PhD Candidacy Examination – Research Summary

Candidate: [Korede R. Bishi] **Date:** February 2026
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Department: Computer Science, University of Georgia

Background

My research focuses on **discrete event simulation** and **microscopic traffic simulation** using the ScalaTion 2.0 framework (Scala 3). I develop, calibrate, and validate car-following models against real-world California freeway data (PeMS) to create accurate digital twins of highway networks. This work combines discrete-event simulation, numerical methods, and optimization algorithms.

Coursework Completed

Course Code	Course Title	Grade
[CSCI 6470]	[Algorithms]	[B]
[CSCI 6050]	[Software Engineering]	[A-]
[CSCI 6760]	[Computer Networks]	[A]
[CSCI 6795]	[Cloud Computing]	[A-]
[CSCI 8780]	[Advance Distributed Systems]	[A]
[CSCI 8265]	[Trustworthy Machine Learning]	[A]
[CSCI 8945]	[Advance Representation Learning]	[A-]
[CSCI 8000]	[Machine Learning in IoT]	[A]
[CSCI 8000]	[Advance Topics in Human Center Computing]	[A]
[CVLE 8120]	[Transportation Planning]	[Spring-2026-Ongoing]

Paper 1: ANNSIM 2026 (Submitted January 2026)

Title: *Lane-Level Validation of Microscopic Traffic Simulation: Numerical Integration and Arrival Process Trade-offs*
Abstract: This work advances microscopic traffic simulation through lane-level validation of speed and flow dynamics, addressing a critical gap in conventional macro-aggregated approaches. We systematically evaluated the trade-offs between numerical integration methods and vehicle arrival processes when reproducing empirical trajectory data from California's freeway network.
Key Findings:

- The choice of a numerical integrator has **negligible impact** (<1% variation between 8 methods)
- **The changed Erlang-2 distribution** reduces the flow-prediction error by ∼28% vs. Poisson (NHPP)
- Lane-level validation reveals dynamics that aggregated metrics obscure

Paper 2: WSC 2026 (In Progress – Deadline: April 5, 2026)

Working Title: *Comparative Analysis of Car-Following Models and Optimization Algorithms for Lane-Level Traffic Simulation Calibration*
Abstract: Building on our ANNSIM 2026 findings, this work systematically compares three car-following models (IDM, Gipps, Krauss) with multiple optimization algorithms (SPSA, Nelder-Mead, Differential Evolution) for calibration against PeMS sensor data. We evaluate which combination of model-optimizer yields the best lane-level accuracy.
Expected Contributions:

- First systematic comparison of CF model × optimizer combinations at lane-level
- Evaluation on US-101 corridor with real PeMS validation data
- Guidance for practitioners on model selection for microscopic simulation

Why ScalaTion? Methodological Justification

A natural question arises: *Why develop in ScalaTion when established simulators like SUMO exist?* The answer lies in the **research flexibility** required for systematic scientific comparison.

1. Unified Architecture for Heterogeneous Models. Car-following models fall into two mathematical categories:

- *Continuous-time* (e.g., IDM): Output acceleration $\dot{v} = f(s, v, \Delta v)$, requiring ODE integration
- *Discrete-time* (e.g., Gipps, Krauss): Output next velocity $v(t + \tau)$ directly

ScalaTion's **polymorphic trait-based design** allows both model types to operate through a common interface, enabling fair comparison under identical simulation conditions. SUMO's architecture does not permit runtime model switching or configurable integration.

2. Configurable Numerical Integration. ScalaTion offers 8 ODE integrators (Euler, Heun, RK2–RK5, Dormand-Prince, Ballistic), selectable at runtime. This enabled our ANNSIM finding that integrator choice has <1% impact on car-following accuracy—an experiment *impossible* in SUMO, which uses fixed Euler integration.

3. Native Calibration Pipeline. Calibration in ScalaTion occurs within the same codebase as simulation, allowing tight coupling between optimization algorithms (SPSA, Nelder-Mead, DE) and the fitness function. SUMO requires external interfaces (TraCI), adding latency and complexity.

4. Lane-Level Validation by Design. ScalaTion's architecture records per-lane flow and speed natively, enabling the lane-level validation central to both papers. Extracting equivalent data from SUMO requires significant post-processing.

In summary: ScalaTion is not a replacement for SUMO's production-scale capabilities, but a **research instrument** designed for controlled experimentation on simulation methodology—precisely what this dissertation requires.

Request

Per the guidance of my major professor, I am initiating the scheduling of my PhD candidacy written examination. I respectfully request that written examination questions be prepared in accordance with departmental procedures.

Committee Members

1. Dr. John A. Miller – Major Professor
2. Dr. Maria Hybinette – Committee Member
3. Dr. Qianwen Li – Committee Member