Optical Data Interface
ODI-2 Transport Layer
Preliminary Specification

Revision 2, Date 180420

The ODI Specification is managed by the AXIe Consortium.
For more information about ODI, go to http://axiestandard.org/odispecifications.html
For more information about the AXIe Consortium, go to http://axiestandard.org

ODI 3-part Specification

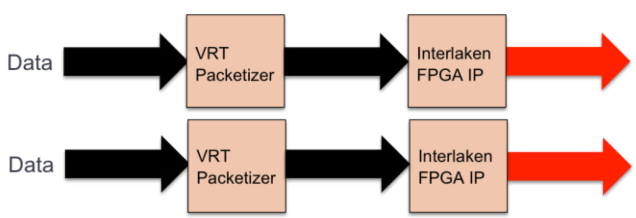
ODI-2.1: High-Speed Formats

- 8 to 16 bit data formats
- Packing Methods
- Optimized for SDR & 5G

. . .

Data Formats

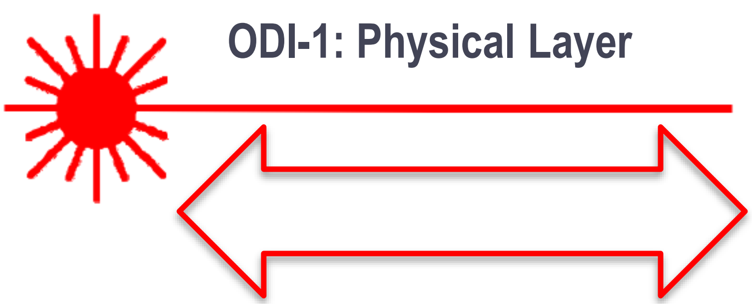
ODI-2: Transport Layer



- VITA-49 “VRT” Packets
- FPGA Optimized
- Port Aggregation
- Context Packets

Transport Layer

ODI-1: Physical Layer



- 12 lane multimode optics
- 12.5 & 14.1 Gb/s
- Interlaken Protocol
- Flow Control

Physical Layer

ODI-2 Scope

- ODI-2 defines the transport layer of the Optical Data Interface (ODI) specification. The ODI-2 Transport Layer sits one level higher than the ODI-1 Physical Layer, and defines the packet structure for sending data from a producer to a consumer. ODI-2 also uses the packet structure to aggregate optical ports together for higher aggregate bandwidth. Any data may be streamed using ODI-2, while the next layer higher, ODI-2.1, defines specific data formats for high speed sample streaming.

- Packet definitions are based on VITA 49.2-2017, also known as the VITA Radio Transport Standard, and is commonly abbreviated as VRT.

- The transport layer includes:
  - VRT packet rules
  - VRT packet definition for arbitrary block data
  - ODI Port aggregation

ODI-2 Compliance

- RULE: All implementations of of this specification SHALL comply with all the rules in this specification.
- RULE: All implementations of of this specification SHALL comply with all the requirements in the Interlaken Protocol Definition, Revision 1.2 or later.
- RULE: All implementations of of this specification SHALL comply with all the requirements in the VITA 49.2-2017 VITA Radio Transport (VRT) standard
- RECOMMENDATION: All implementations of of this specification SHOULD comply with all the recommendations in this specification.
- RULE: All implementations of of this specification SHALL clearly specify any and all deviations from the recommendations in this specification.
- RULE: All implementations of of this specification SHALL comply with the documentation requirements of this specification

Glossary - 1

- Device
  - An assembly that generates or receives data and has one or more optical ports
- Port
  - A single optical connector on a device, and the associated electronics
- Cable
  - A multiple fiber cable that connects between two ports
- Link
  - A unidirectional connection between two ports, consisting of 12 lanes of multimode optical transmission. A bi-directional connection has two links, one in each direction.
- Producer
  - ODI device that generates data to be sent over one or more optical ports
- Consumer
  - ODI device that receives data sent over one or more optical ports
- Transmitter
  - Interlaken term for a producer
- Receiver
  - Interlaken term for a consumer. VITA term for an RF receiving device.
- Emitter
  - VITA term for a producer.
- Exciter
  - VITA term for an RF signal generator

Glossary - 2

- Interlaken
  - Interlaken is the name of a chip-to-chip interface specification that is used by ODI to transfer packets between two ODI ports. It is the primary communication protocol. Separately, the packet structure sent over Interlaken is defined to be VRT, defined in the ODI-2 specifications.
- VRT
  - VRT is an abbreviation for VITA Radio Transport, standardized in VITA 49.2, and enhanced by other VITA 49x specifications. VRT specifies the structure and behavior of VRT packets, which carry data, context, and control information about signals, and the data stream itself. VITA 49 may be abbreviated as V49, as VITA 49.x may be abbreviated as V49.x
- Channel
  - "Channel" is used differently in Interlaken specifications than is commonly understood in operational or instrumentation systems as a signal channel.
  - Channel is used by Interlaken to enable a completely different data stream with its own flow control. ODI generally uses only a single Interlaken channel.
  - Channel is used by VRT similarly to instrumentation systems.
  - Synchronous instrumentation channels are encoded into the VRT stream in a rotating sequence, and are referred to as a "sample vector" in VRT parlance. VRT Sample Vector Size field is the number of instrumentation channels minus 1. This assumes synchronous channels, all at the same data rate and resolution.

Glossary - 3

- Word
  - An Interlaken Word is 8 bytes (64 bits)
  - A VRT Word is 4 bytes (32 bits)
- Burst
  - In Interlaken, data is divided into data bursts, each delineated by one or more burst control words.
- BurstMax
  - An Interlaken parameter that determines the maximum number of data bytes sent for each burst. Typically, streaming data will be set with these burst lengths. ODI allows 256 and 2048 byte BurstMax.
- BurstShort
  - An Interlaken parameter that reflects the shortest burst allowed.
- BurstMin
  - An Interlaken parameter for the Optional Scheduling Enhancement that guarantees all packets are at least BurstMin in length, and no idle control words will be needed for long packets.
- Packet
  - A packet refers to the block of data sent between Interlaken SOP and EOP (Start of Packet and End of Packet) indicators. At the Interlaken layer, the format of the packet is unknown. ODI-2 has defined the packet to be VRT packets. The term packet within ODI refers to both.

Glossary - 4

- Prologue
  - The Prologue refers to fields within a VRT data, context, or command packet that precede the data payload or context/command data payload respectively. A standard 28-byte Prologue is defined for each packet type.
- Trailer
  - The Trailer refers to the 4-byte field that follows the data payload within a VRT Data packet. There is no trailer associated with Context Packets or Command Packets.
- Processing-efficient packing
  - Processing-efficient packing refers to a data packing method within the VRT Packet data payload where the packed data is aligned to 32-bit boundaries.
- Link-efficient packing
  - Link-efficient packing refers to a data packing method within the VRT Packet data payload where the data is packed as tightly as possible, leading to the highest sample density and speed.

Glossary - 5

- Stream
  - A VRT term for a sequence of related packets. All packets of the same stream have the same Stream ID sent from the producer. A typical stream has consecutive Signal Data Packets, with optional Context Packets and/or Command Packets occasionally.

- Signal Data Packets
  - VRT term for a packet carrying digitized samples of one or more signals. This is the primary packet type of ODI. Most ODI systems will only include Signal Data Packets.

