# Characterizing Satellite-Based Communications to provide Seamless and Effective Transoceanic Data Dissemination

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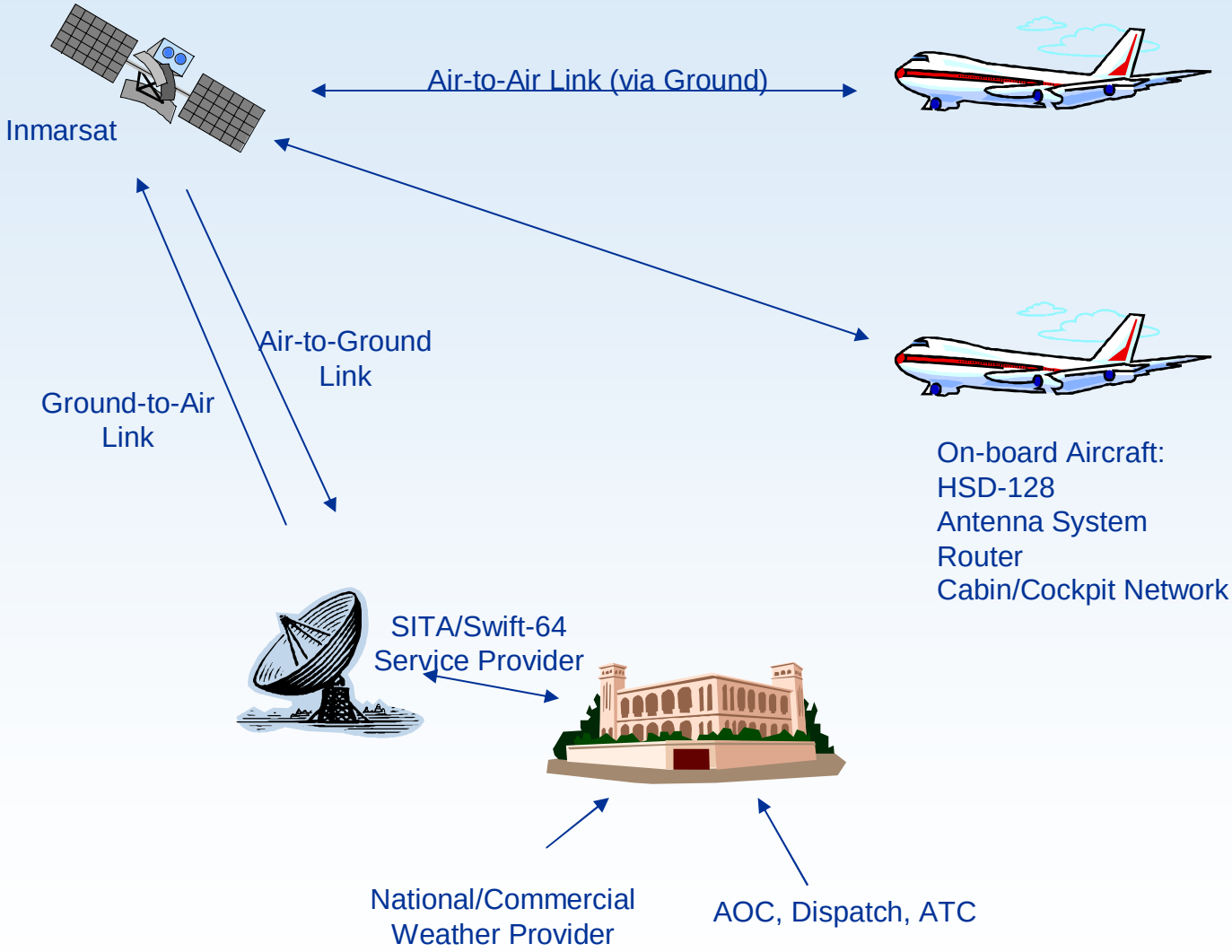
# Introduction

- Part of the International/Oceanic Scenario
  - Involves flights over the oceanic regions where communications are limited and weather information and dissemination is minimal.
- The International/Oceanic Scenario is part of WINCOMM and the Aeronautical and Satellite Communications Research (ASCR) Group.
- ***WINCOMM Goal:*** Provide advanced communications and information technologies that provide for the efficient dissemination of weather and turbulence products.
- ***ASCR Goal:*** Advance satellite-based communications for future aeronautical systems.
  - Leverage existing terrestrial technologies and applying open-based standards and systems.
  - Co-led by Ohio Aerospace Institute (OAI) and NASA/GRC.
  - The Aeronautical and Satellite Communications Project Plan is in development.

