-dir --upgrade -r requirements.txt

EXPOSE 8000

ENTRYPOINT ["uvicorn", "src.main:app", "--host", "0.0.0.0", "--port", "8000"]
```

CMD vs ENTRYPOINT

Making Your Container Executable

CMD:

- Can be easily overridden from command line
- If you provide runtime arguments, entire CMD is replaced
- Good for default behavior that might change

ENTRYPOINT:

- Runtime arguments are added to ENTRYPOINT arguments
- Harder to override (needs --entrypoint flag)
- Good for containers that always run the same command

CMD vs ENTRYPOINT

Making Your Container Executable

```
# Dockerfile

CMD ["python", "app.py"]


# Runtime - completely replaces CMD

docker run myimage echo "hello"  # runs: echo "hello"
```

CMD vs ENTRYPOINT

Making Your Container Executable

```
# Dockerfile

ENTRYPOINT ["python"]


# Runtime - adds to ENTRYPOINT

docker run myimage app.py  # runs: python app.py

docker run myimage -V      # runs: python -V
```

CMD vs ENTRYPOINT

Making Your Container Executable

Best Practices:

- Use `ENTRYPOINT` for "main executable" that should always run
- Use `CMD` for arguments that might change
- Always use JSON array format ["command", "arg"]

```
ENTRYPOINT ["uvicorn"]

CMD ["main:app", "--host", "0.0.0.0", "--port", "8000"]
```

Interactive Docker

Great for debugging

```
# Only overrides the CMD
docker run -it my-image /bin/bash

# for Alpine-based images
docker run -it my-image /bin/sh

# Ignores both ENTRYPOINT and CMD
docker run -it --entrypoint /bin/bash my-image
```

Interactive Docker

Great for debugging

```
# Check installed Python packages
pip list

# Test imports
python
>>> import numpy

# Check environment variables
env

# Check file system
ls -la
cat requirements.txt
```

Makefile

Using Makefile to automate the docker commands

```
build:
    @echo "building docker image"
    docker build -t fastapi-app:latest .

run:
    docker run -p 8000:8000 fastapi-app:latest
    @echo "running on http://localhost:8000"

interactive:
    @echo "Entering container interactively"
    docker run -it --entrypoint /bin/bash fastapi-app:latest
```