P5-25: Networked and Secure Systems

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

SHREC Annual Workshop (SAW24-25)

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

January 14-15, 2025

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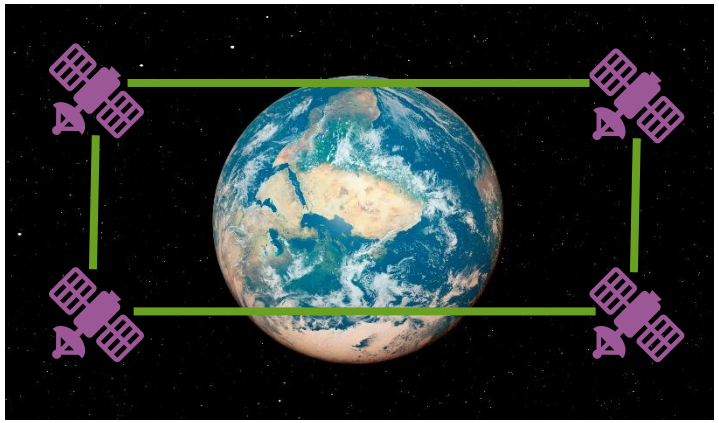
Number of requested memberships ≥ 2

Goals, Motivations, & Challenges



Goals

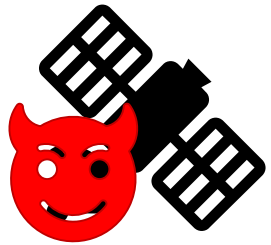
- Develop **trust** assessment framework for constellations
- Leverage predictable topology for **routing** packets through network
- Create **secure** routing algorithm for constellations by integrating trust into routing

Motivations

- **Dependence** on space-based systems for critical applications
- Constellations are growing in **size** and **complexity**
- Increasing connectivity leads to increasing **attack surface**
- Lower **computational overhead** and **latency** for satellite networks

Challenges

- Computational complexity of simulating **large-scale** satellite constellations
- Satellites must be **resilient** to many different types of attacks
- **Distributed** trust systems have access to limited amounts of information



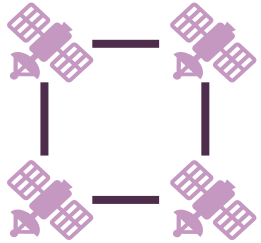
Proposed Tasks for 2025

T1 Trust Assessment

- Enhance our trust algorithm to accurately detect complex attack patterns
- Extend our trust algorithm to consider other factors in trust

T2 Constellation Routing

- Improve network modelling fidelity for analyzing network performance
- Develop trust-based routing algorithms for satellite networks