- Context Packet
  - VRT term for a packet carrying meta-data or "context" data related to the digitized signals in the same stream. This may include information such as reference level or sampling rate. Context Packets are optional in ODI, but a standard Context Packet is defined in ODI-2.1 if used.

- Command Packet
  - VRT term added in V49.2. Command Packets are used to control devices, and the control and acknowledgement process. The Control Packet is the only recommended Command Packet subtype, and has the same field types as the Context Packet, which are used for control. Control and other Command Packets are optional in ODI, but a standard Control Packet is defined in ODI-2.1 if used.

Glossary - 6

- Extension Packet
    - Extension Signal, Context, and Command packets are used when it is impossible to use the pre-defined data types. An example may be the sending of encrypted data.
- Train
    - For streaming applications, the Train refers to a series of packets, typically of the same size, sent sequentially from a producer, but not including the final packet, called the Caboose
- Caboose
    - For streaming applications, the Caboose refers to the final packet sent from the producer. It may or may not be the same size as the Train packets.
- Sample Vector
    - A Sample Vector is defined within V49.2 as a collection of synchronous Data Samples. This is the common method of transporting multi-channel sample data within the VRT data payload fields. Vector size describes the number of channels. However, the VRT Vector Size Field, used in V49.2 and ODI-2.1, is calculated as the vector size minus one. Therefore a two-channel stream has a vector size of two, but a Vector Size Field of 1.

ODI-2 What is it?

- ODI-2 specifies the transport layer for one or more ODI ports specified in ODI-1 Physical Layer. The transport layer includes definition of the packet structure, which is largely based on the VITA 49.2 VITA Radio Transport (VRT) standard. ODI-2 specifies how V49.2 functionality is translated into ODI, while ODI-2.1 specifies standardized packets and data formats. ODI-2 also uses the packet structure to aggregate ports, allowing several ODI ports to combine their bandwidth into a single stream.

- ODI-2 defines a number of methods and requirements to allow VRT packets to be processed efficiently by FPGA-based devices. This includes mandated fixed-length “Prologue” and “Header” fields, and that all packets be a multiple of 32 bytes in length. The latter may be achieved using null data if needed.

- Along with VRT Signal Data Packets, ODI-2 also describes the operations for VRT Extension Data Packets, Context Packets, and Command Packets. Context and Command Packets are typically used to describe or control metadata about the signal stream.

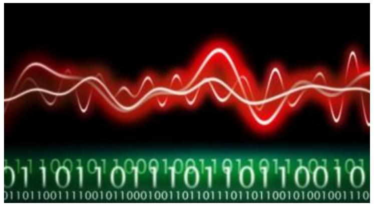
- ODI-2 specifies the rules for aggregating ports. ODI ports are aggregated by synchronizing the packet transmission from each of the ports being aggregated. Each port sends a VRT data packet at the same time. Interlaken SOP (Start of Packet) signals are combined with VRT Prologue data to synchronize the packets.

- ODI-2 does not specify the content and data formats of the data. However, ODI-2.1 specifies the data formats for 8-bit to 16-bit multi-channel sample data.

ODI-2 Packet Specifications

Packets are fundamental to ODI

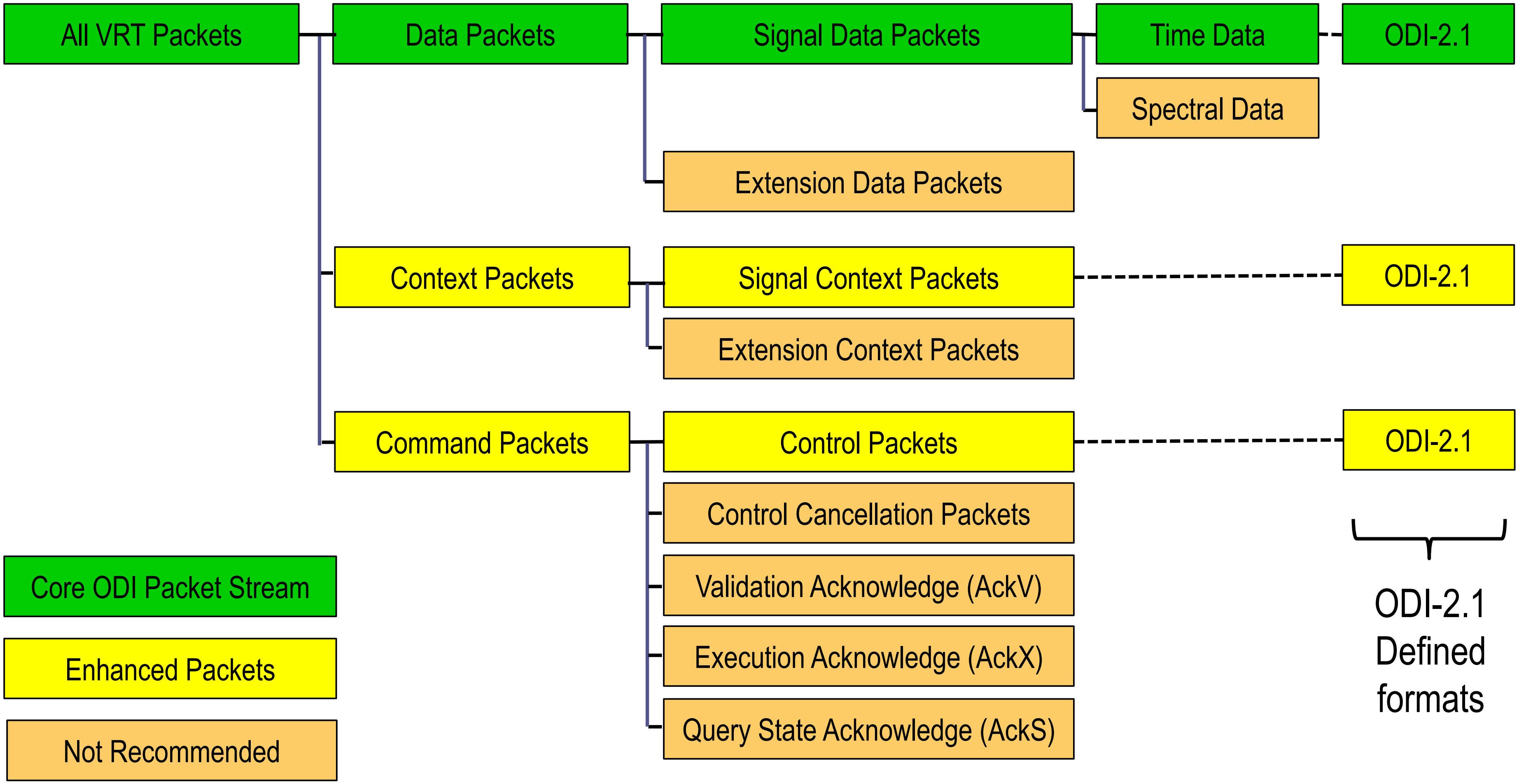
VITA 49 "VRT" Data Packets



- VITA Radio Transport
- Standard data formats
- Multiple channels
- Storage framing
- SDR compatible

- Packets are bracketed by Interlaken SOP and EOP signals
- Packets contain single channel or multi-channel sample data
- Packet boundaries allow for error recovery
- Packets allow port aggregation and synchronization
- Consecutive packets are sent to stream data
- All data is stored as packets
- Packets are independent of the underlying transmission method
- Packets are compliant with VITA 49.2 standard