# Research Status

- Provide a project update of the transoceanic scenario for the past year.
- Development of an Aeronautical Testbed
  - Leverage existing terrestrial infrastructure including the Internet Protocol (IP)
    - Determine the advantages of using open source technologies
  - Starting with weather data and turbulence messages.
  - Eventually implement safety services of a packet-based service (e.g., Swift-64)
    - Reliability and Availability.
    - Recognize the existing infrastructure, ATN, does support safety services.
- Delineation of the Quality of Service (QoS) schemes and algorithms.
  - Test the schemes for efficient separation of cabin and cockpit services in the on-board aircraft network.

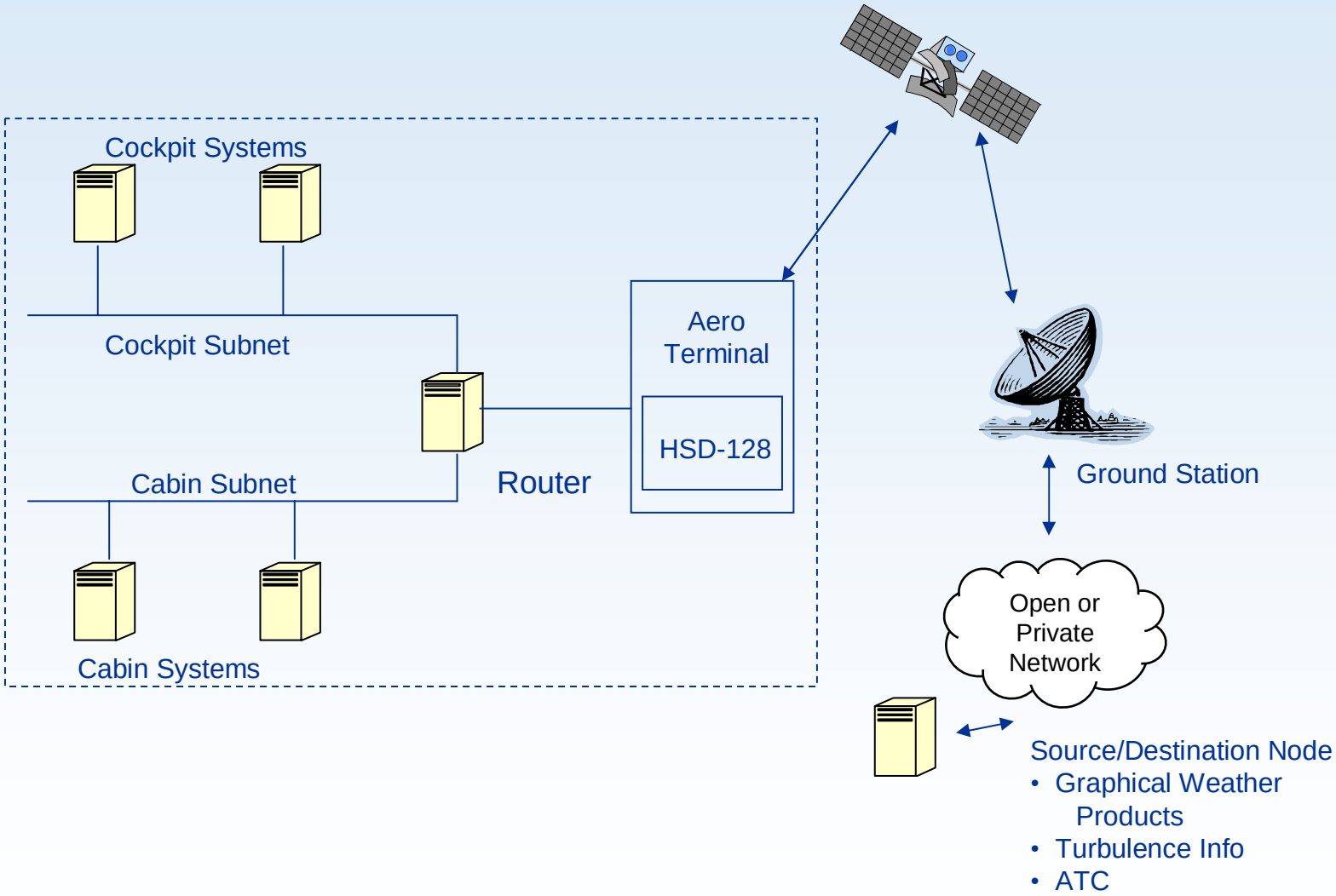
# International Oceanic Architecture



# Testbed

- The airborne testbed environment reflects a typical on-board network configuration.
  - Leverages Internet-based/Open-Source technologies
    - Linux-based routers
    - Workstations/Distributed Networking
- Configure standard QoS algorithms for efficient data sharing without implementing proprietary solutions.
  - Single Aircraft/Local Area Network (LAN) Environment
  - Multi-Aircraft/Wide Area Network (WAN) Environment
- Provides an path for integrating technologies into an operational network.
  - Real equipment including the Aeronautical Terminal, Data Link with Inmarsat Access.

