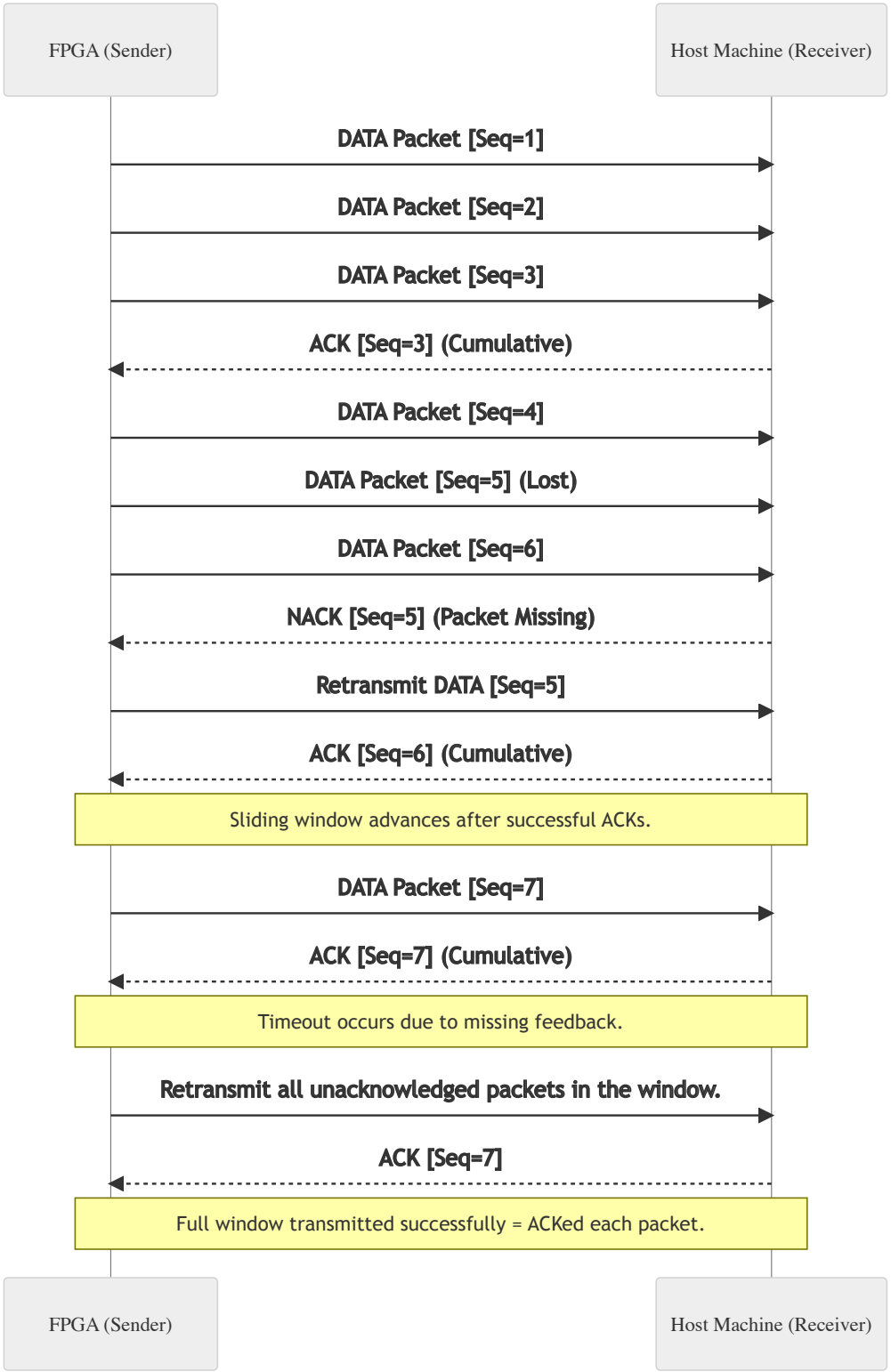
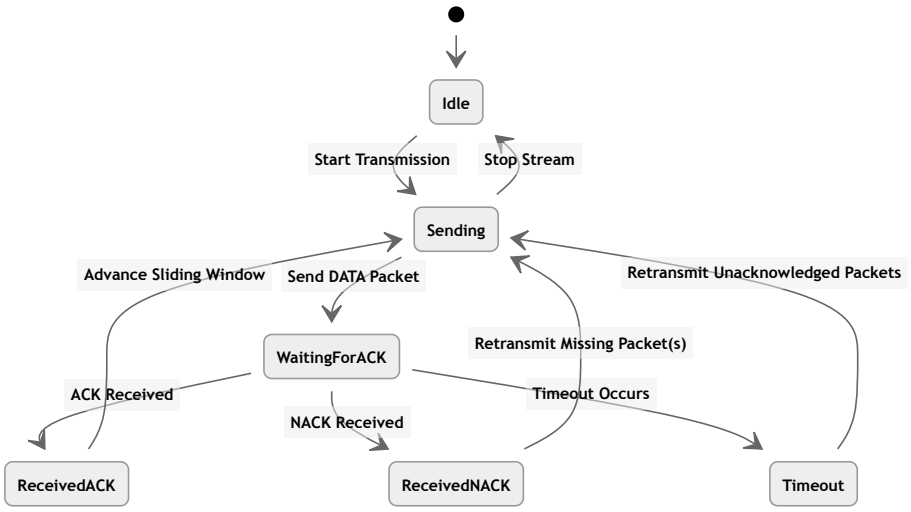
ICD for RFSoC I-Q High-Speed Streaming Protocol

