VUSE Summer Research 2021

High Performance CPS Co-Simulations

Udit Malik

PIs: Dr. Janos Sztipanovits
Dr. Yogesh Barve

VANDERBILT UNIVERSITY

ISIS
Institute for Software Integrated Systems

Introduction

- **Cyber-physical systems (CPS):** deeply intertwined physical and software components
- **Co-simulations:** enable better understanding of complex scenarios arising from CPS

Problems:

- Co-simulations are compute-intensive and execute slowly in traditional development and server environments
- Performance is affected by available platform and resources
- Cloud computing provides elastic resources for scaling simulations across large clusters

Proposal:

- Argo Workflows!
- Leveraging Kubernetes Cloud Deployment
- Offers high-performance execution of the co-simulations
- Easy integration of highly parallel jobs, and running CI/CD pipelines

This summer, I built: A full-stack web service/REST API from scratch, that automates the workflow submission process from end to end for the user!

Core technologies: AngularJS (frontend), Java with Spring Boot (backend)
Docker (containerization), Kubernetes (container management)
PostgreSQL (database management), Argo Workflows (workflow management)

Other: MinIO (S3 object storage), Postman (API endpoint testing)

Institute for Software Integrated Systems

VANDERBILT UNIVERSITY

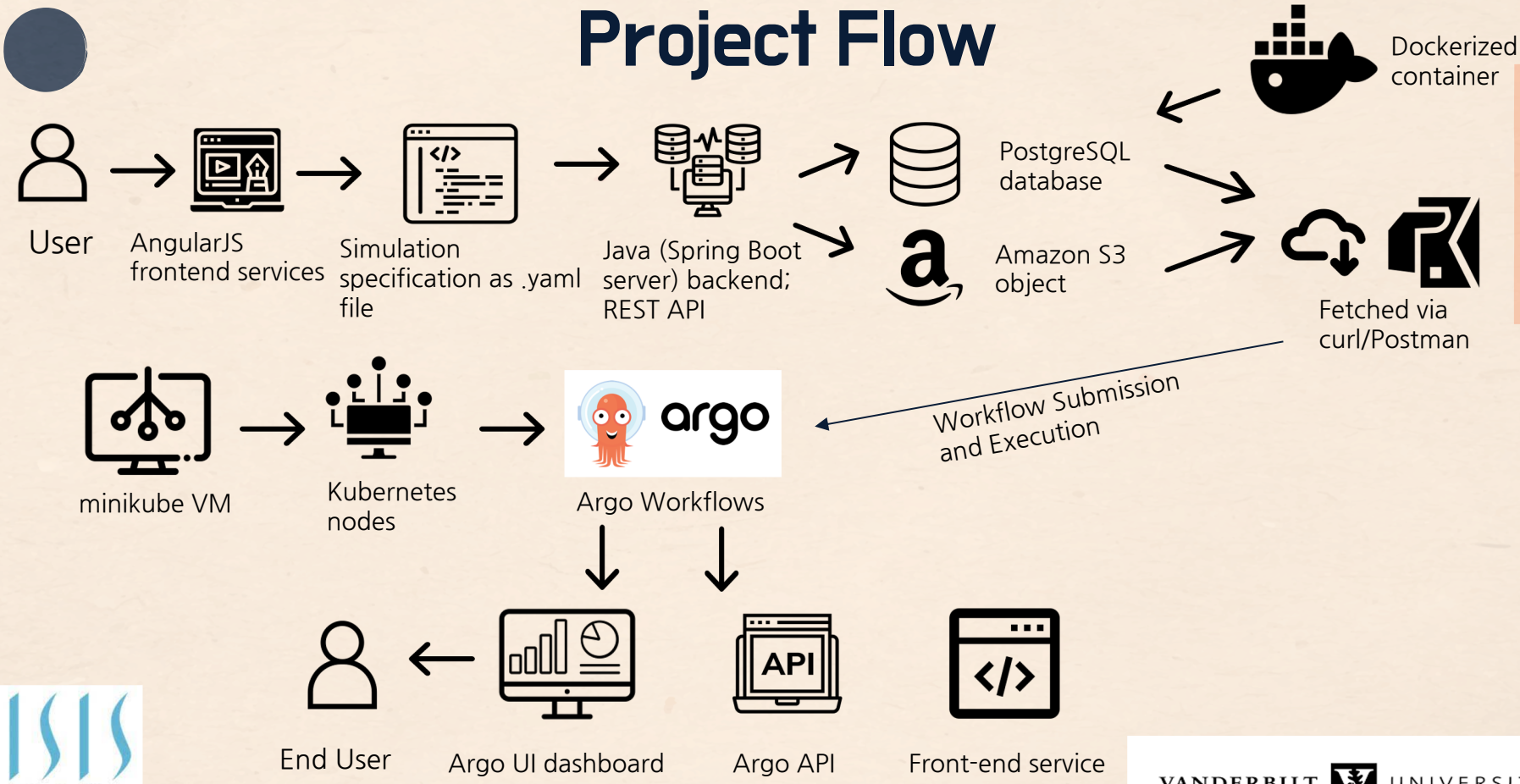
What exactly is a simulation/workflow?

```yaml
apiVersion: argoproj.io/v1alpha1
kind: Workflow
metadata:
  generateName: coinflip-recursive-
spec:
  entrypoint: coinflip
  templates:
  - name: coinflip
    steps:
    - - name: flip-coin
        template: flip-coin
    - - name: heads
        template: heads
        when: "{{steps.flip-coin.outputs.result}} == heads"
      - name: tails
        template: coinflip
        when: "{{steps.flip-coin.outputs.result}} == tails"

  - name: flip-coin
    script:
      image: python:alpine3.6
      command: [python]
      source: |
        import random
        result = "heads" if random.randint(0,1) == 0 else "tails"
        print(result)

  - name: heads
    container:
      image: alpine:3.6
      command: [sh, -c]
      args: ["echo \"it was heads\""]
```

