The way to the future has already started: ICAO Aeronautical Telecommunication Network (ATN) using Internet Protocol Suite (IPS) Standards and Protocol evolution update

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Introduction

- Global aviation community is working on standardizing Aeronautical Telecommunication Network (ATN) using Internet Protocol Suite (IPS) Standards and Protocol
- Three mobility solutions under evaluation: Location/Identifier Separation Protocol, Asymmetric Extended Route Optimization and Mobile IPv6 with Extensions
- Communications for aviation dates back to 1920s where AT used colored flags to control takeoffs and landings.
- In 1930s, the Cleveland airport in Ohio was the first to use radio communications for Air Traffic Control (ATC)
- ATC communications technology has experienced many changes since the early days and increased complexity gave rise to new requirements for information exchange
- The modernization and evolution of global aviation requires a transition from analog communications to digital information exchange
- There is an increasing need for critical information exchange over multiple links between air and ground networks
Aviation Operational Networks

The Aircraft Communications Addressing and Reporting System (ACARS)

- Developed by ARINC and in use since late 1970’s for transmission of data only (no voice).
- Data link originally provisioned for services between the aircraft and Airline Operations Centers Systems, later expanded to support Air Navigation Service Providers and the aircraft.
- Airborne system consists of a Control Unit (CU) and a Management.
- Ground subnetwork is made-up of Remote Ground Radio Stations that are connected to a Datalink Service Processor
- Character-oriented
  - Send 7-bit characters
  - Maximum message of 220 characters
- Modulation on VHF band:
  - 2400 bps (bits-per-second) over AM (amplitude modulation) using MSK (Minimum Shift Keying) in the 25kHz channels.
- Aircraft Messages generated automatically based on discrete events e.g. brake release, Out of gate, Off the ground, On the ground, Into gate = OOOI
Aviation Operational Networks

• Based on the OSI reference model
• OSI model divides the communications functions into seven layers.
• ATN design to integrate data communications networks and services.
  – Consists of application entities and communication services that enable ground, air-to-ground, and avionics data subnetworks to interoperate
  – standardizes common interfaces, services, and protocols.
• ATN specified to provide data communications for Air Traffic Services Communication, Aeronautical Operational Control, Aeronautical Administrative Communication and Aeronautical Passenger Communication
Standardization

- 2010 - First publication of ICAO Manual on the Aeronautical Telecommunication Network using Internet Protocol Suite Standards and Protocol - Document 9896
  - Defined data communications protocols and services to be used for implementing ATN using the IPS
  - Provided technical specifications that addressed security, network and transport protocols, described applications
  - Based on IPv6 protocol
- 2015 Document 9896 R2 revised to include VoIP
- Document 9896 undergoing third revision to include mobility, multilink operations, DNS, naming and addressing.
- 2016 - EUROCAE WG-108 and RTCA SC-223 are collaborating in developing
  - Minimum Aviation System Performance Standards
  - IPS Technology Profile - used to provide useful guidance to the technology designers
  - Development use mature and proven IETF RCF standards to addresses both airborne and ground segments
**Proposed Mobility Solutions - LISP**

