P5-24: Secure and Efficient Systems

Mission-Critical Computing
NSF CENTER FOR SPACE, HIGH-PERFORMANCE, AND RESILIENT COMPUTING (SHREC)

SHREC Annual Workshop (SAW23-24)

University of Pittsburgh · BYU Brigham Young University · Virginia Tech · UF University of Florida

January 17-18, 2024

Dr. Mai Abdelhakim
Assistant Professor of ECE
University of Pittsburgh

Dr. Robert Cunningham
Vice Chancellor of Research Infrastructure
University of Pittsburgh

Robert Esswein
Quincy Bayer
Graduate Students
University of Pittsburgh

Number of requested memberships ≥ 2

Goals, Motivations, & Challenges

Goals

- Develop **trust** assessment framework for constellations
- Create **secure** routing algorithm for constellations by integrating trust into routing
- Characterize **scalability** of satellite constellations

Motivations

- **Dependence** on space-based systems for critical applications
- Constellations are growing in **size** and **complexity**
- Increasing connectivity leads to increasing **attack surface**
- Understanding how **scaling** constellations affects performance

Challenges

- Computational complexity of simulating **hundreds** of satellites
- Satellites must be **resilient** to many different types of attacks
- **Distributed** trust systems have access to limited amounts of information

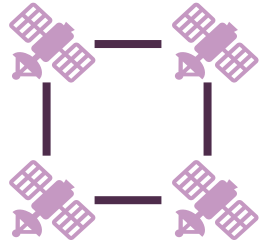
Proposed Tasks for 2024

T1 Trust Assessment

- Analyze network performance under non-ideal operating conditions
- Create trust algorithm for capturing node behavior

T2 Constellation Scalability

- Examine constellation network performance as parameters change
- Refactor simulation environment for multithreaded processing



Task 1: Trust Assessment

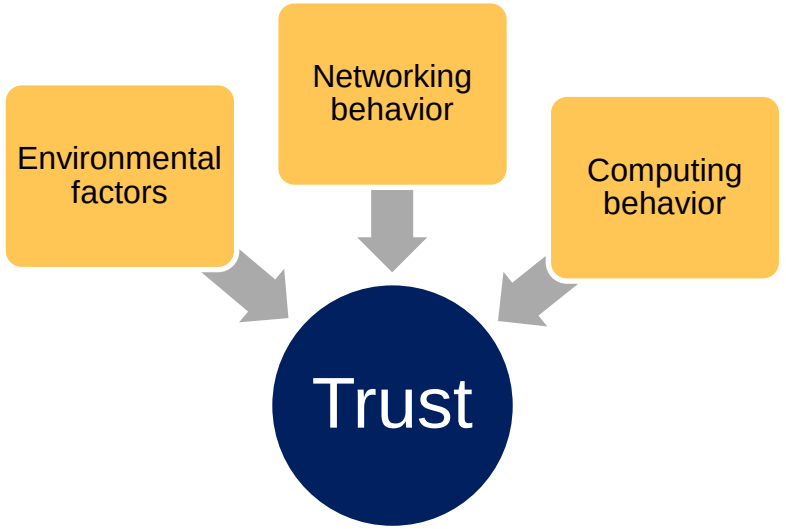
Task leader: Quincy Bayer

- Analyze network performance under non-ideal operating conditions
- Create trust algorithm for capturing node behavior

T1: Trust Assessment

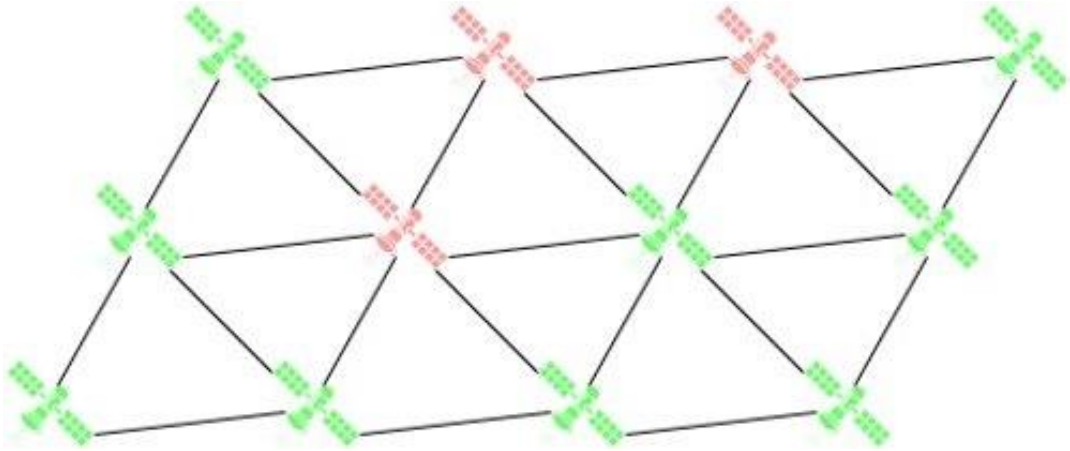
Trust Assessment

- **Direct** trust, **Indirect** trust, **Functional** trust
- Combine multiple aspects of node behavior to determine trust