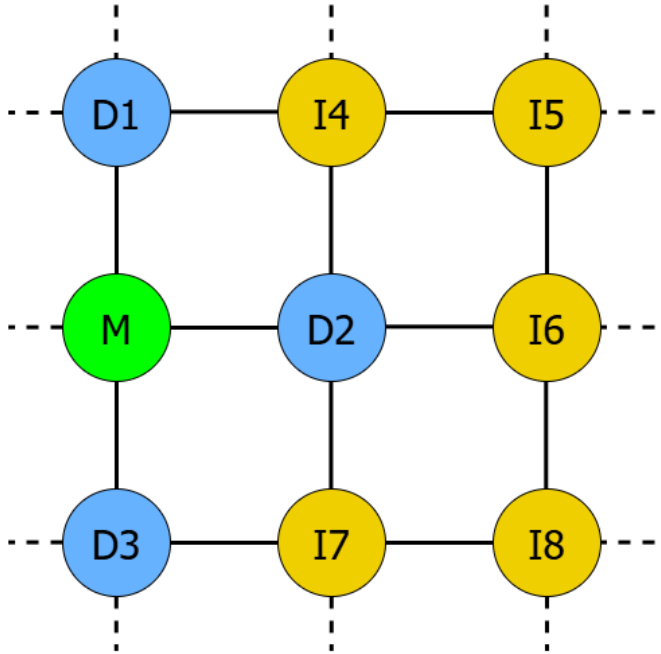
Task 1: Trust Assessment

Task leader: Quincy Bayer

T1: Trust Assessment

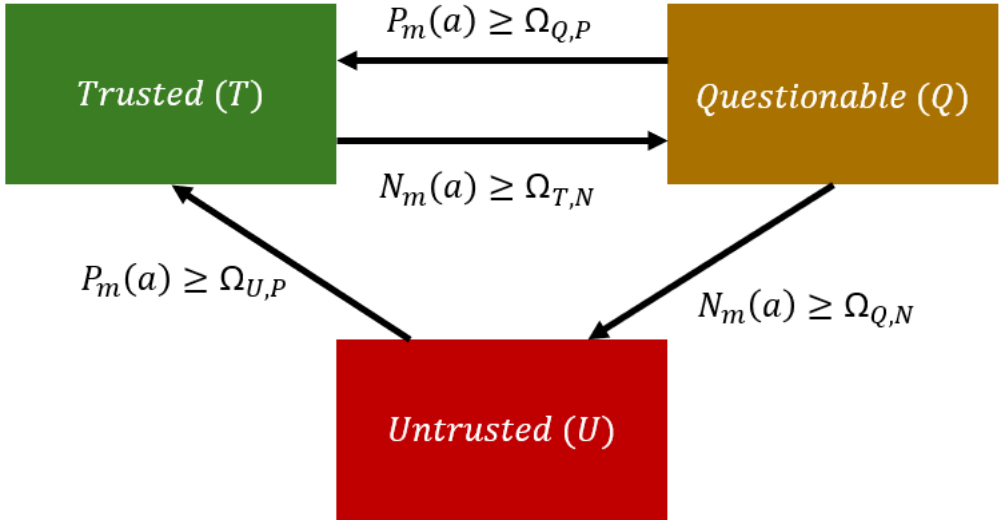
Trust Assessment

- **Direct** trust, **Indirect** trust, **Aggregate** trust



TAU Trust Algorithm

- Novel decentralized trust algorithm based on **FSMs**
- **Asynchronous communication** reduces resource overhead

