DTN Satellite Network Simulator: User Guide and Quick-Start Manual

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***Abstract*—This document provides a concise user guide and quick-start reference for the Delay-Tolerant Networking (DTN) Satellite Simulator. The simulator integrates orbital mechanics, RF link modeling, and DTN routing protocols into a full-stack research and visualization platform. This guide summarizes installation, basic navigation, simulation configuration, experiment workflows, and troubleshooting procedures.**

I. Introduction

The DTN Satellite Simulator is an interactive tool enabling analysis of delay-tolerant routing protocols within realistic satellite constellations. The system includes a Python-based backend, a React/Three.js frontend, orbital propagation models, RF link budget calculations, and implementations of DTN protocols such as Epidemic, PRoPHET, and Spray-and-Wait.

This user guide outlines essential steps for installation, configuration, and operation.

II. System Requirements

A. Hardware

- CPU: Intel i5 / AMD Ryzen 3 or better
- RAM: 8 GB minimum (16 GB recommended)
- GPU: WebGL-capable device
- Storage: 2 GB free

B. Software

- Python 3.8+
- Node.js 18+
- Modern WebGL browser (Chrome, Firefox, Safari)
- Windows 10+, macOS 10.14+, or Ubuntu 18.04+

III. Installation

A. Quick Start

```
git clone https://github.com/YourUsername/
delay-tolerant-networks.git
cd delay-tolerant-networks
./scripts/start-dev.sh
```

After startup:

- Frontend: http://localhost:3000
- API Docs: http://localhost:8000/docs

B. Manual Installation

Backend

```
cd backend
pip install -r requirements.txt
python src/main.py
```

Frontend

```
cd frontend
npm install
npm run dev
```

IV. Interface Overview

The UI consists of three primary modules:

1) **Constellations** – Load or upload satellite constellations.
2) **Simulations** – Configure and execute individual runs.
3) **Experiments** – Perform multi-run comparisons.

V. Constellation Management

A. Built-In Constellations

TABLE I
Preconfigured Constellations

Name	Sats	Alt. (km)	Type
Starlink Phase 1	1584	550	LEO
Kuiper	3236	590–630	LEO
GPS	31	20200	MEO
GEO Minimal	3	35786	GEO
Molniya	12	26600	HEO

B. Custom Uploads

Custom constellations must follow the CSV format:

```
satellite_id,name,altitude,inclination,
raan,ecc,perigee,mean_anomaly
sat001,MySat1,550,53,0,0,0,0
```

Upload through the *Constellations* panel.

VI. Running Simulations

A. Creating a Simulation

Steps:

1) Open **Simulations**.
2) Select **Create New Simulation**.
3) Choose a constellation.

4) Select routing protocol(s).
5) Configure duration and weather options.
6) Choose ground station endpoints.

B. Execution Controls

- Play – Start simulation
- Pause – Temporarily halt
- Stop – End and save

Metrics update in real time.

VII. 3D Visualization

The visualization interface provides satellite trajectories, coverage footprints, bundle flow, and ground station views.

A. Elements

- Satellites (color-coded status)
- Ground stations
- Footprint circles
- Bundle indicators

B. Controls

- Drag – Rotate
- Scroll – Zoom
- Click – Inspect satellite
- Double-click – Reset view

VIII. Experiment Framework

A. Creating Experiments

Users can configure:

- Routing algorithms
- Duration and iterations
- Traffic pattern (uniform/bursty)
- Bundle size, TTL, and buffer size

B. Outputs

Generated metrics include:

- Delivery ratio
- End-to-end delay
- Overhead ratio
- Buffer utilization

Results export to CSV and plots.

IX. Troubleshooting

A. Backend Issues

- Ensure backend is running.
- Test using: `curl localhost:8000/health`
- Clear port lock:

```
lsof -ti:8000 | xargs kill -9
```

B. 3D Rendering Problems

- Enable WebGL.
- Update browser and GPU drivers.
- Use Chrome/Firefox.

C. Performance Tips

- Reduce satellite count.
- Increase time-step.
- Disable 3D view during heavy compute.

X. Conclusion

This guide provides the essential workflow for operating the DTN Satellite Network Simulator, including installation, constellation setup, simulation execution, experiment workflows, visualization tools, and troubleshooting. The simulator supports realistic DTN research using orbital mechanics and RF models.