Trust Simulation

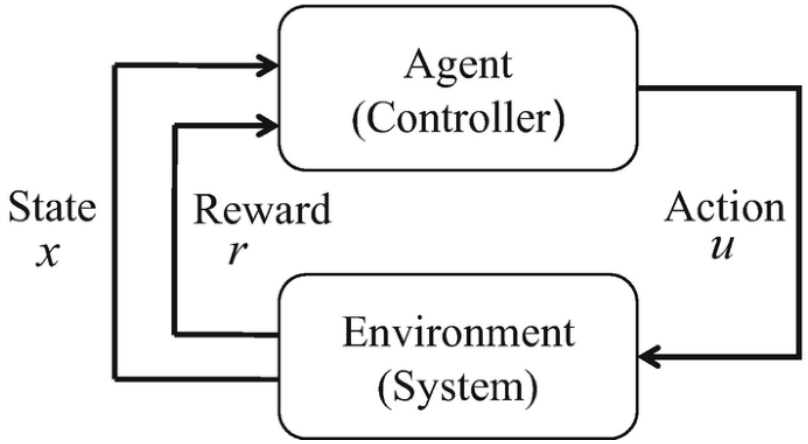
- Distributed trust assessment simulator with **modular** framework
- Evaluate multiple trust algorithm responses to attacks



T1: Next Steps

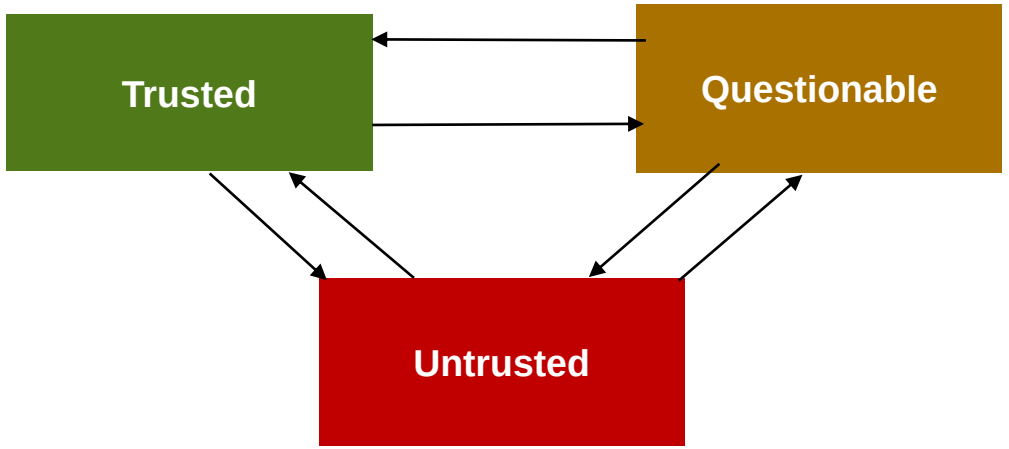
Trust Assessment

- Develop **reinforcement learning** based trust algorithm
- Capture variability of environment by interacting with other nodes



Trust Simulation

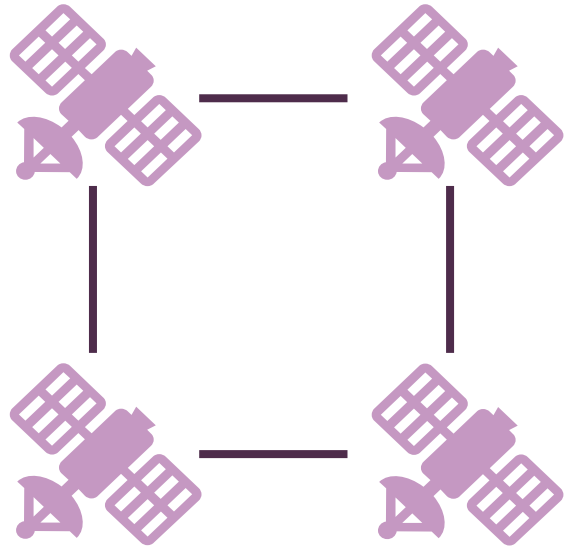
- Measure ability of trust assessments to identify **untrustworthy** nodes
- Simulate **attacks** on satellites