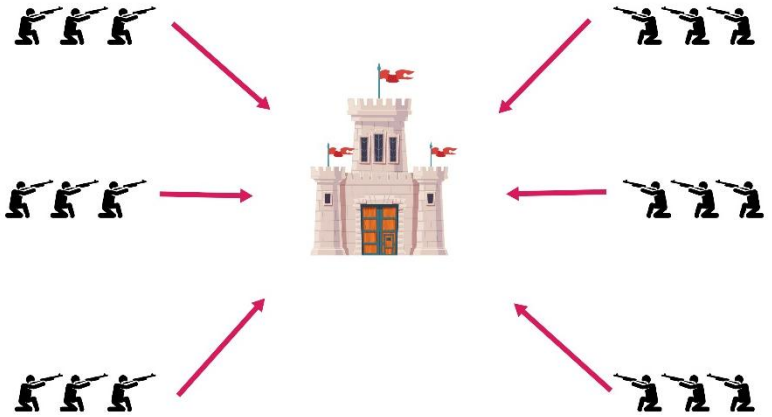


TAU: Trust via Asynchronous Updates
FSM:: Finite State Machine

T1: Next Steps

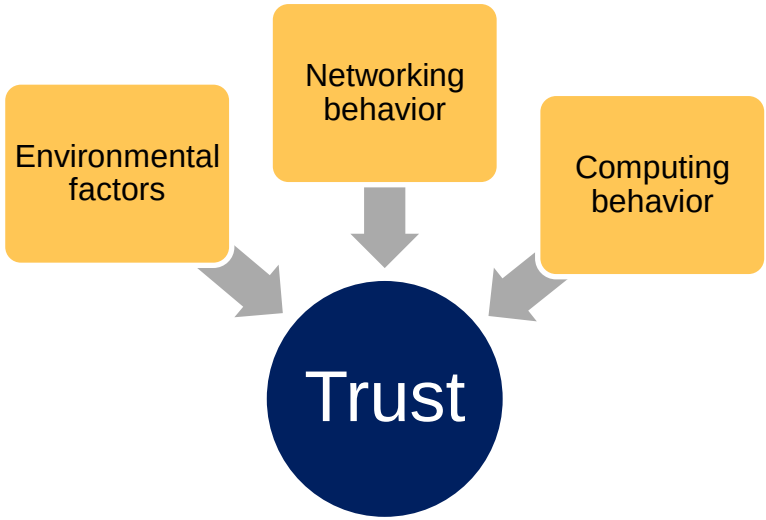
Modeling Attacks

- Account for more **complex attacks** such as bad mouthing and the Byzantine problem
- Improve our algorithm's precision by **reducing false positive** rate



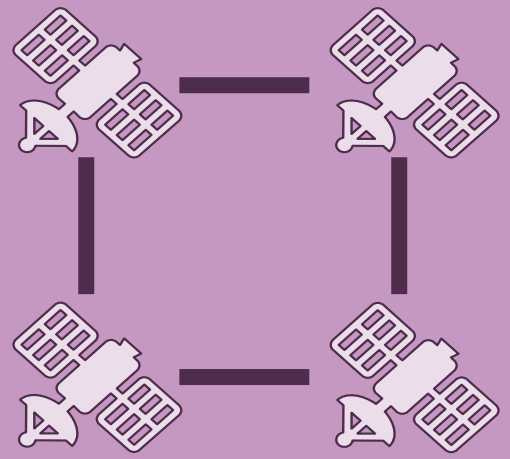
Extending Our Algorithm

- Extend our algorithm to consider more aspects of node behavior
- Incorporate impacts of **extreme radiation** environments