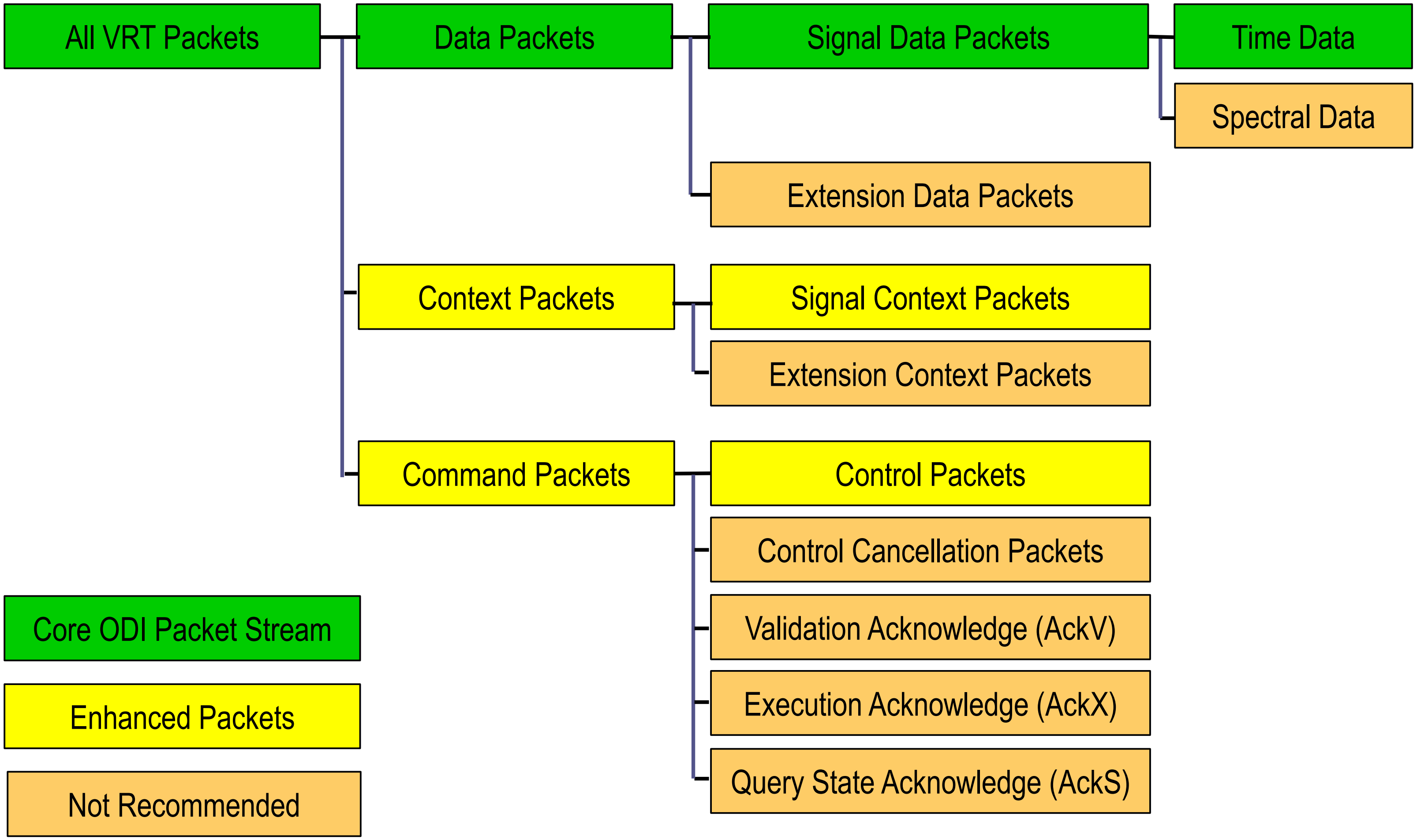
VRT Packet Hierarchy for ODI



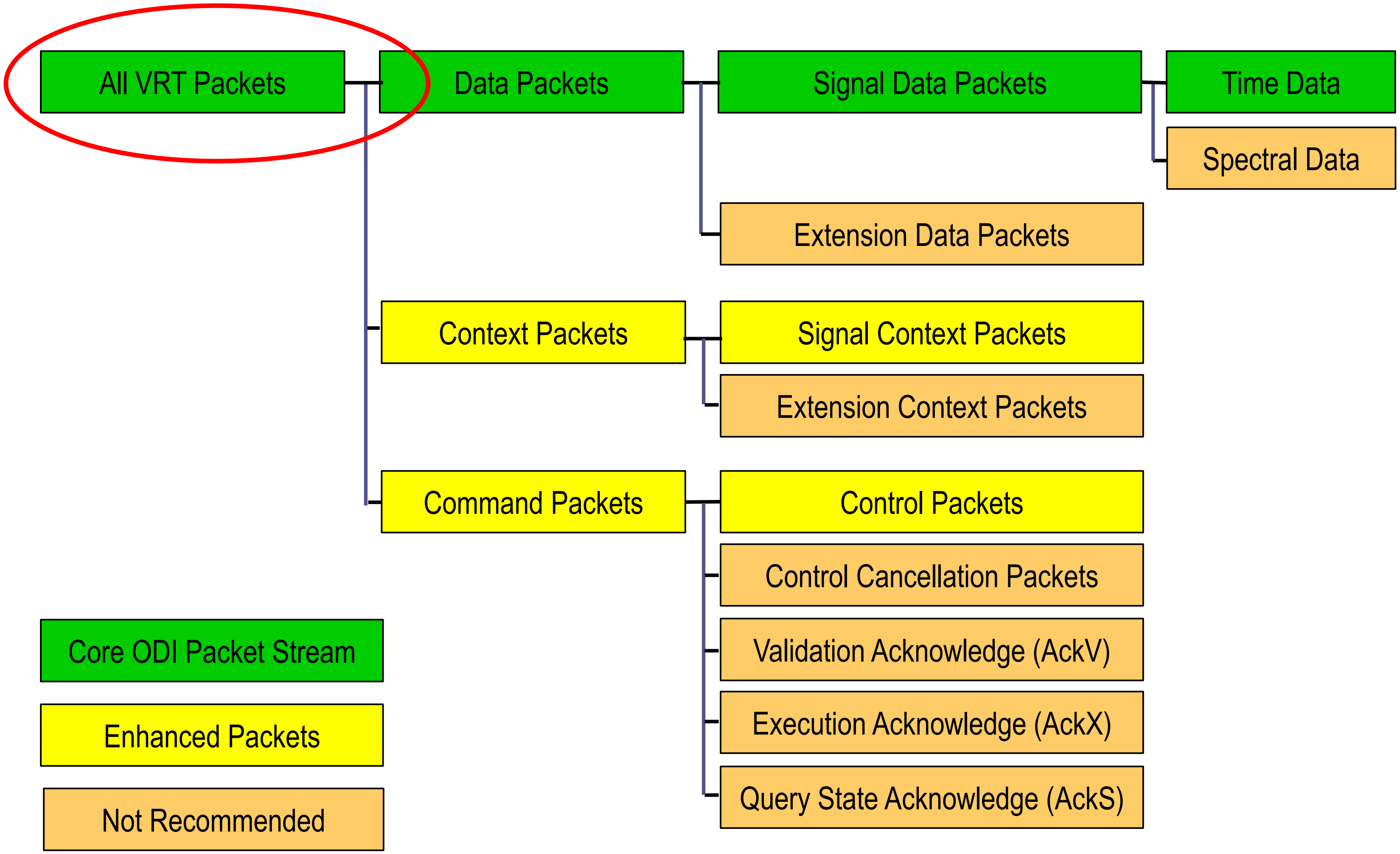
VRT Packet Hierarchy for ODI

- The previous figure shows the packet hierarchy for ODI-2 and ODI-2.1.
- The principal ODI Packet Stream consists of consecutive Signal Data Packets sending Time Data. No other Packet Streams are required. It is expected that many ODI systems will be built using only Signal Data Packets. ODI-2.1 further defines standard Signal Data Packets formats for interoperability. These are known simply as ODI-2.1 Data Packets.
- Context Packets optionally send additional information about the signal. ODI-2.1 further defines a standard Context Packet for interoperability. These are known simply as ODI-2.1 Context Packets.
- Control Packets, a subset of Command Packets, are similar to Context Packets but send additional information as commands to be executed. ODI-2.1 further defines a standard Control Packet for interoperability. These are known simply as ODI-2.1 Control Packets.
- Packet subtypes marked in orange are not recommended. However, ODI-2 specifies the rules for implementing those packet subtypes if needed.