# WINCOMM Testbed Configuration



# Testbed Configuration

- On-board network
  - HSD-128 - A two-channel aeronautical terminal that provides Inmarsat/Swift-64 services to the aircraft.
    - In process of upgrading for the I4/Swift-BB services.
  - Router - provides the same functions as a terrestrial router by moving data to the correct subnet (cabin or cockpit)
  - Subnets - separates the cockpit and cabin data flows.
  - Workstations - represents computers and avionics that will be in the cockpit and cabin.
- Other parts of the testbed include:
  - Inmarsat Satellite Constellation
  - SITA (Inmarsat Service Provider)
  - Source/Destination Node.

# Quality of Service (QoS)

- What is Quality of Service (QoS)
  - Defined as the ability for an application to obtain the network service it requires for successful operation.
- Why QoS?
  - For transoceanic scenario, QoS will be essential for network management.
  - To ensure priority is given to cockpit related traffic for on-demand service
    - Packets could be prioritized or pre-empted.
  - Dynamically reallocates bandwidth for critical traffic while limiting non-critical traffic
  - Reduces delay of cockpit data
  - Minimizes packet loss

# QoS Schemes

- Why Linux based algorithms?
  - Open source
  - Source code is available for examination and modification
- Linux handles QoS or traffic management in two ways
  - Queuing: deals with how packets are handled on a device.
  - Filters: organize packets based on properties such as port numbers, IP headers, IP addresses, etc
- There are two basic QoS Schemes available
  - Integrated Services
  - Differentiated Services

# QoS Schemes - Integrated Services

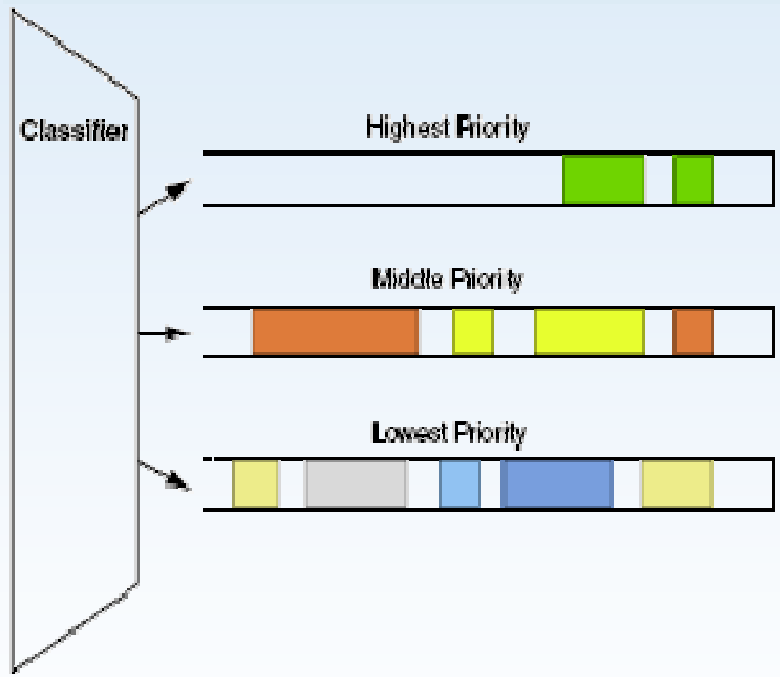
- Developed by the IETF IntServ working group
- A reservation-based approach
  - Circuit Switched
- Provision true *end-to-end* QoS on a per-flow basis
  - Enables end-to-end QoS guarantee.
- It operates on per-flow basis
  - More state information to be maintained (resource intense)
- The more concurrent flows on the network, the higher the complexity introduced.
- IntServ could have scalability issues on large networks.