Task 2: Constellation Routing

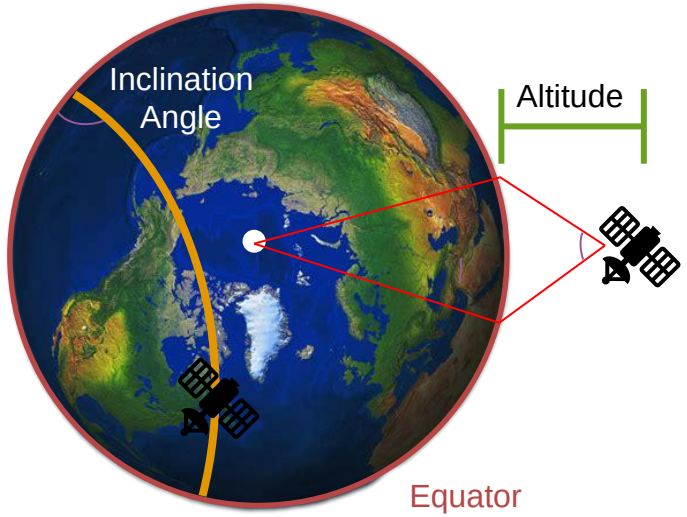
Task leader: Robert Esswein



T2: Satellite Constellation Routing

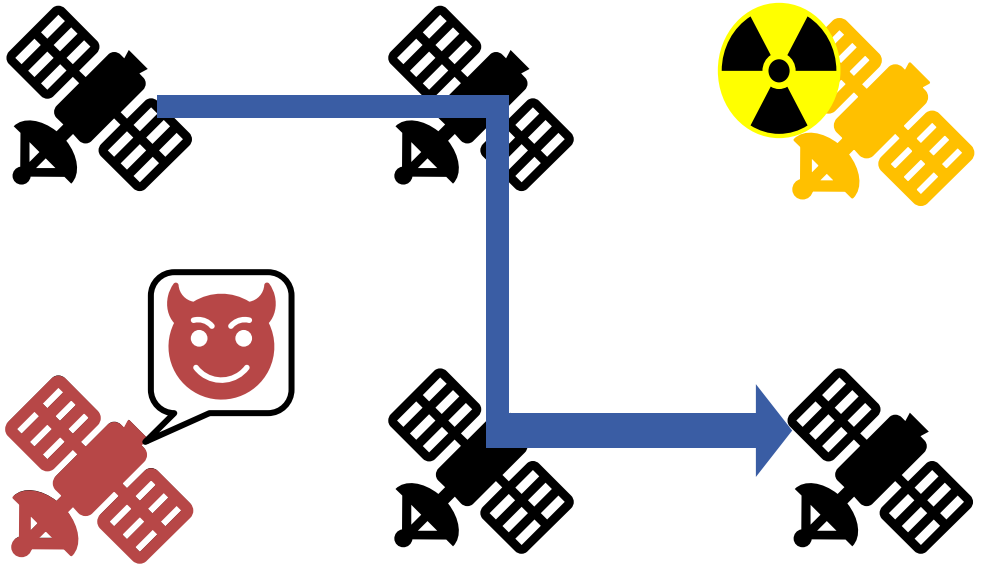
Routing Algorithms

- Utilize **predictable** topology to improve routing
- Measure effects of constellation **configuration** on routing



Trust-Based Routing

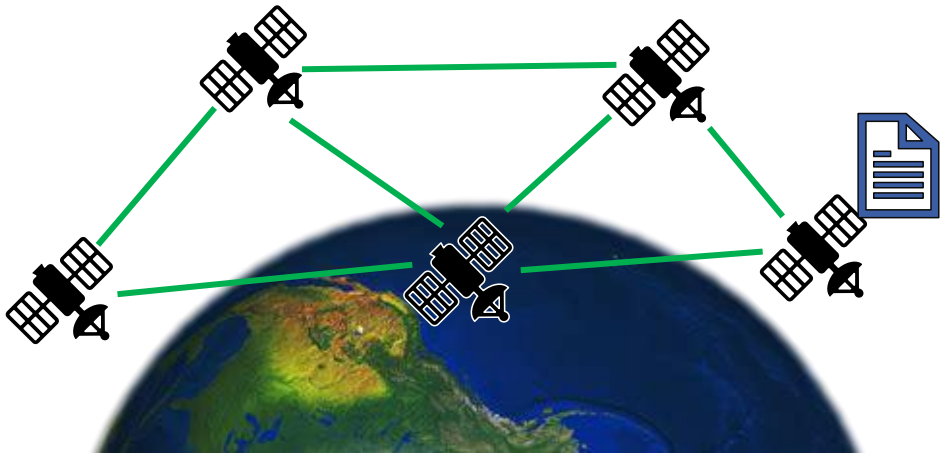
- Utilize **trust assessment** as input to routing algorithm
- Route through **trusted** links