- The following figure will be used repeatedly in the remainder of the ODI-2 specification to describe the rules and recommendations of the various packets and packet subtypes.

VRT Packet Hierarchy for ODI-2



Rules for all VRT Packets



Interlaken Command	
VRT Prologue & Trailer	
Data	

VRT Packet structure

← 8 Bytes → = 1 Interlaken Word

SOP	
Header	Stream ID
Class ID 1	Class ID 2
TSI	TSF 1
TSF 2	Data
Data	Data
Data	Data
Data	Data
Data	Data
Data	Data
Data	Data
Data	Data
Data	Trailer
EOP	

- Packets are documented by using the structure shown to the left. A Signal Data Packet is shown
- Interlaken defines words to be 64 bits, or 8 Bytes. VRT words are 32 bits, or 4 Bytes. Packets are documented using 8-Byte words as shown to the left to match Interlaken, the physical transmission methods.
- These words are often divided into two 4-Byte areas due to VRT field boundaries.
- Fields are color coded to indicate Interlaken commands, VRT Prologue and Trailer fields, and Data fields.

VRT Packet - Rules

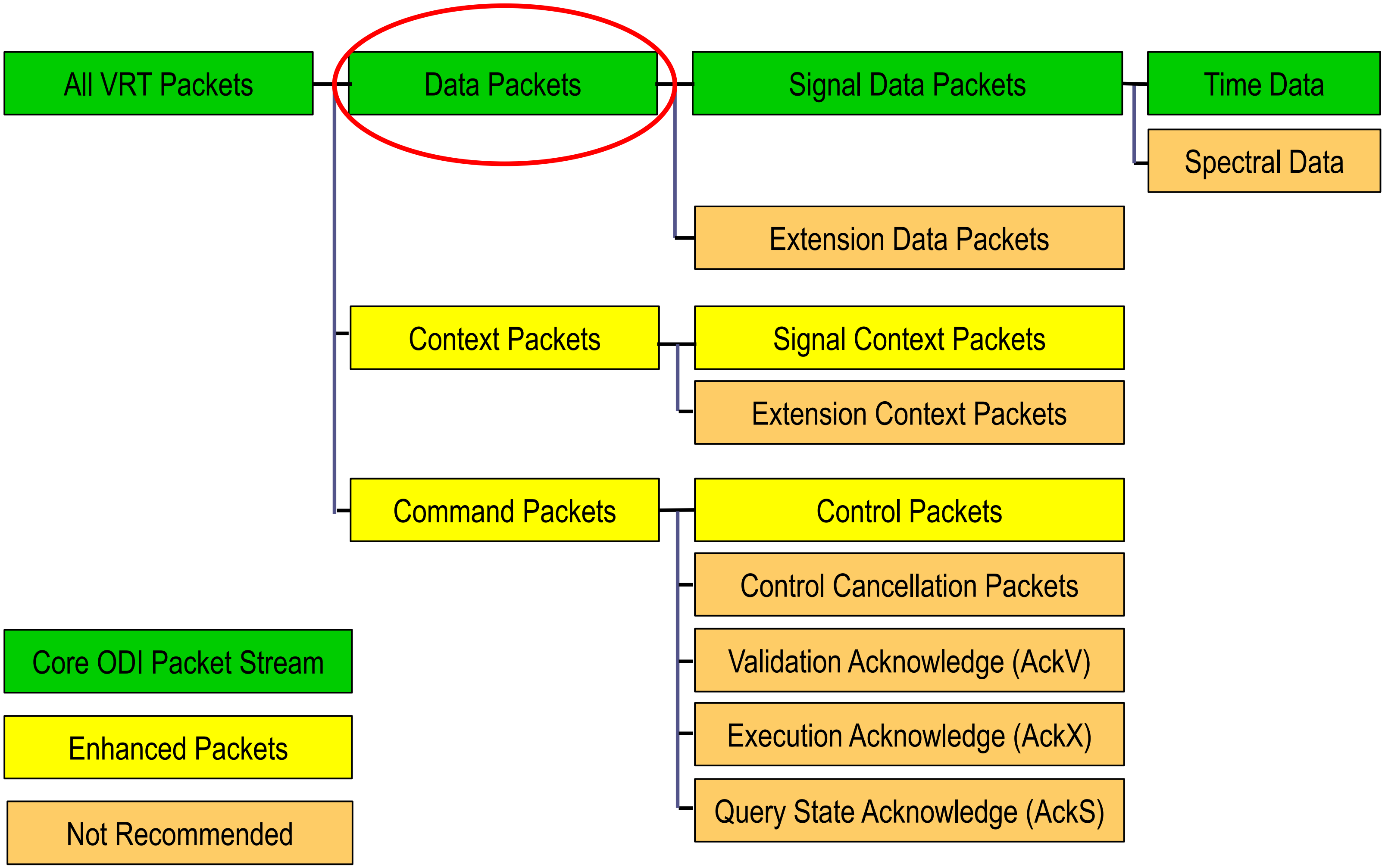
Legend
Interlaken Command
VRT Prologue & Trailer
Data

← 8 Bytes → = 1 Interlaken Word

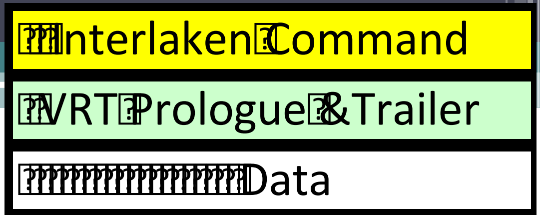
SOP	
Header	Stream ID
Class ID 1	Class ID 2
TSI	TSF 1
TSF 2	Data
Data	Data
Data	Data
Data	Data
Data	Data
Data	Data
Data	Data
Data	Data
Data	Trailer
EOP	