# QoS Schemes - Differentiated Services

- Developed by the IETF DiffServ working group.
- Classify and mark individual packets of an application flow to indicate class of service (COS).
  - Helpful to differentiate cockpit data from cabin data
- Uses the extended Precedence field in the IP packet header to store the COS for the packet.
- Network layer devices use each packet's COS as the indication of the treatment the packet should receive.
- Focus on QoS provisioning across a *single domain* and not *end-to-end*
- The two main service levels of DiffServ
  - Expedited Forwarding (EF): Applications that require a guarantee on delay and jitter.
  - Assured Forwarding (AF): Applications that require a better reliability that best-effort service.

# Flow Classification

- There are different methods of identifying packets in order to provide differential treatment
  - Some classification criteria
    - Protocol
    - Address
      - Source IP Address
      - Destination IP Address
    - Port Number
      - Source port
      - Destination port
    - Incoming interface
    - Type of Service
    - Virtual circuit number
    - DSCP (DiffServ Code Point)



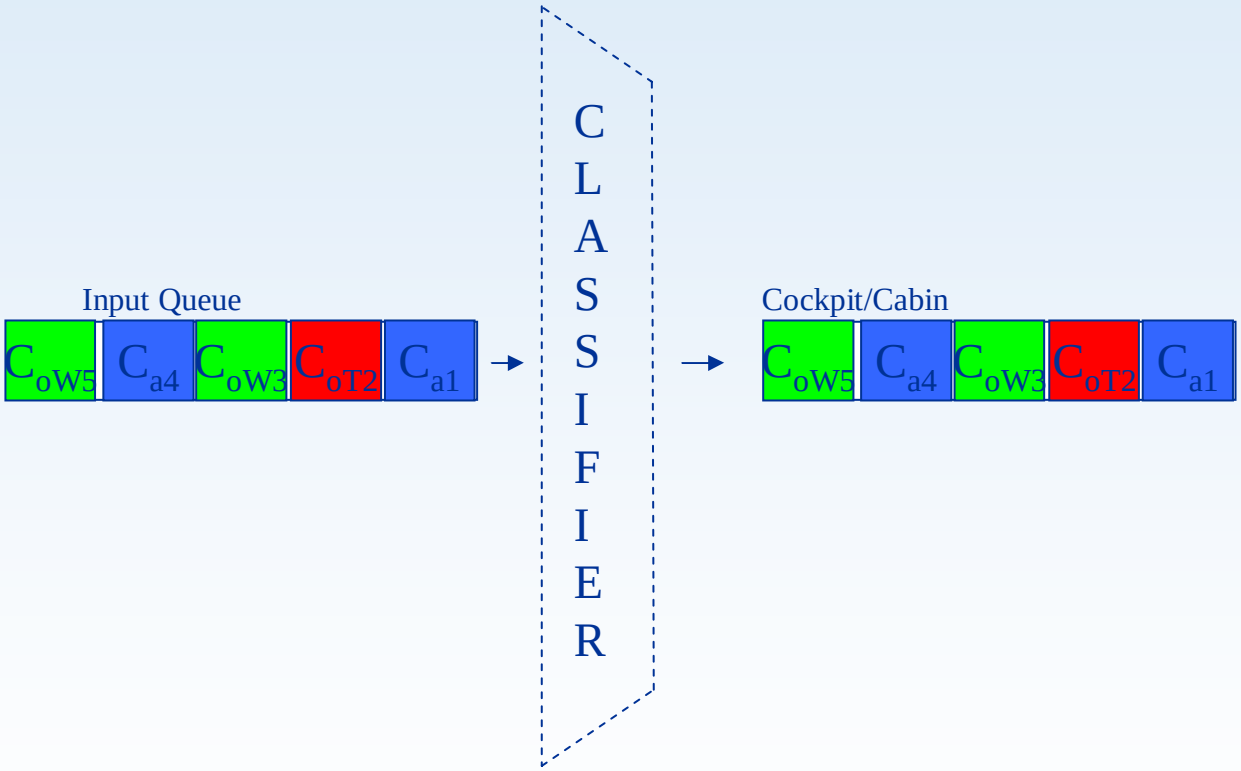
# Queuing Schemes in Linux

- Queuing and Scheduling methods were developed to handle traffic when it arrives during times of restricted capacity.
- The following queuing schemes will be evaluated
  - First-In, First-Out (FIFO) Queuing
  - Priority Queuing (PQ)
  - Fair Queuing
  - Weighted Fair Queuing (WFQ)
  - Class-Based Queuing (CBQ)

# First-In, First-Out (FIFO) Queuing

- Concept
  - Only one queue is maintained.
  - Packets are stored in the queue in the same order of arrival.
  - Does not account for priorities or other filtering mechanisms.
- Advantage
  - Easy to implement.
- Disadvantage
  - Does not handle any prioritization schemes.

