Open-Source Prototyping of 5G Wireless Systems for UGV/UAV

TEAM: SDMAY20-36

TEAM MEMBERS: WILLIAM BYERS, IBRICA TUTIC, SAMUEL STANEK, NATHAN WHITCOME, ANDREW ESCHWEILER, NICHOLAS LORENZ

FACULTY ADVISOR/CLIENT: HONGWEI ZHANG

Project Plan

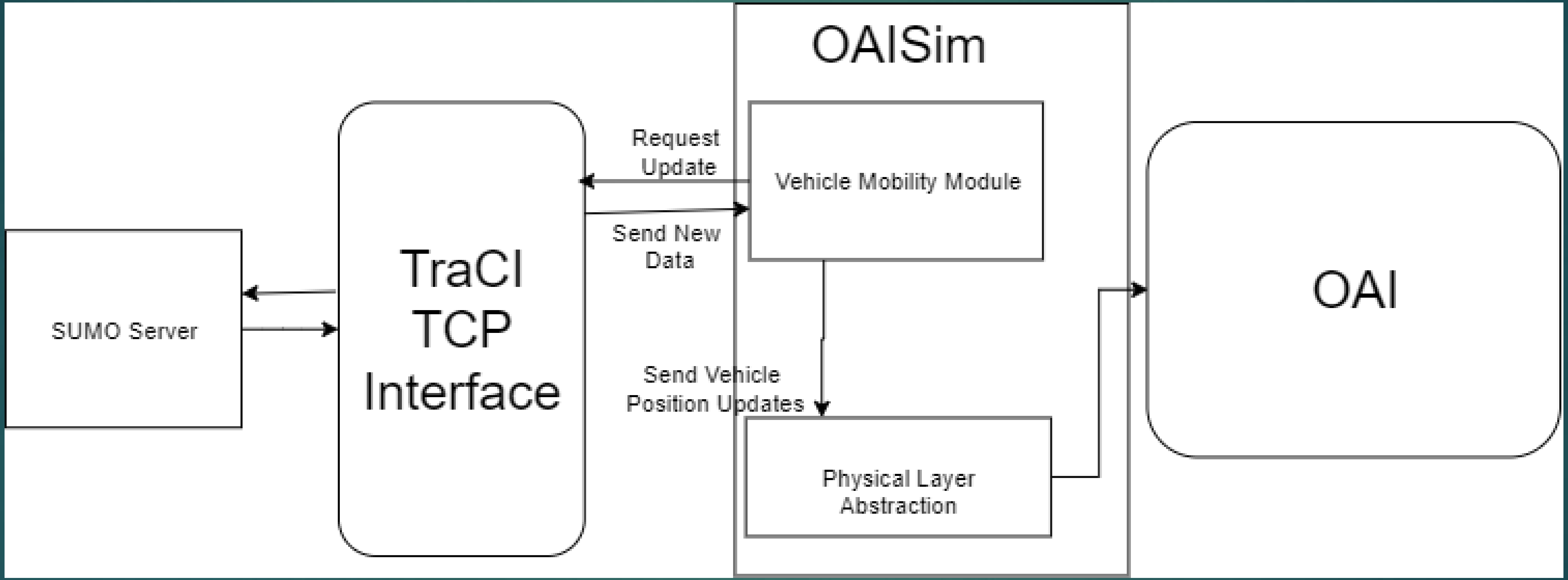
High Level Overview

- Create a 5G wireless solution that allows for large scale simulation of wireless networks
  - Low latency
  - High throughput
  - Extremely reliable network
- Tools
  - Open Air Interface (OAI)
  - Simulation of Urban Mobility (SUMO)
- Future uses
  - Connected autonomous transport
  - Smart agriculture

Problem Statement

- Need to modify OAI to simulate 5G networks in various traffic conditions
  - Need to simulate 100s of nodes
  - Ensure simulation output matches theory (no bugs)
- Utilize open source tools to solve the above problem

Conceptual Sketch



Functional Requirements

- Design a scalable system to test 5G scheduling algorithms
- Ensure the solution is:
  - Reliable
  - Has low latency
  - Has high throughput
- Utilize open source tools and follow good software practices
  - CI/CD
    - Jenkins
  - Cloud Deployments
  - OAI
  - SUMO

Technical/Other Constraints

- Limited in terms of hardware
  - Current server specs:
    - Intel Xeon 8 core processor (2.4 Ghz)
    - 8 GB of RAM
    - 120 GB disk
- Simulator is difficult to use
  - Requires multiple computers for various components
  - Very specific hardware requirements
    - Linux Low Latency Kernel
    - AVX512 Instruction Support
    - Turbo Decoding
    - Disable Processor Power Saving Features

Potential Risks & Mitigation

Risks

- Difficulty scaling networks to many UEs and eNBs
- New scheduling algorithm integration
- Difficulty recreating system configurations
  - Similar issues with cloud deployments
- Unknown simulator bugs
  - Large software project
  - Lots of legacy code

Mitigation

- Potentially deploy to cloud services
  - Cloudlab, ExoGENI
- Use CI/CD to verify old functionality isn't broken
- Use scripts where possible to create network layouts
  - Cloud formation templates
- Verify experiments match theory

System Design

Functional Decomposition

- SUMO Traffic Generation
  - SUMO Server to create traffic simulations
  - Update positions of nodes in OAI using SUMO data
  - Interface between OAI and SUMO
- Network Emulation
  - Various eNB and UE in configurations
    - 1 eNB, 1 UE
    - 1 eNB, Many UEs
    - Many eNBs, Many UEs
- Scheduling Algorithm (CPS-V2X)
  - Based on PKRS, CPS, and UCS
  - Adjusted for dynamic node configurations