Task 2: Constellation Scalability

Task leader: Robert Esswein

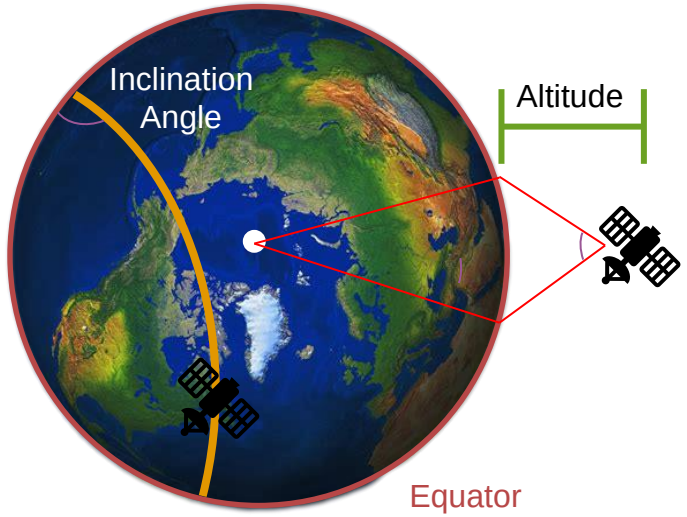
- Examine constellation network performance as parameters change
- Refactor simulation environment for multithreaded processing



T2: Constellation Scalability and Security

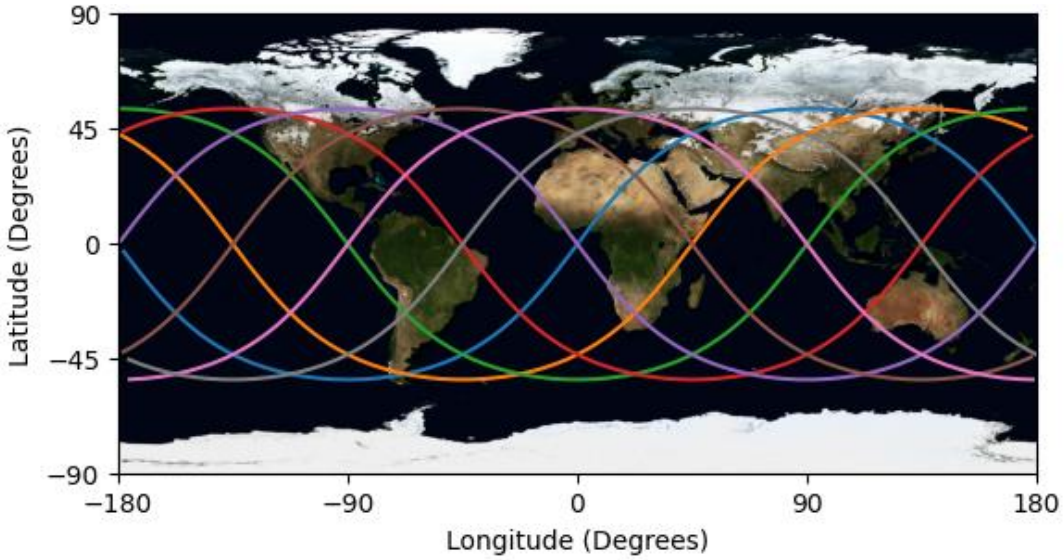
Satellite Constellation Scalability

- Parameters: altitude, topology, number of satellites, etc.
- How do parameters affect **network** behavior



Network Simulation

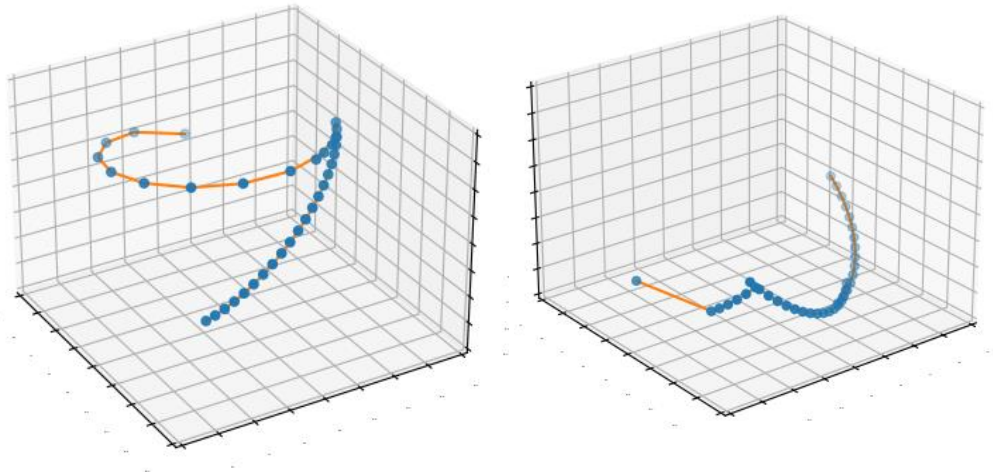
- High-fidelity **network** simulator
- Vary parameters of **simulation**
- Measure **latency**