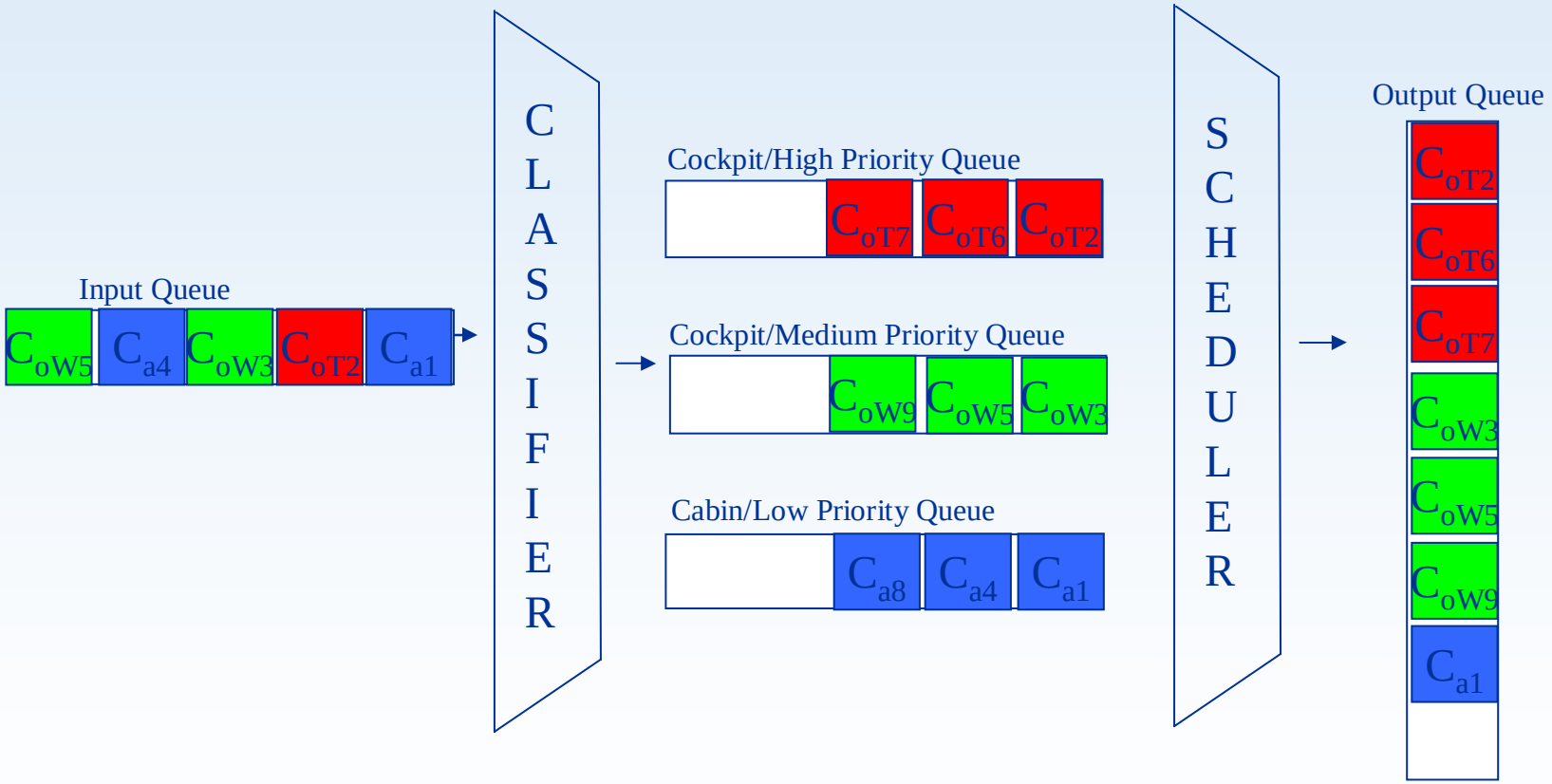
# First-In, First-Out (FIFO) Queuing



# Priority Queuing (PQ)

- Concept
  - Multiple output queues are maintained.
    - One for each priority.
  - Outgoing queue will take the packets from the highest priority queue until that queue is empty. Then the packets will be request from the next highest priority queue.
- Advantage
  - Higher priority packets will get processed sooner.
- Disadvantage
  - Lower priority queues have the potential of being starved.