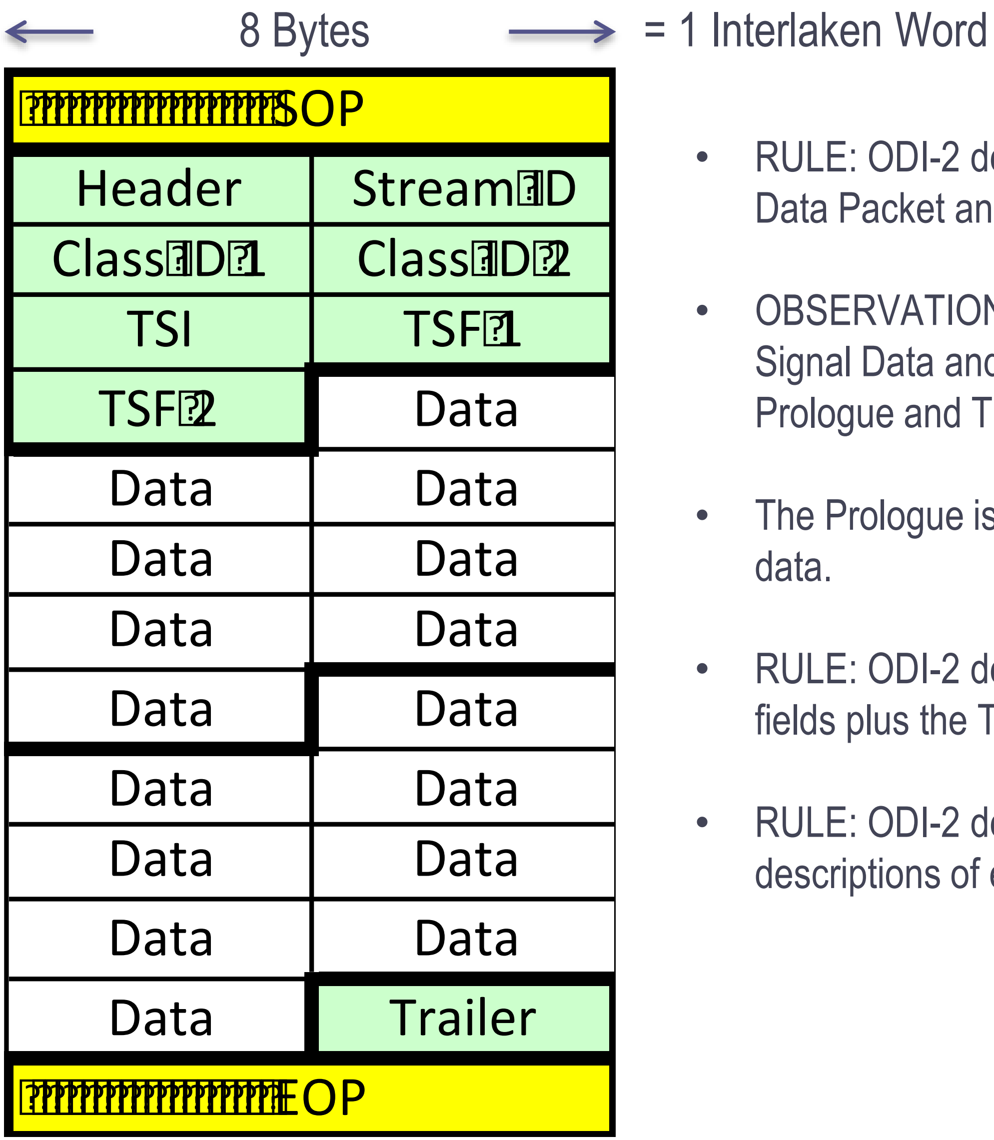
- Rule: All VRT Packets SHALL include the following fields: Header, Stream ID, Class ID 1, Class ID 2, TSI, TSF 1, TSF 2.
- All VRT Packets SHALL be an integer multiple of 32 bytes in length.
- Observation: A VRT Packet whose length is not a multiple of 32 bytes may be made to be so by adding Null data in the Data Payload.

VRT Data Packets



Packet structure - Data





- RULE: ODI-2 devices sending data SHALL comply with the Data Packet and Streams section of VITA 49.2, Section 6.
- OBSERVATION: VITA 49.2 specifies two data packet types, Signal Data and Extension Data, but they have similar Prologue and Trailer requirements.
- The Prologue is the mandated 28 Bytes that precedes the data.
- RULE: ODI-2 devices SHALL include all seven Prologue fields plus the Trailer field, as defined in VITA-49.2
- RULE: ODI-2 devices SHALL comply with the diagrams and descriptions of each field.

Interlaken Command
VRT Prologue & Trailer
Data

Packet structure - Data

← 8 Bytes → = 1 Interlaken Word

SOP	
Header	Stream ID
Class ID 1	Class ID 2
TSI	TSF 1
TSF 2	Data
Data	Data
Data	Data
Data	Data
Data	Data
Data	Data
Data	Data
Data	Data
Data	Trailer
EOP	

← Interlaken Start of Packet Command

VRT Data Prologue. 28 Bytes.

Stream ID, Length of packet, Data formats, time stamps. The time stamp fields are always present, though functioning time stamps are optional.

Data Payload

Up to 256 Kbytes of data

Always a multiple of 32 bytes

Typically long (>16K) to get efficiency

← **VRT Trailer** (errors, overload, events)

← Interlaken End of Packet

Data Packet Structure, Header

- The figure below shows the content of the mandatory header for Data packets
- Packet Type (28-31): If X=0, the header indicates a Signal Data packet.
  If X=1, the header indicates an Extension Data packet.
- Bit 28 of the Packet Type SHALL be set to 1. This indicates Stream ID field is present
- C bit (27) SHALL be set to 1. This indicates a Class ID fields are present
- T Indicator bit (26) SHALL be set to 1. This indicates a Trailer is present after the data payload.
- r Indicator bits (25) SHALL be set to 1. This indicates NOT V49.0
- S Indicator bit (24) SHALL be set to 0 for time domain information, and set to 1 for spectral domain information.
- TSI bits (22-23) SHALL be set to either 01, 10, or 11, depending on the VITA timestamp method chosen. These indicate that TimeStamp-Integer field is present. If the device does not support timestamps, then 11 SHALL be used.
- TSF bits (20-21) SHALL be set to either 01, 10, or 11, depending on the VITA timestamp method chosen. These indicate that TimeStamp-Fractional fields are present. If the device does not support timestamps, then 11 SHALL be used.
- Packet Count (16-19) is a modulo-16 counter that counts the number of data packets sent. Bit 16 is the LSB. Packet Count will increment for each packet sent.
- Packet Size (0-15) indicates how many VRT 32-bit (4-Byte) words are present in the entire data packet, including the mandatory 7 (seven) Prologue fields and the Trailer field. Therefore, the Packet Size indicates the data payload size plus 8 (eight). Maximum VRT size is 65535 4-Byte words. Since ODI-1 requires all packet lengths to be divisible by 32 Bytes, the maximum ODI size is 65,528 VRT words, or 262,112 Bytes.