T2: Next Steps

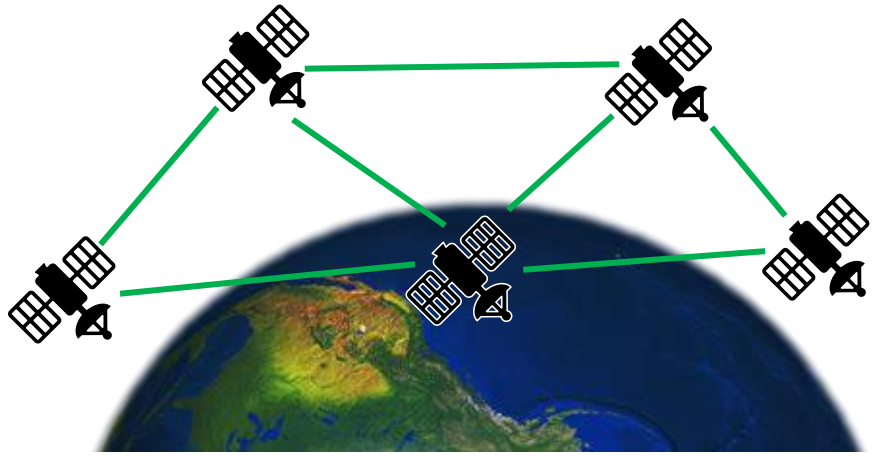
Satellite Constellation Scalability

- Minimize **delay** by selecting altitude, size, topology, etc.
- Develop trust-based algorithm for **secure** routing



Network Simulation

- Measure network **throughput**
- Simulate **attacks** on satellites
- **Optimize** constellation parameters



Milestones, Deliverables, Budget

MILESTONES

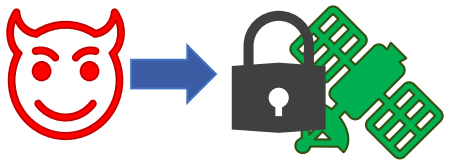
- SMW25 (06/25): Showcase preliminary results on all project tasks
- SAW24-25 (01/25): Completion of all project tasks

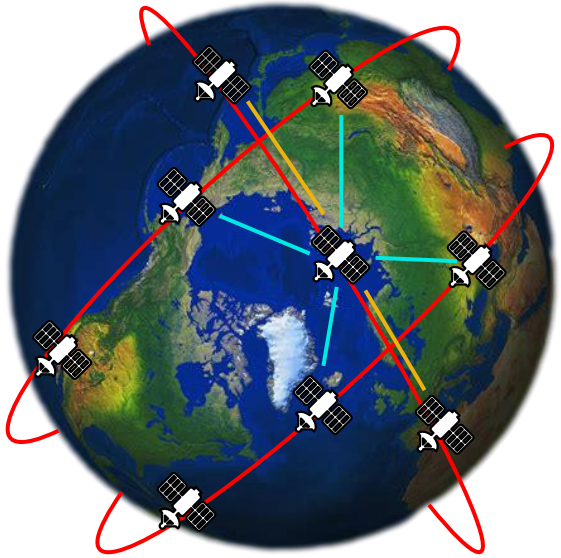
DELIVERABLES

- Monthly progress reports from all projects
- Midyear and end-of-year full reports from all projects
- 2 conference and 2 journal publications

BUDGET

- Minimum recommended: Two (2) memberships
  (80 Votes)

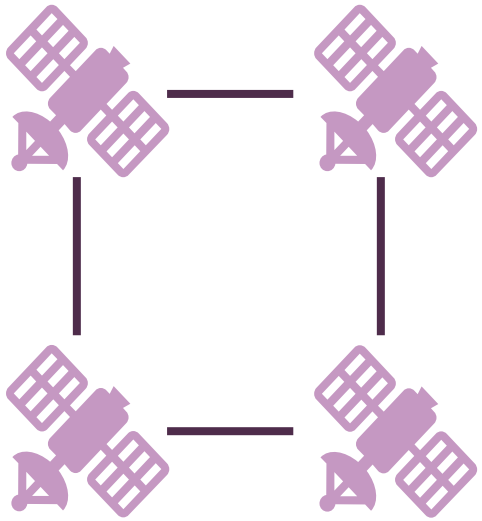




Conclusions & Member Benefits

Conclusions

- Develop trust assessment simulator for distributed satellite networks
- Utilize reinforcement learning to develop new trust assessment algorithm
- Refactor satellite constellation network simulator for multithreaded processing
- Expand constellation scalability study across more parameters



Member Benefits

- Direct influence over processors and frameworks studied
- Direct influence over apps and datasets studied
- Direct benefit from new methods, data, code, models, and insights from metrics, benchmarks, and emulations