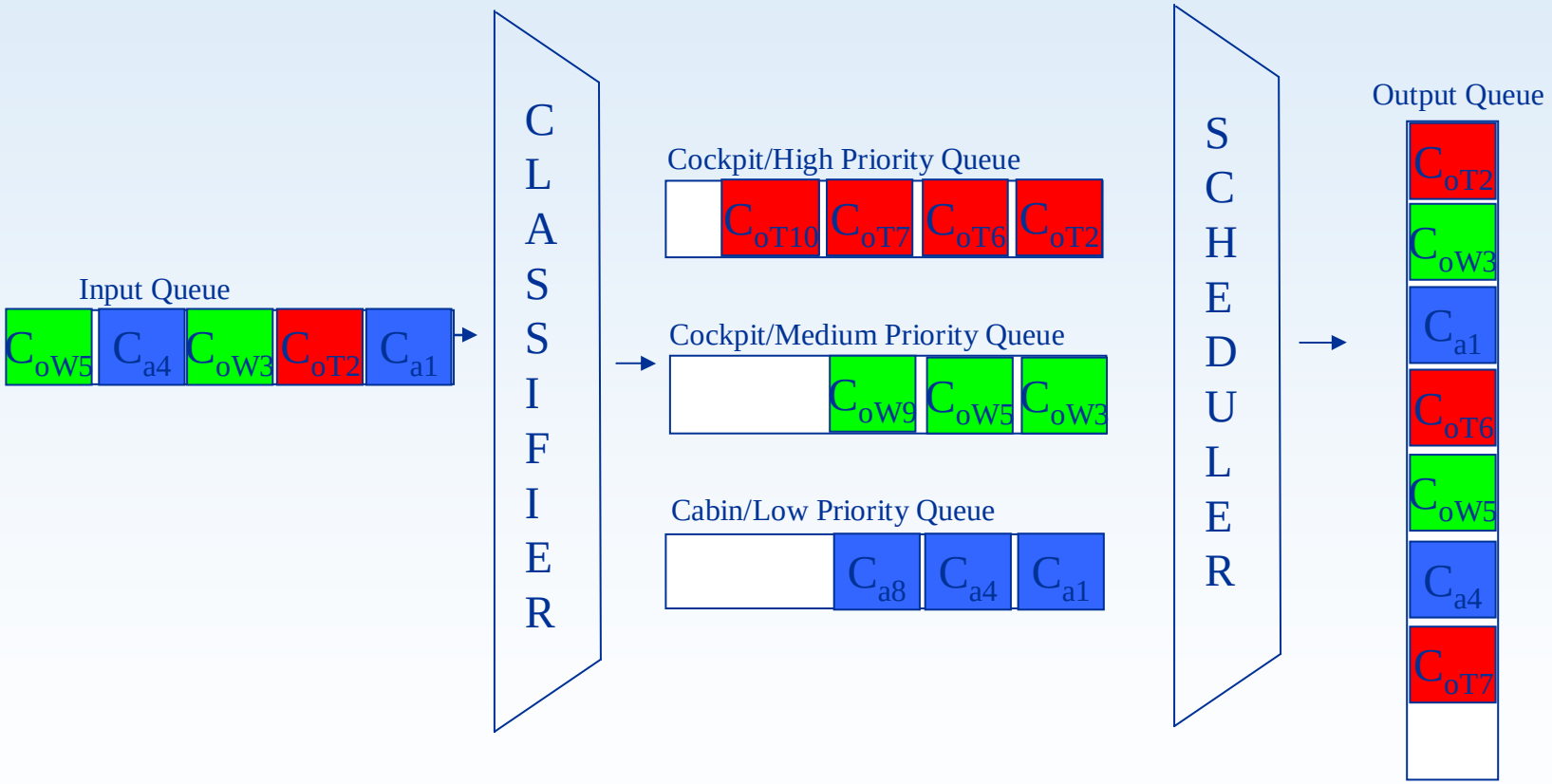
# Priority Queuing (PQ)



# Fair Queuing (FQ)

- Concept
  - Multiple output queues are maintained.
    - One for each priority.
  - Packets are removed from each queue in a round-robin methodology.
- Advantage
  - Improves fairness by implement round-robin retrieval
    - No starvation among the data queues.
- Disadvantage
  - Fair Queuing is not applicable for our application.

