ADAPTIVE HANDOVER DETECTION FOR QUIC OVER LEO SATELLITE NETWORKS

Nurulfaizal Bin M. Shukeri, Jianping Tian, Yung-Wey Chong, Muhammad Niswar, Sye Loong Keoh, Achmad Basuki

OVERVIEW

- Introduction
- Problem Statement
- Research Objectives
- Literature Review
- Methodology
- Implementation
- Results
- Conclusion and Future Work

INTRODUCTION

- Satellite communication is key to global connectivity, with LEO networks as the fastest-growing paradigm.
- Compare to GEO and terrestrial systems, LEO offers wider coverage, terrain independence, lower latency, and fewer obstructions.
- As of Jan 2026, Starlink operates 9,000+ satellites serving ~9M subscribers.
- Challenge: satellites move at ~7.5 km/s, forcing frequent handovers which cause certain problem.

PROBLEM STATEMENT

- Handover Misinterpretation: Rapid LEO satellite movement (~7.5 km/s) causes frequent handovers that create RTT spikes and temporary packet loss. Traditional protocols misinterpret these link-level disturbances as genuine network congestion.

- Performance Penalties: This misjudgment triggers unnecessary congestion window reductions and "slow-start" recovery cycles. This leads to significant throughput degradation and impacts latency-sensitive applications like live video streaming.

- Current approaches either need link-layer feedback which unavailable in closed-source systems, or rely on fixed handover patterns that lack generalizability across regions and constellations.

RESEARCH OBJECTIVES

- To propose a dynamic congestion window algorithm to increase throughput without being affected by LEO satellite handover.

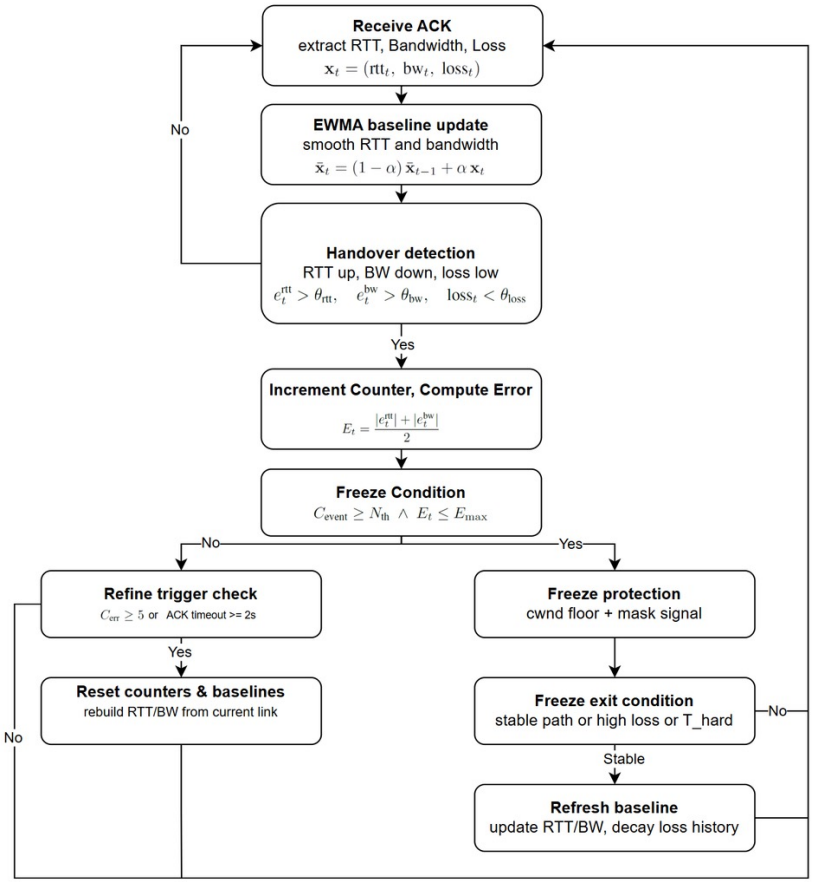
- To propose an adaptive handover detection algorithm to reduce packet loss during LEO satellite handover process by accurately identifying handover events.

- To evaluate the proposed mechanism on key indicators by comparing with existing schemes such as default TCP, QUIC, and StarQUIC.

