Enhancing Aeronautical Communication with HIP: Implementation and Evaluation in Future Communication Infrastructure (FCI)

1. Introduction

The **Host Identity Protocol (HIP)** is an advanced networking protocol designed to enhance security, mobility, and flexibility in IP-based networks. HIP achieves this by separating the traditional roles of IP addresses into two distinct functions: host identities and locators. In this framework, each host is assigned a cryptographic identity, known as a Host Identity (HI), which remains constant regardless of the host's network location. This HI is typically represented by a public key, providing a unique and verifiable identity for secure communication between devices. On the other hand, IP addresses are redefined as locators, which indicate the current network location of a host, guiding the routing of data packets. This separation allows HIP to offer significant advantages in dynamic and mobile environments, where hosts may frequently change their network locations. HIP's use of cryptographic identities ensures enhanced security, as hosts are authenticated through Host Identity Tags (HITs), and communication is often encrypted using IPsec. Moreover, HIP supports both mobility and multi-homing, enabling hosts to move between networks or connect to multiple networks simultaneously without disrupting ongoing communication sessions. This makes HIP particularly valuable for applications requiring secure, continuous communication across diverse and changing network environments. Importantly, HIP is designed to be compatible with existing IP-based networks, allowing for gradual integration and deployment without requiring extensive changes to the current infrastructure.
Overall, HIP provides a robust and flexible solution for secure and resilient networking in modern, dynamic environments.

Future Communication Infrastructure (FCI) is envisioned as the next generation of aeronautical communication systems, integrating diverse communication technologies such as **LDACS (L-band Digital Aeronautical Communication System)**,

AeroMACS (Aeronautical Mobile Airport Communication System), and **SATCOM (Satellite Communications)**. These systems must work together to provide continuous, secure communication for aircraft as they transition between different airspaces and network coverage areas. Managing this seamless transition and ensuring secure communication across diverse technologies presents significant challenges.

HIP addresses these challenges by providing a robust framework that decouples host identities from their network locations. This enables secure, seamless communication across different networks, allowing aircraft to maintain uninterrupted connectivity while transitioning between technologies like SATCOM, LDACS, and AeroMACS. This project aims to enhance aeronautical communications' security, resilience, and continuity by integrating HIP into FCI.

2. Project Description

This project focuses on implementing and evaluating the **Host Identity Protocol (HIP)** within the **Future Communication Infrastructure (FCI)** framework, specifically for use in aeronautical communication systems. The project will leverage HIP's capabilities to manage secure, seamless handovers and multi-homing across multiple communication technologies, including **LDACS**, **AeroMACS**, and **SATCOM**.

Students will have the option to use one of two advanced network simulation tools to carry out this project:

1. **CORE Network Emulator:**
    - An interactive platform that allows for the design and testing of network topologies, providing real-time simulation of the interactions between different FCI components. CORE is particularly useful for visualizing and analyzing how HIP manages handovers and multi-homing in a dynamic environment.
    - You need to install CORE: https://www.ida.liu.se/~TDDE21/info/COREInstallUbuntu16.04-20161005.pdf

- Compiling OpenHIP in Ubuntu: See all the branches here: https://bitbucket.org/openhip/openhip/src/master/
- Sample Test of Network Scenario.

The project will involve designing HIP configurations that support seamless handovers and multi-homing, implementing these configurations in the chosen simulation environment, and evaluating their performance under various conditions. The ultimate goal is to assess how well HIP enhances the security, resilience, and efficiency of communication systems in the aviation sector.

3. Project Objectives

1. **Seamless Handover:**
    - Implement HIP to manage seamless handovers between different communication technologies within FCI.
    - Simulate scenarios where aircraft transition between networks like SATCOM, LDACS, and AeroMACS, and evaluate HIP's effectiveness in maintaining continuous communication without interruptions.
2. **Multi-Homing Support:**
    - Enable HIP's multi-homing capabilities, allowing aircraft to connect to multiple networks simultaneously and dynamically switch between them based on real-time conditions and Quality of Service (QoS) requirements.
    - Test and evaluate HIP's ability to manage multiple network connections, ensuring optimal communication performance.

    a. **Secure Communication:**

    - Ensure all communications within the HIP-FCI environment are secure, using HIP's cryptographic methods to dynamically identify and authenticate hosts.
    - Protect data integrity and maintain secure communication channels during network transitions and potential threat scenarios.

4. Project Performance Evaluation

- Evaluate HIP's performance within the FCI environment, focusing on key metrics such as handover latency, session continuity, multi-homing efficiency, and security overhead.
- Compare these metrics to traditional approaches, such as LISP, to assess HIP's benefits in managing dynamic and secure communication across multiple networks.

5. Project Deliverables

1. **Source Code:**
   - Complete source code for the HIP implementation, including seamless handover, multi-homing support, and security mechanisms.
   - Scripts and configuration files required to run simulations in CORE.
2. **Technical Documentation:**
   - User manual detailing how to deploy and test the HIP-FCI system in different network scenarios.
   - Documentation of the integration process between HIP and the FCI components (LDACS, AeroMACS, SATCOM).
3. **Simulation Results and Analysis:**
   - Detailed report on the performance evaluation of the implemented HIP-FCI system.
   - Discussion of results, highlighting the strengths and limitations of the HIP-based approach.

6. Required prerequisites

1. Advanced Python programming skills are essential for developing HIP implementations and running simulations in CORE.

7. Recommended (not mandatory) prerequisites:

1. It would be beneficial to have a basic understanding of networking concepts and knowledge of aeronautical communication technologies (LDACS, AeroMACS, SATCOM).
2. Familiarity with network emulators like CORE is recommended, as these tools will be used to simulate and evaluate the HIP-FCI environment.

8. Papers recommended for reading

1. Kampichler, Wolfgang, et al. "LISP: A novel approach towards a future communication infrastructure multilink service." 2013 IEEE/AIAA 32nd Digital Avionics Systems Conference (DASC). IEEE, 2013.

2. Hu, Yim-Fun, et al. "A SDN-based aeronautical communications network architecture." 2018 IEEE/AIAA 37th Digital Avionics Systems Conference (DASC). IEEE, 2018.