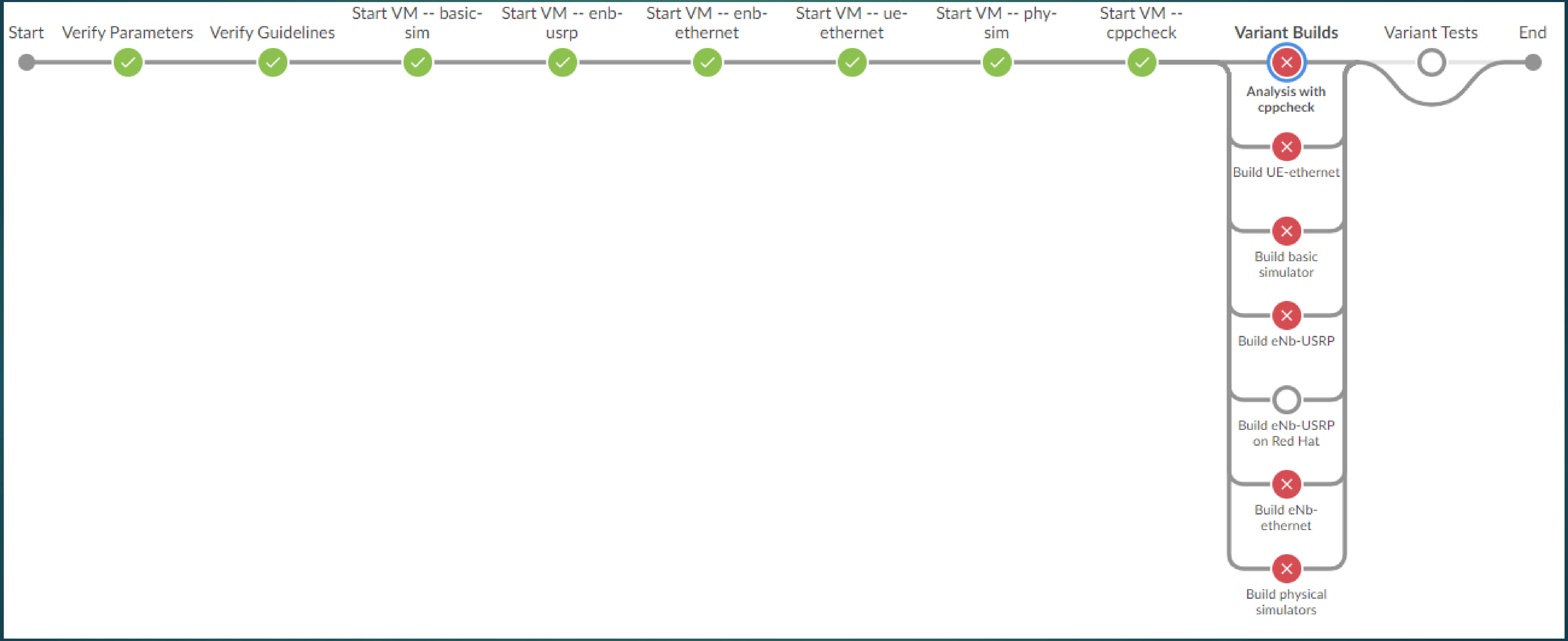
HW/SW/Technology Platforms Used

- OAI
  - Open Air Interface
  - Open source 5g network simulator/emulator/test bench
  - Highly optimized, written in C
- SUMO
  - Simulation of Urban Mobility
  - Open source, highly customizable traffic simulator
  - Include an API to get vehicle positioning data
- Jenkins
  - CI/CD
  - Pipelined build jobs for regression testing

Detailed Design – OAI Simulation

- Run UE and eNB on one server
  - Run EPC on another server
    - Network Access Controls, Packet Routing, Mobility Management, Security
- Integrate SUMO traffic data for dynamic situations
- Integrate new algorithm in MAC layer of test bed
- Measure network statistics
  - Latency
  - Throughput
  - Reliability
- Ensure any new code passes all previous tests

Detailed Design - Jenkins



Test Plan

- Configure simulation test bed
  - 1 UE, 1 eNB to start with
  - Use nFAPI to facilitate communication
    - Network functional API
    - Connects Physical Network to Virtual Network (Layer 1 to Layer 2)
  - Modify number of eNBs/UEs
  - Incorporate SUMO traffic data
- Implement new scheduling algorithm
  - Does the simulation test bed break?
  - Unit tests using simple UE/eNB sets
  - Reliability, throughput, and latency measurements

Prototype Implementations

- Currently running 1 UE and 1 eNB
  - Have configuration files for multiple UE/eNBs created
- Built a C client to support SUMO API
  - Used for traffic data
- Newest version of OAI running on server
  - Updated from v.5.2 -> 1.2.0 -> 1.2.1

Conclusion

Current Project Status

- Trying to finish three main tasks by early April
  - Algorithm implementation
  - Interfacing OAI/SUMO
  - OAI simulation test bed and physical layer abstraction
- Currently running 1 eNB and 1 UE on our server
  - Need to configure EPC to begin testing
- Jenkins server is set up, need to move to server with more RAM

Task Responsibility/Contribution

- Ibrica Tutic – Phys. Layer Abstraction/OAI Simulation Environment
- William Byers – Algorithm Development
- Andrew Eschweiler – Algorithm Development
- Nathan Whitcome – SUMO/OAI Interfacing
- Samuel Stanek – SUMO/OAI Interfacing
- Nicholas Lorenz – System Power Theoretical Analytics