LITERATURE REVIEW

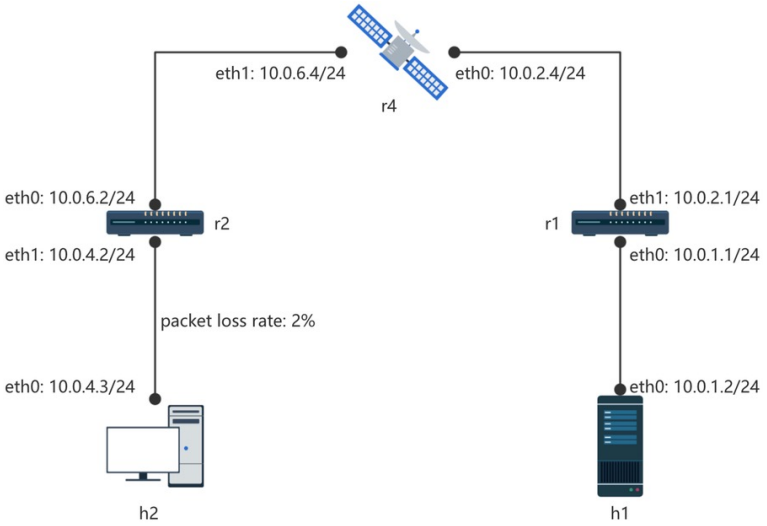
	Method	Results	Limitation
SaTCP (Cao & Zhang)	Predicts handovers via satellite orbit data	Avoids unneeded CC drops before handover	Needs proprietary signaling, simulator-only, no real deployment
QUIC+BBR Evaluation (Wang et al./ Bujari et al.)	Compared BBR vs. CUBIC in QUIC under satellite loss condition	BBR wins on throughput, stability, fairness	No handover awareness and needs satellite-specific tuning
StarQUIC (Kamel et al.)	Freezes cwnd during known Starlink handover times	Reduces QUIC transmission completion time by up to 35%	Relies on fixed Starlink schedule
AHD (Adaptive Handover Detection)	Non-schedule-dependent handover detection algorithm	Benchmarked vs. BBR and StarQUIC	Simulated Environment

METHODOLOGY



IMPLEMENTATION

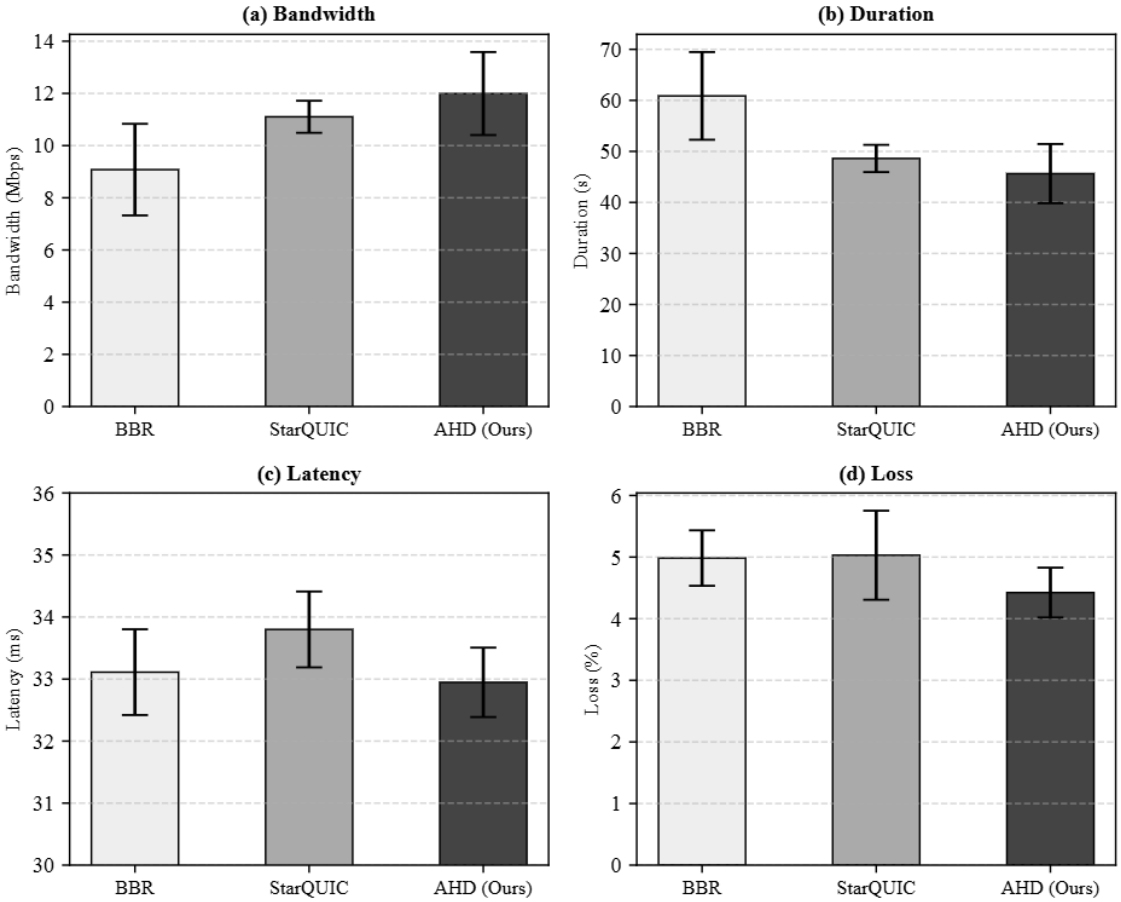
Simulation Setup



Evaluation Setup

- Simulation platform: Mininet with real Starlink measurement traces.
- Evaluated using non-ISL Starlink traces
- Performance evaluation: 256 MB file transferred using BBR, StarQUIC, and AHD