T2: Next Steps – Routing Algorithms

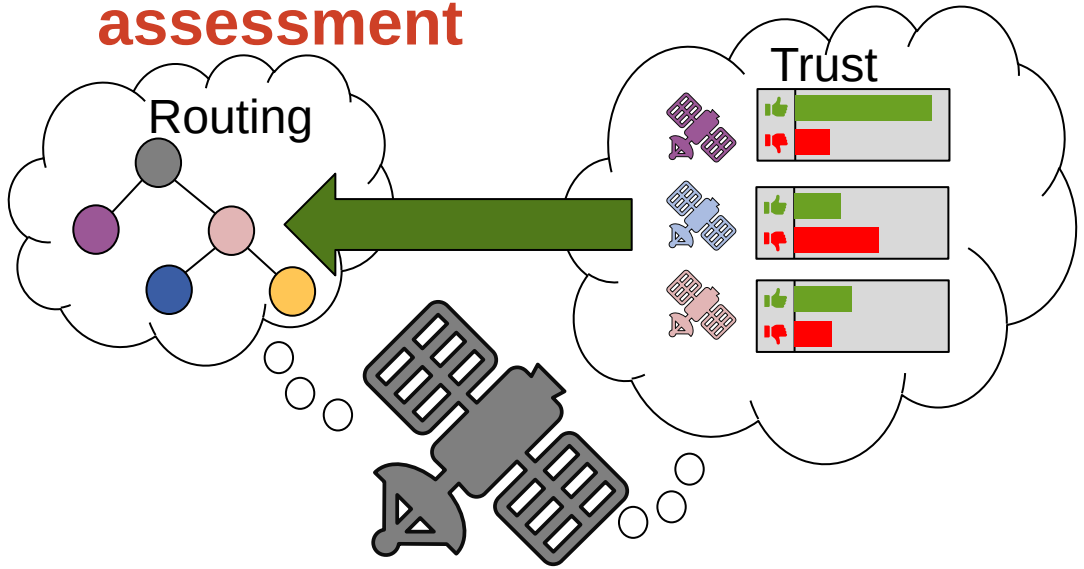
Offline Algorithm

- Develop offline **shortest path** routing algorithm
- Minimized online computations with **low latency**



Trust Based Routing

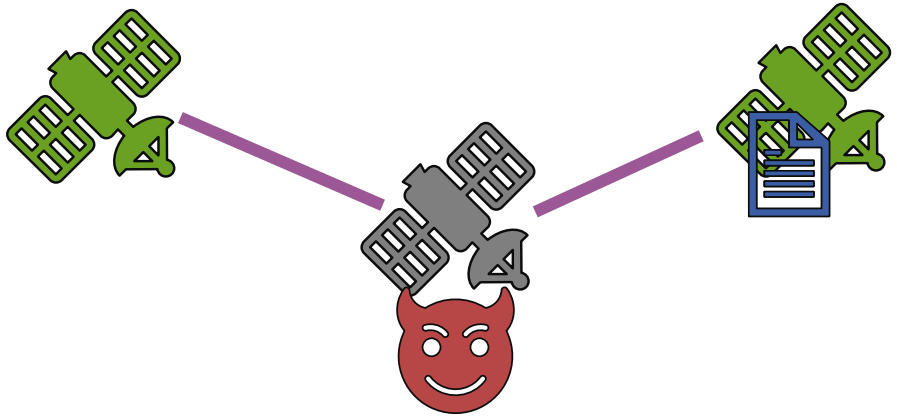
- Continue development of satellite network **simulator**
- Add support for **trust assessment**