Signal Data Packet Header

Word	31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
1	**Packet Type**				**C**	***Indica-tors***			**TSI**		**TSF**		**Packet Count**				**Packet Size**															
	0	0	X	1	C	T	r	*S*	TSI		TSF		Pkt Count				Packet Size															

Figure 6.1-2: Signal Data Packet Header Bits

Data Packet Structure, Stream ID

- Stream ID is an abbreviation for Stream Identifier
- The Stream ID is a 32-bit field, whose value is the same for all data and context packets associated with that stream
- RULE: All ODI-2 devices SHALL include a Stream ID field
- RULE: The default Stream ID for a single port device SHALL be 4096, as shown in the diagram below.
- OBSERVATION: Default Stream ID of 4096 matches the default Stream ID of VITA 49A.
- RULE: In a multi-port device where the ports are to be aggregated, each additional port's Stream ID SHALL be incremented by 1024 by default.
- OBSERVATION: In a 4-port aggregation, the Stream IDs are
  - Port 1: 4096
  - Port 2: 5120
  - Port 3: 6144
  - Port 4: 7168
- OBSERVATION: By incrementing by 1024 for each additional port, each port can be identified by the Stream ID. Incrementing by 1024 still allows downstream devices processing the data to increment the Stream ID by 1, as envisioned by VITA 49A, without causing duplication of Stream ID.
- RULE: Stream ID SHALL be programmable by the user.

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0

Figure shows Stream ID field configured for Stream ID= 4096

Data Packet Structure, Class ID

- Class ID is a required field of 64 bits, shown as two 32-bit words below.
- The purpose of Class ID is to identify the Information Class used for the application, and the Packet Class from which each packet was made.
- RULE: ODI-2 devices SHALL include a Class ID structure as documented below, and the VITA 49.2 diagram
- OUI will be set to the AXIe OUI of 2-4-5-C-C-B or to the OUI of the device vendor.
- Reserved (24-26) is set to 0 per VITA 49.2
- Pad Bit Count (27-31) is set per VITA 49.2
- PERMISSION: IF a device vendor uses their own OUI, they MAY define the Information Class Code and Packet Class Code as they wish, pursuant to VITA 49.2.
- RULE: IF a vendor uses the AXIe OUI, and they are implementing Signal Data Packets defined in an auxiliary ODI specification, such as ODI-2.1, THEN they SHALL set the Information Class Code and the Packet Class Code to the value specified in the auxiliary ODI standard.

<table>
<tr><th>Word</th><th>31</th><th>30</th><th>29</th><th>28</th><th>27</th><th>26</th><th>25</th><th>24</th><th>23</th><th>22</th><th>21</th><th>20</th><th>19</th><th>18</th><th>17</th><th>16</th><th>15</th><th>14</th><th>13</th><th>12</th><th>11</th><th>10</th><th>9</th><th>8</th><th>7</th><th>6</th><th>5</th><th>4</th><th>3</th><th>2</th><th>1</th><th>0</th></tr>
<tr><td>1</td><td colspan="5">Pad Bit Count</td><td colspan="3">Reserved</td><td colspan="24">Organizationally Unique Identifier (OUI)</td></tr>
<tr><td>2</td><td colspan="16">Information Class Code</td><td colspan="16">Packet Class Code</td></tr>
</table>

Figure 5.1.3-1: Contents of the Class ID Field

VITA 49.2
and ODI-2

Data Packet Structure, Timestamps

← 8 Bytes →

SOP	
Header	Stream ID
Class ID 1	Class ID 2
TSI	TSF 1
TSF 2	Data
Data	Data
Data	Data
Data	Data
Data	Data
Data	Data
Data	Data
Data	Data
Data	Trailer
EOP	

- Timestamp fields are mandatory to keep a constant Prologue length.
- Timestamp fields include TSI, TSF 1, and TSF 2, each 4 bytes wide.
- RULE: A device SHALL NOT set TSI=00 or TSF=00
- IF a device does not produce valid timestamps it shall set TSI=11 and TSF=01
- RECOMMENDATION: If the device can execute Timestamps, then it SHOULD execute GPS timestamps (TSI=10).
- A consumer of data SHALL ignore timestamp fields if it cannot operate on the timestamps.

Timestamps

Signal Data Packet Header

<table>
<tr><th>Word</th><th>31</th><th>30</th><th>29</th><th>28</th><th>27</th><th>26</th><th>25</th><th>24</th><th>23</th><th>22</th><th>21</th><th>20</th><th>19</th><th>18</th><th>17</th><th>16</th><th>15</th><th>14</th><th>13</th><th>12</th><th>11</th><th>10</th><th>9</th><th>8</th><th>7</th><th>6</th><th>5</th><th>4</th><th>3</th><th>2</th><th>1</th><th>0</th></tr>
<tr><td rowspan="2">1</td><td colspan="4">Packet Type</td><td>C</td><td colspan="3">Indica-tors</td><td colspan="2">TSI</td><td colspan="2">TSF</td><td colspan="4">Packet Count</td><td colspan="16">Packet Size</td></tr>
<tr><td>0</td><td>0</td><td>0</td><td>0/1</td><td>C</td><td>T</td><td>r</td><td>S</td><td colspan="2">TSI</td><td colspan="2">TSF</td><td colspan="4">Pkt Count</td><td colspan="16">Packet Size</td></tr>
</table>

Figure 6.1-2: Signal Data Packet Header Bits

Table 5.1.1-2: Meaning of TSI Codes

TSI Code	Meaning
00	No Integer-seconds Timestamp field included
01	UTC
10	GPS time
11	Other

- Not allowed in ODI-2
- Not Recommended for use
- Recommended format if absolute timestamps are supported
- Used when no timestamp supported, or when using Free Running Count Timestamp. See complete matrix.

Table 5.1.1-3: Meaning of TSF Codes

TSF Code	Meaning
00	No Fractional-seconds Timestamp field included
01	Sample Count Timestamp
10	Real-Time (Picoseconds) Timestamp
11	Free Running Count Timestamp

- Not allowed in ODI-2
- Extends TSI resolution to one data sample period
- Extends TSI resolution to one picosecond
- Free running sample counts

Allowed TSI, TSF combinations

RULE: The TSI and TSF codes SHALL accurately reflect the type of timestamps used from the nine allowed combinations below:

TSF \ TSI	00	01	10	11
00	Prohibited	Prohibited	Prohibited	Prohibited
01	Prohibited	UTC time plus Sample Count	GPS time plus Sample Count	No Valid Timestamps
10	Prohibited	UTC time plus Picoseconds	GPS time plus Picoseconds	Picoseconds Timestamps
11	Prohibited	Free running Sample Count	Free running Sample Count	Free running Sample Count

Green = Recommended combinations
Yellow = Not recommended, but allowed
Red = Prohibited combinations

Data Packet Structure, Data Payload

← 8 Bytes →

SOP	
Header	Stream ID
Class ID 1	Class ID 2
TSI	TSF 1
TSF 2	Data
Data	Data
Data	Data
Data	Data
Data	Data
Data	Data
Data	Data
Data	Data
Data	Trailer
EOP	

- Data Payload occurs between the 28-Byte Prologue and the 4-Byte Trailer
- RULE: Data Payload length SHALL be an integer multiple of 32 Bytes.
- OBSERVATION: ODI-1 requires all packets to be an integer multiple of 32-bytes. Since the Prologue and Trailer sum to 32 Bytes, the above rule forces the entire packet to be a multiple of 32 Bytes.
- PERMISSION: IF an ODI-2 device uses Extension Data Packets, THEN there is no restriction on the content of the data.
- RULE: IF the ODI-2 device uses AXIe OUI and does not use Extension Data Packets, then the data SHALL comply with the auxiliary standard specified.
- OBSERVATION: If the data payload is not naturally divisible by 32 Bytes, null data may be appended at the end of the data payload to do so. With Packet Length specified in the Packet Header and Pad Bit Count specified in the Class ID field, the valid data may be determined.
- OBSERVATION: Most multi-channel sample packing can be chosen to make streaming “Train” packets divisible by 32 bytes.