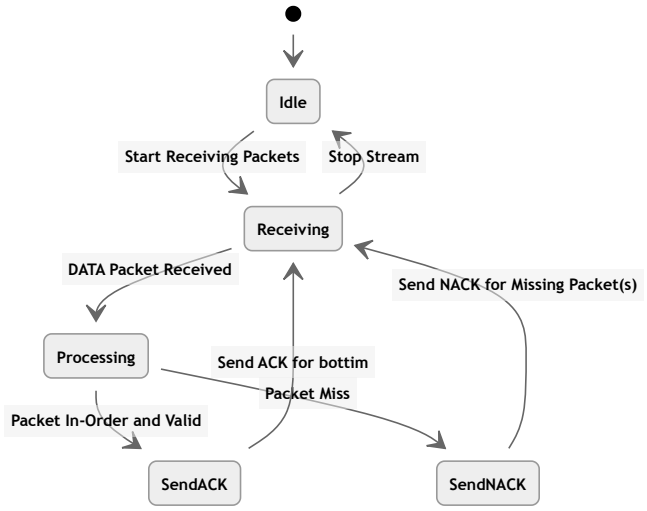
Example Sequence Diagram



Sender State Diagram



Receiver State Diagram



Interface Control Document (ICD) for LAN Streaming Protocol

1.0 Scope

This document defines the interface between an FPGA capable of transmitting UDP packets and a host machine with an SFP28 interface. The protocol ensures reliable data transmission using a sliding window mechanism with acknowledgments (ACKs) and negative acknowledgments (NACKs). It specifies the message structure, data flow, and error recovery mechanisms.

2.0 System Description

2.1 FPGA System Overview

- **Role**: Sender
- **Functionality**: Transmits data packets over UDP using a sliding window protocol.
- **Interface**: SFP28 connection to the host.
- **Capabilities**:
    - Assigns sequence numbers to packets.
    - Maintains a buffer for retransmission.
    - Sends ACKs and NACKs based on received feedback.

2.2 Host Machine Overview

- **Role**: Receiver
- **Functionality**: Receives packets, processes them in order, and provides feedback (ACK/NACK).
- **Interface**: SFP28 connection to the FPGA.
- **Capabilities**:
    - Maintains a receive buffer.
    - Detects missing or out-of-order packets.
    - Sends ACKs for successfully received packets and NACKs for missing ones.

3.0 Detailed Interface Requirements

3.1 Data Protocol

- **Protocol**: UDP with sliding window reliability enhancement.
- **Packet Structure**:
    - **Header Fields**:
        - Sequence Number (32 bits): Unique identifier for each packet.
        - Window Size (16 bits): Indicates the current sliding window size.
        - Control Flags (8 bits): Identifies packet type (DATA, ACK, NACK).

        - Checksum (16 bits): Ensures data integrity.
    - **Payload**:
        - Variable-length data up to the maximum transmission unit (MTU).

3.2 Sliding Window Mechanism

- **Window Size**: Configurable, default is 64 packets.
- **Operation**:
    - Sender transmits packets within the current window range without waiting for individual ACKs.
    - Receiver acknowledges the highest consecutive sequence number received correctly using cumulative ACKs.
    - Gaps in sequence numbers trigger NACKs for specific missing packets.

3.3 Error Recovery

- **Retransmissions**:
    - Upon receiving a NACK, the sender retransmits the specified missing packet(s).
    - Retransmissions are attempted until an ACK is received or a timeout occurs.
- **Timeout Mechanism**:
    - If no feedback (ACK/NACK) is received within a predefined timeout period, the sender retransmits all unacknowledged packets in the current window. It will attempt this three times, before abandoning the connection.

3.4 Communication Flow

1. Receiver sends a Start Stream Command, with a Sliding Window Range.
2. Sender initializes transmission by sending packets within the sliding window range.
3. Receiver processes incoming packets:
    - When the Sender receives a packet, it adds to its sliding buffer
    - If the received packet is at the bottom of the sliding window and there are no empty packets between bottom and top, then Receiver sends and ACK for top of window.
    - Otherwise, sends a NACK for any missing packets.
4. Sender adjusts its window based on feedback:

    - Advances the window upon receiving ACKs.
    - Resends missing packets based on NACKs.

4.0 Physical Requirements

- **Interface Type**: SFP28 transceiver supporting Ethernet at up to 25 Gbps.
- **Cable Type**: Direct Attach Copper (DAC) or optical fiber as per system requirements.

5.0 Data Integrity

- **Data Integrity**: Ensured through checksums in each packet header.

6.0 Testing and Validation

- Simulate high packet loss scenarios to test retransmission mechanisms.
- Validate proper operation of sliding window adjustments under varying network conditions.

Appendix A: Glossary

- **SFP28**: Small Form-factor Pluggable module supporting up to 25 Gbps Ethernet connections.
- **UDP**: User Datagram Protocol, a connectionless transport protocol.