Institute for Software Integrated Systems

VANDERBILT UNIVERSITY

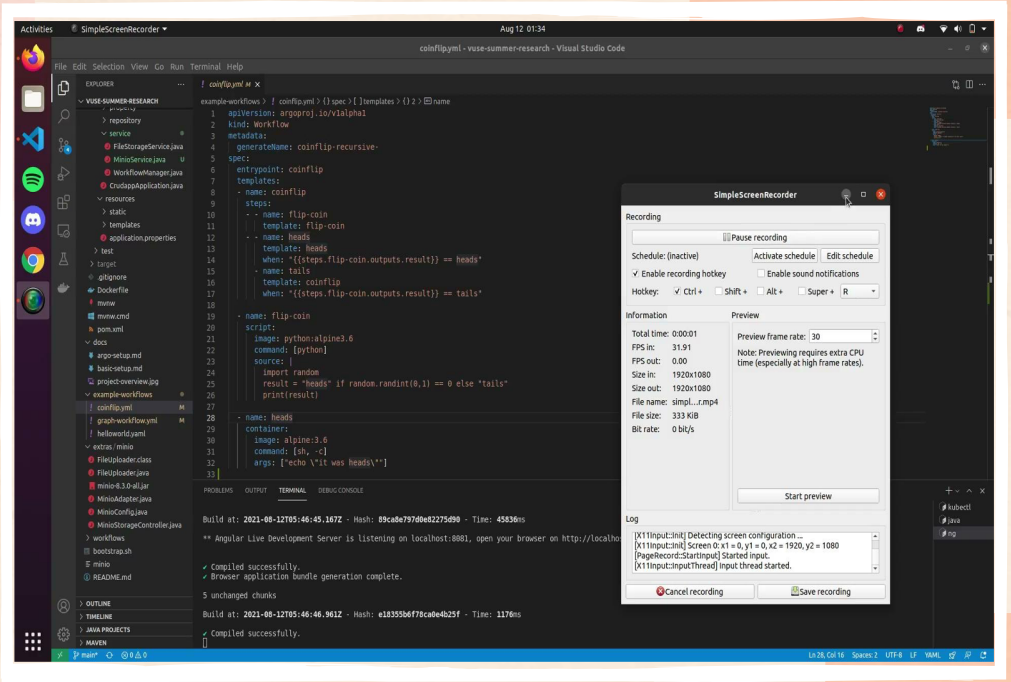
Project Flow



Institute for Software Integrated Systems

VANDERBILT UNIVERSITY

Sample Demo



Recursive coin flip example run

Lessons, Challenges, and Successes

IDEATION

Understanding workflow
Conceptualization
Brainstorming

Prioritizing tasks
Feedback

TIME MANAGEMENT

ASSESSMENT

Testing
Experimentation

New languages
New frameworks
Integration

PROGRAMMING

Thank you!

Institute for Software Integrated Systems

VANDERBILT UNIVERSITY