Data Packet Structure, Trailer

- Trailer is a mandatory field of 32 bits.
- RULE: An ODI-2 device SHALL implement the Data Packet Trailer as defined in VITA 49.2
- RULE: The Calibrated Time Indicator, Valid Data Indicator, Reference Lock Indicator, AGC/MGC Indicator, Detected Signal Indicator, Spectral Inversion Indicator, Over-range Indicator, and Sample Loss Indicator SHALL be enabled and set in the trailer if their values are known.
- PERMISSION: An ODI-2 device MAY use User-Defined Indicators
- PERMISSION: An ODI-2 device MAY use the E field and Associated Context Packet Count field, but is not required to do so.
- RULE: If a consumer receives Trailer information that it can't act on, it SHALL continue normal operation.

VRT Signal Data Packet Trailer

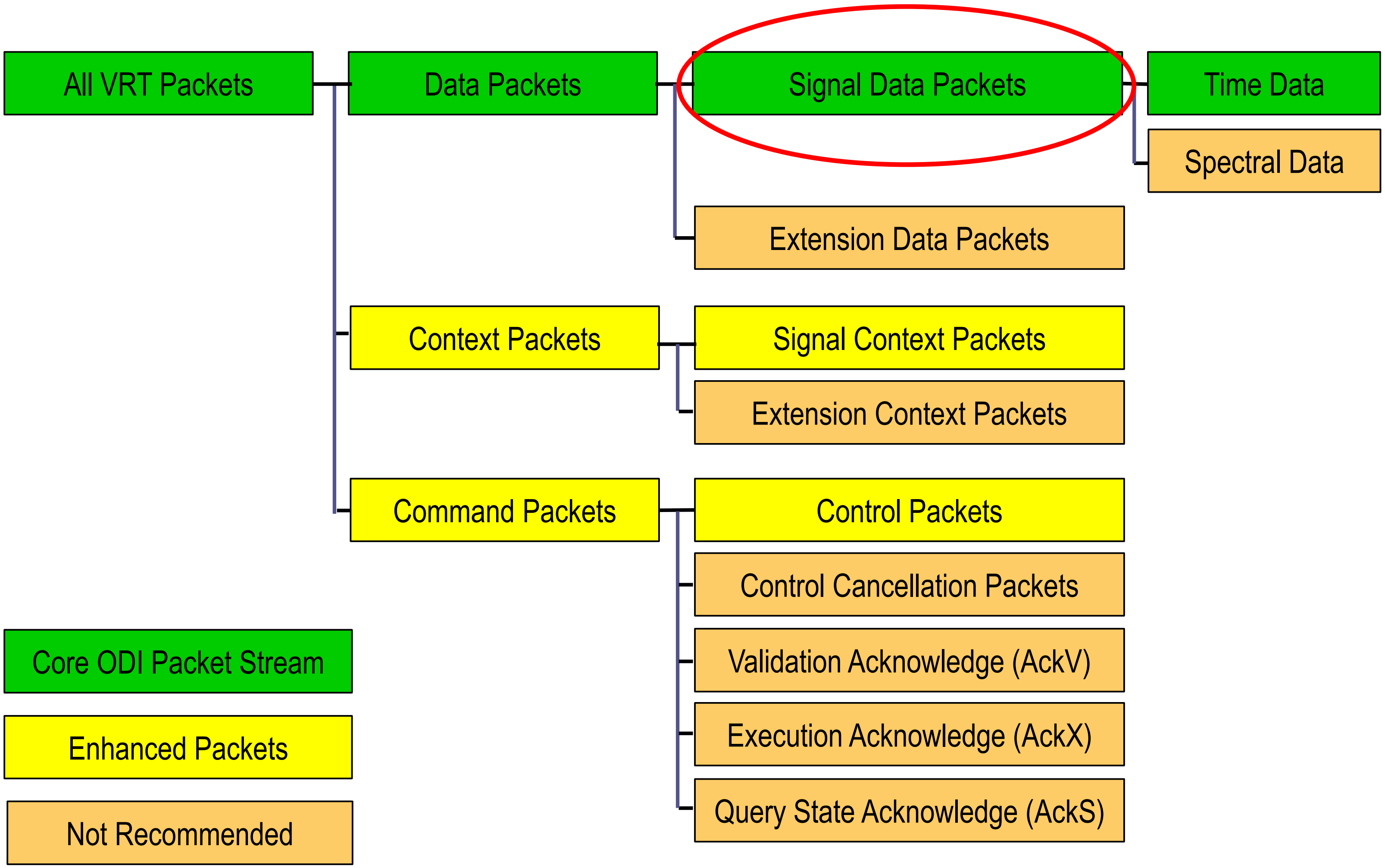
Word	31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
1	Enables												State and Event Indicators												E	Associated Context Packet Count						

Figure 5.1.6-1: VRT Signal Data Packet Trailer

Table 5.1.6-1: Enable and Indicator Bits

Enable Bit Position	Indicator Bit Position	Indicator Name
31	19	Calibrated Time Indicator
30	18	Valid Data Indicator
29	17	Reference Lock Indicator
28	16	AGC/MGC Indicator
27	15	Detected Signal Indicator
26	14	Spectral Inversion Indicator
25	13	Over-range Indicator
24	12	Sample Loss Indicator
23,22	11,10	Sample Frame Indicators, User-Defined
[21..20]	[9..8]	User-Defined Indicators