RESULTS



- Bandwidth: AHD shows a 32.11% improvement over BBR and 9.8% over StarQUIC.
- Flow completion time (FCT): AHD is 24.65% faster than BBR, 6.16% faster than StarQUIC
- Latency: All average 33 ms. AHD is marginally lowest.
- Packet loss: AHD lowest at 4.42% - 11% reduction vs. both BBR and StarQUIC

CONCLUSION AND FUTURE WORK

- Proposed Adaptive Handover Detection (AHD) to improve QUIC/BBR performance in LEO satellite networks, which only detects handovers using end-to-end network measurements (RTT, bandwidth, and packet loss) without requiring proprietary satellite information or fixed handover schedules

- Experimental results show the throughput increase 32% over standard BBR, reduction of 11% packet loss and low flow completion time while maintaining low latency.

- Future works:
  - Improve detection accuracy using additional network indicators (jitter, packet reordering),
  - Evaluate AHD on ISL-enabled LEO networks and multiple PoPs
  - Compare with SaTCP and machine learning-based handover detection approaches
  - Validate performance on live satellite networks

UNIVERSITI SAINS MALAYSIA

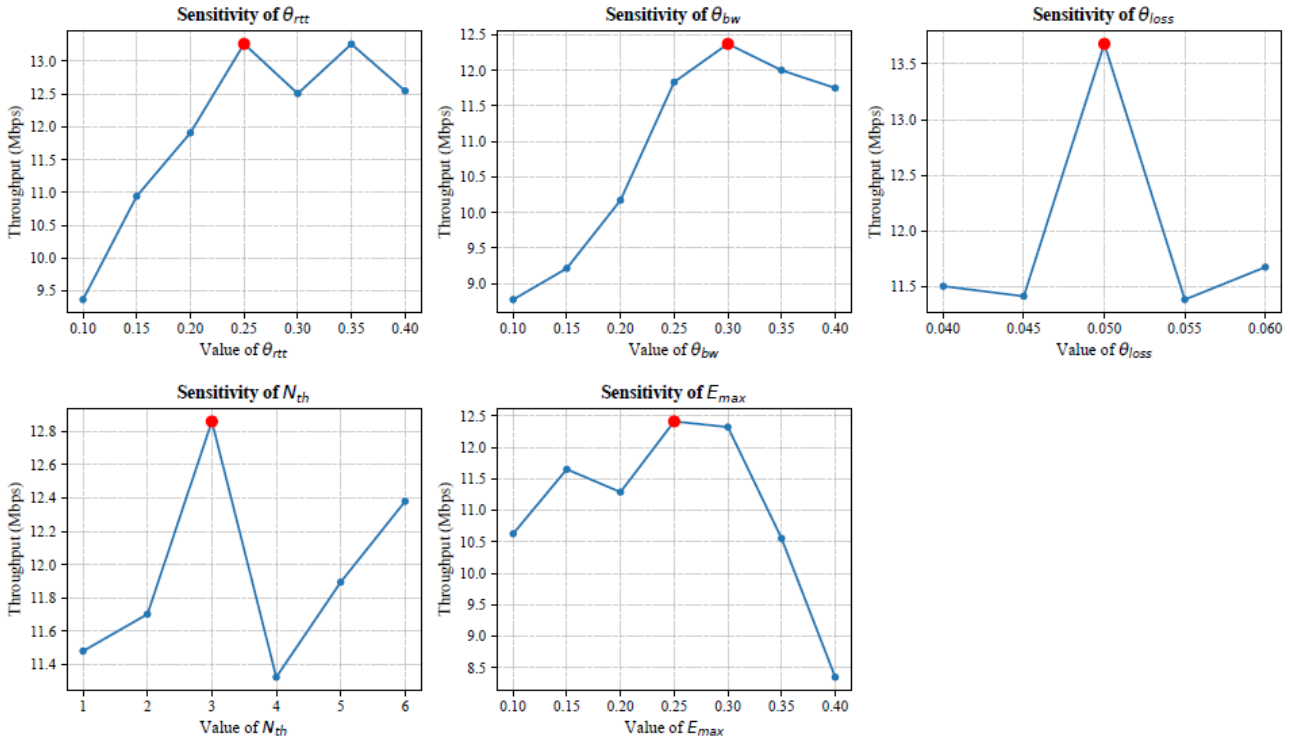
APEX™

ASEAN IVO

Thank You

This work is the output of the ASEAN IVO Phase II project, 'PEP-star: A Performance Enhancing Proxy for Low Earth Orbit Satellite Communications in Disaster-Resilient ASEAN Network Infrastructure' and financially supported by NICT (http://www.nict.go.jp/en/index.html).

Parameter Sensitivity Analysis



ABLATION STUDY RESULTS

TABLE I
ABLATION STUDY RESULTS

Variant	**Bandwidth** (Mbps)	**Packet Loss Rate** (%)
EWMA + Freeze	12.00	4.42
No EWMA	10.29	4.63
No Freeze	9.45	4.91