T2: Next Steps – Constellation Simulation

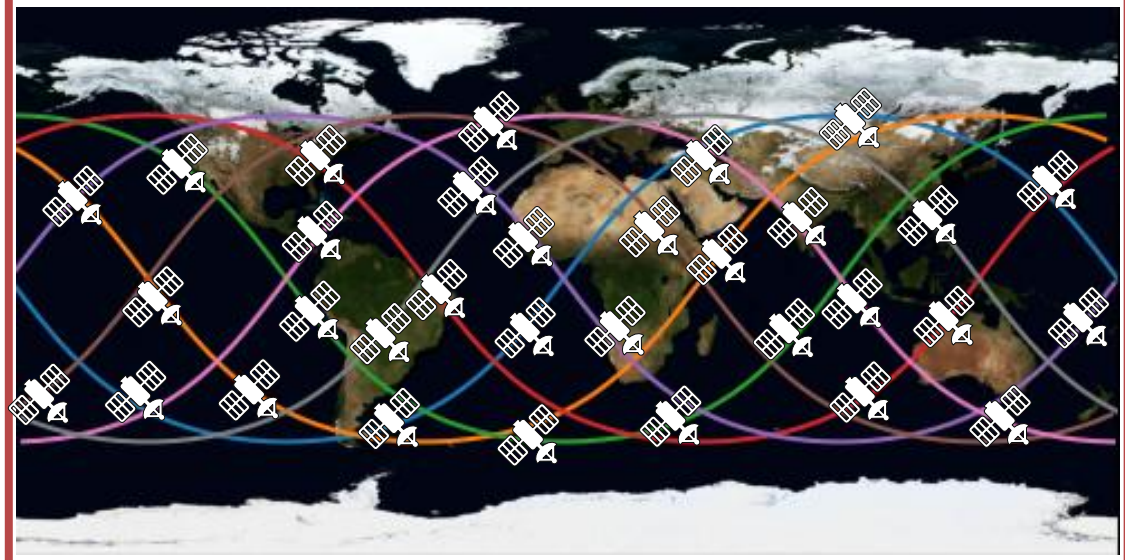
Network Simulation

- Collaborate with UF (Dr. McNair), develop **comprehensive** satellite network simulator
- Add support for **cyber-attacks** and **trust assessment**



Simulator Scalability

- Support **large** constellations
- Assess **queuing delay** and **link contention** in satellite networks



Milestones, Deliverables, Budget

MILESTONES

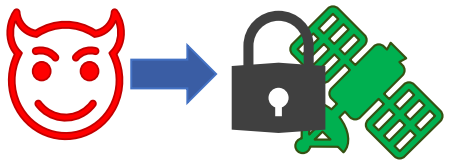
- SMW25 (06/25): Showcase preliminary results on all project tasks
- SAW25-26 (01/26): Completion of all project tasks

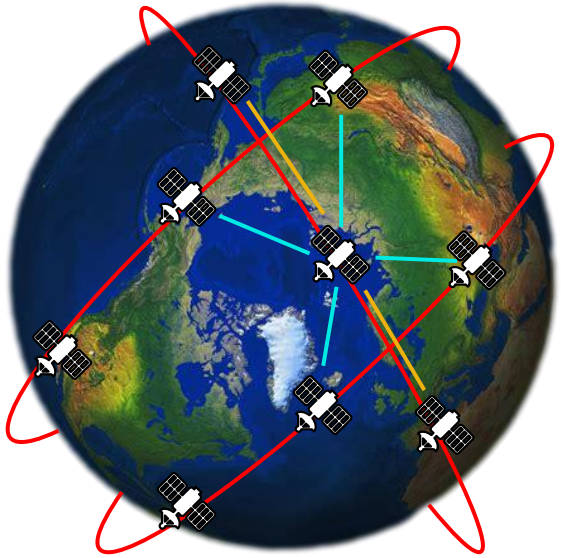
DELIVERABLES

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

BUDGET

- Minimum recommended: Three (3) memberships
  (150 Votes)

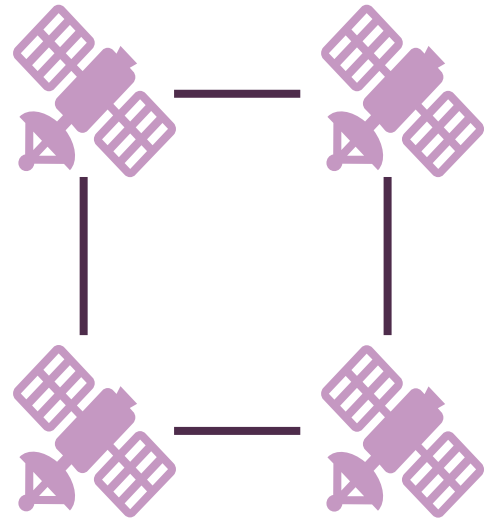




Conclusions & Member Benefits

Conclusions

- Extend the TAU algorithm to account for additional behavioral and environmental indicators to perform trust assessment
- Further optimize the parameters of the TAU algorithm in order to reduce the false alarms and respond to more complex attacks
- Create trust-based routing algorithm utilizing stored routing tables
- Continue to develop network simulator for varying traffic conditions and constellation parameters and configurations



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