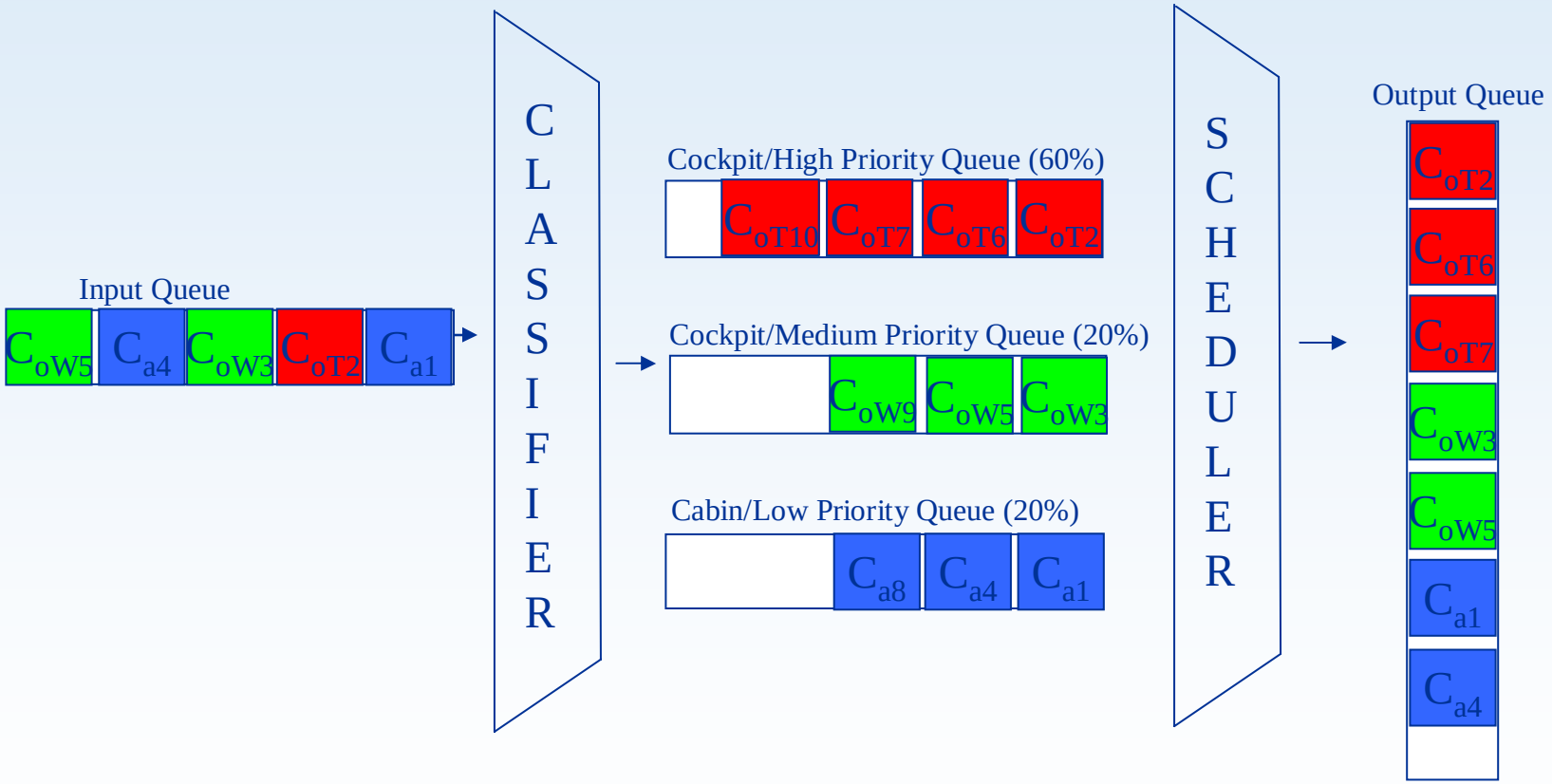
# Fair Queuing



# Weighted Fair Queuing (WFQ)

- Concept
  - Multiple output queues are maintained.
    - One for each priority.
  - Each flow is assigned a weight.
  - Packets are removed in a weighted round robin fashion.
- Advantage
  - Dynamically allocate bandwidth to high-priority users.
    - No starvation among the data queues.
- Disadvantage
  - Significant processing overhead.