<table>
<thead>
<tr>
<th>Locator/Identifier Separation Protocol</th>
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<tbody>
<tr>
<td>• Developed by CISCO Corporation – RFC 6830</td>
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<tr>
<td>– Splits address into Endpoint Identifier (EID) and Routing Locator (RLOC)</td>
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<tr>
<td>• RLOC – Interdomain routing</td>
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<tr>
<td>• EID – Intradomain routing</td>
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<tr>
<td>– Overlay Architecture, requires LISP capable routers, uses packet encapsulation, UDP</td>
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<tr>
<td>– Decouples data (EID, RLOC space) and control plane (Mapping System similar to DNS)</td>
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<tr>
<td>– Incremental Implementation</td>
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<td>• LISP based mobility solutions can be derived as follows:</td>
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<tr>
<td>– Aircraft based LISP Mobility</td>
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<tr>
<td>– Ground based LISP Mobility</td>
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<tr>
<td>• Attributes</td>
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<tr>
<td>– Optimized mobility – No anchor points, minimal/scoped state</td>
</tr>
<tr>
<td>– Streamlined load balancing and path preference model</td>
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<tr>
<td>– Guaranteed Packet delivery – Lossless mobility and convergence</td>
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<tr>
<td>– Simplicity of Aircraft functionality (minimal to no additions)</td>
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<tr>
<td>– Global Scale through Modular Design</td>
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<tr>
<td>– Interoperability for Incremental/regional adoption</td>
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<tr>
<td>– Normalized behavior for unicast and multicast with seamless mobility</td>
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Proposed Mobility Solutions - AERO

Asymmetric Extended Route Optimization

- Based on IETF standards and Internet-Drafts
  - Neighbor Discovery, BGP, Standard Encapsulation techniques
  - Overlay architecture (UDP)
- AERO Components - Clients, Proxys, Servers and Relays
  - AERO Clients are Aircraft that connect to data link subnetworks via aviation data links (also ATC/AOC/etc.)
  - AERO Proxys connect data link subnetworks to the ATN/IPS Internetwork, placed at boundaries
  - AERO Servers - BGP routing overlay over the Internetwork, tracks AERO Clients.
  - AERO Relays – COTS BGP Router
- Internetwork is a link that connects all AERO neighbors??
- Scalable by adding server/relay systems.
- AERO supports:
  - IPv6 Neighbor Discovery (ND) protocol
  - dynamic link selection
  - mobility management
  - Multilink
  - quality of service (QoS) signaling
  - route optimization
Proposed Mobility Solutions - MIPv6 with Extensions

- ICAO Document 9896, Version 2 defines the data communications protocols and services to be used for implementing the ICAO ATN/IPS.
- ICAO Document 9896 does not support multilink operations
- The fundamental approach to Mobile IP is packet forwarding
- Mobile Node (MN) has a permanent home address (HoA) and a dynamic CoA that changes as the mobile node changes its point of attachment.
- A Correspondent Node (CN), which can be any peer node an aircraft communicates with, sends packets to the home agent (HA) of the mobile node.
- Aircraft reaches the Home Agent (HA) through normal IP routing.
- Upon receipt of a packet from the CN (e.g. AT Control), the HA forwards these packets to the MN at its current CoA.
- The HA tunnels the original packet in another packet with its own source address and a destination address of the current CoA
- Mobile IPv6 with Multiple CoA: Extensions to bind more than one CoA to a HoA
- Mobile IPv6 with Flow Bindings: is used to identify a particular flow which is bound to one or more CoAs
Emerging Operational Concepts

• Voice Air-Ground Communications, the DOC 9896 provides the VoIP requirements only on the ground part of the existing VHF A/G communication infrastructure
• Unmanned aircraft fast evolution increasing demand for RPAS to operate in non-segregated airspace and at aerodromes.
• Small Unmanned Aircraft Systems (sUAS) vehicles are proliferating and regulation has been develop to enable safe operations.
• Unmanned Traffic Management (UTM) concepts to enable safe, efficient and organized use of airspace for altitudes between 0 and 400 feet
• Urban Air Mobility (UAM) is a NASA project that will investigate and develop technologies for airspace and vertiport management with the intent to enable urban missions by small electrified vehicles
Conclusions

• Need to enable seamless dissemination of information over diverse sub-networks
• ATN/IPS will enable mobility, multi-link, multi-homing, multi-service, end-to-end interconnectivity and support the integration of new vehicle types navigating existing and emerging airspace configurations
• Global aviation will eventually transition to a native IPS system.
• ATN/IPS will meet the challenging needs of different airspace users, vehicle types and enable continued aviation advances well into the future