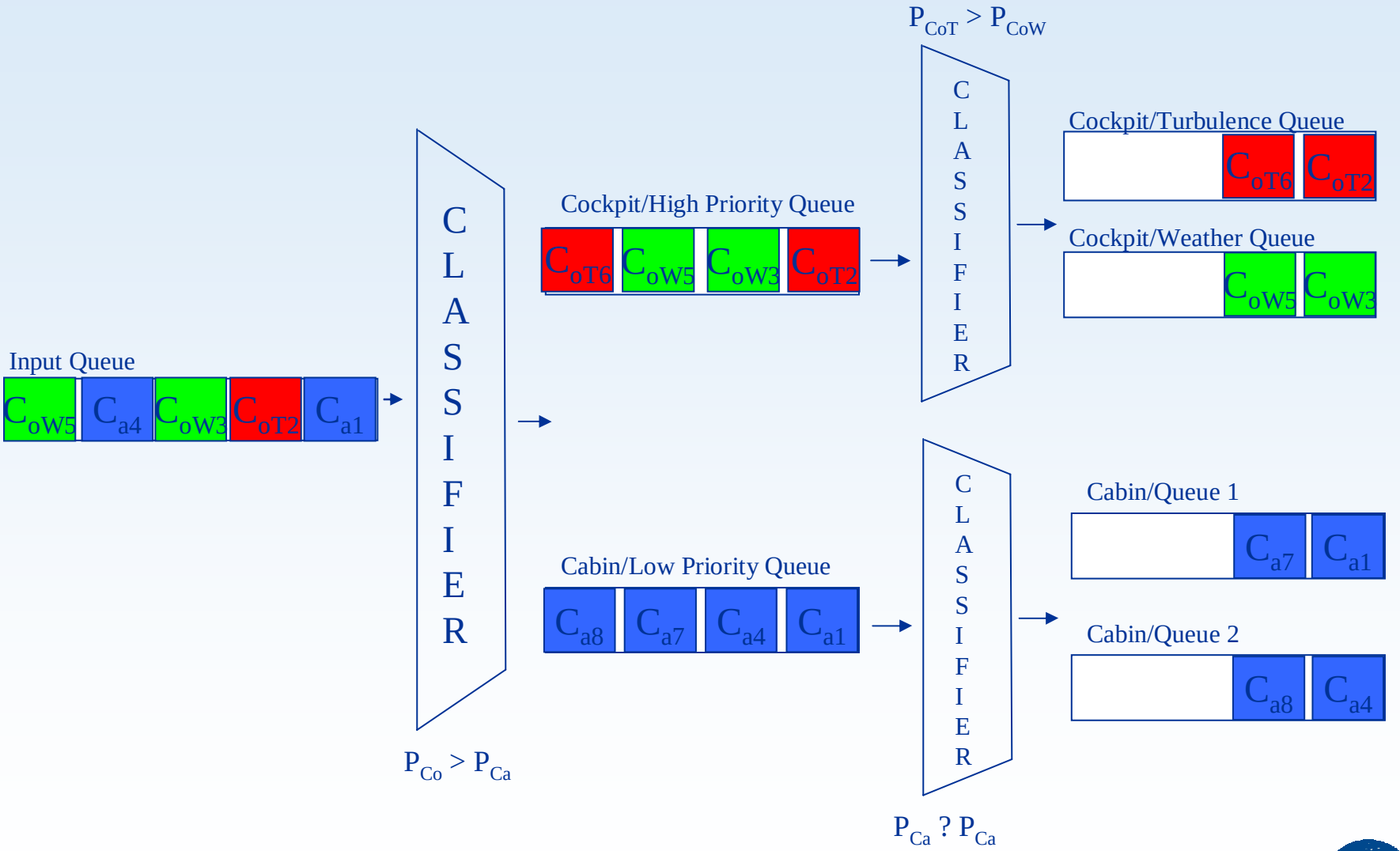
# Weighted Fair Queuing (WFQ)



# Class Based Queuing (CBQ)

- Concept
  - Multiple output queues are maintained.
    - One for each priority.
  - Can have multiple class to allow for different levels of prioritization.
  - Uses a weighted round robin approach where multiple packets can be removed from each queue.
- Advantage
  - Highly flexible scheme.
- Disadvantage
  - Complex

# Class-Based Queuing (CBQ)



# Future Directions

- Upgrade Communications Services to I4
  - Inmarsat is launching the I4 satellites that will provide Swift-BB services.
    - Data rates up to 432 kbps.
    - First launch was in ‘05.
  - Working with commercial companies to beta test the Inmarsat I4 services.
- Evaluation of Safety Services using IP Technologies
  - Evaluating the use of Swift-BB
  - Currently, Inmarsat is not approved for safety services
    - Attain approval by ~2010.
- Implementation of a Ground Station into the Testbed
  - Provide the testbed with changing ground station software “on-the-fly”
  - Currently, must have agreements and concurrence between multiple parties.

# Contact Information

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