VRT Signal Data Packets



Signal Data Packet, Header

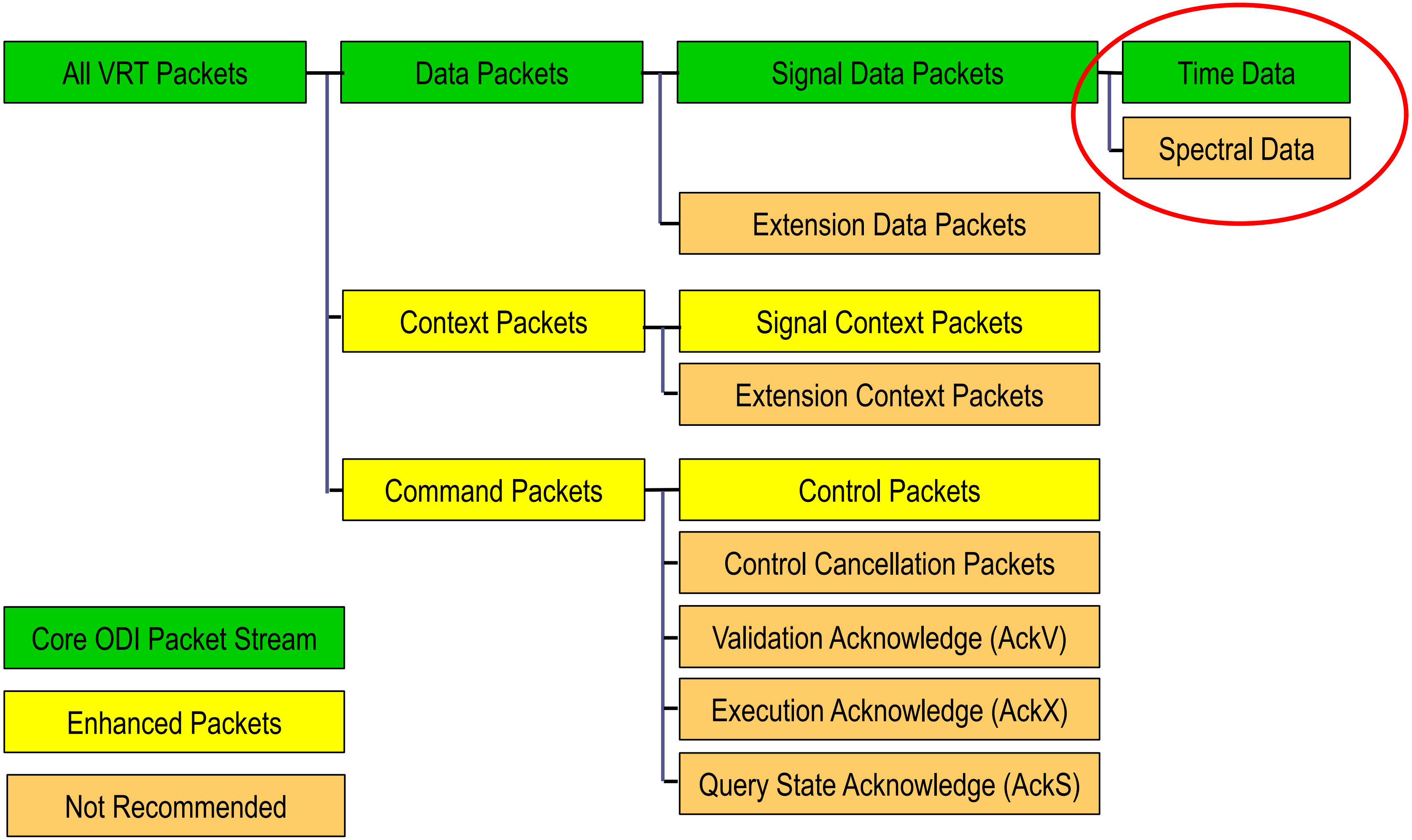
- The figure below shows the contents of the mandatory header for Signal Data Packets
- Note that Packet Type (28-31) is set to 0001, indicating a Signal Data Packet
- All other fields are defined as indicated in section about Data Packets, Header

Signal Data Packet Header

Word	31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
1	**Packet Type**				**C**	***Indica-tors***			**TSI**		**TSF**		**Packet Count**				**Packet Size**															
	0	0	0	1	C	T	r	*S*	TSI		TSF		Pkt Count				Packet Size															

Figure 6.1-2: Signal Data Packet Header Bits

VRT Data Packets



Time and Spectral Data

- VRT Data Packets can send either Time Data or Spectral Data
- IF S=0, THEN the Data Payload SHALL represent Time Data
- IF S=1, THEN the Data Payload SHALL represent Spectral Data

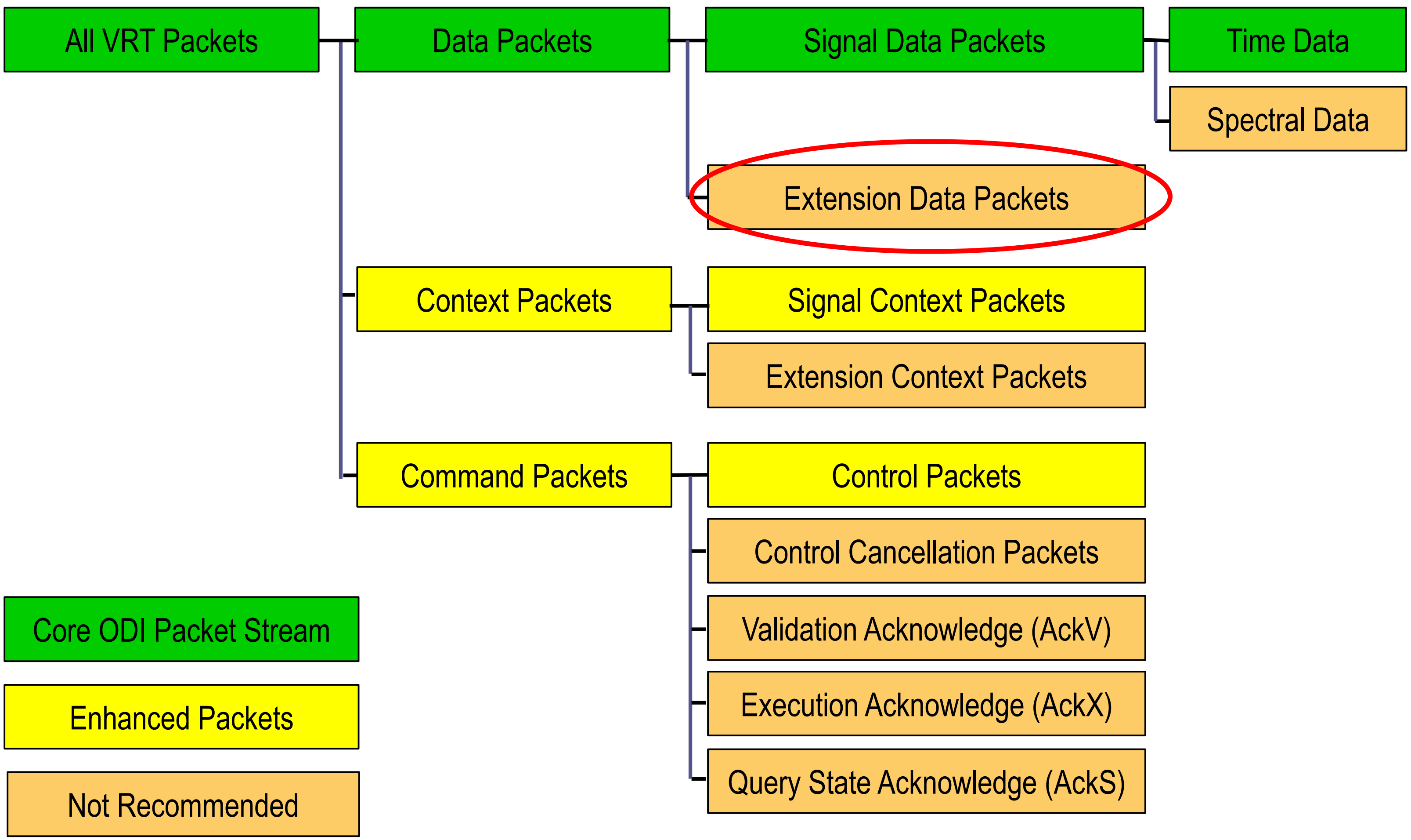
Signal Data Packet Header

Word	31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
1	**Packet Type**				**C**	***Indica-tors***			**TSI**		**TSF**		**Packet Count**				**Packet Size**															
	0 0 0 1				C	T	r	*S*	TSI		TSF		Pkt Count				Packet Size															

Figure 6.1-2: Signal Data Packet Header Bits

“S” bit indicates Time or Spectral Data, as above.

Extension Data Packets



Extension Data Packet, Header

- Extension Data is used for data sequences that are not defined time or spectral data
- An example of Extension Data may be encrypted data
- IF the data payload is time or spectral data, THEN an Extension Data Packet cannot be used

- The figure below shows the contents of the mandatory header for Signal Data Packets
- Note that Packet Type (28-31) is set to 0011, indicating an Extension Data Packet
- All other fields are defined as indicated in section about Data Packets, Header

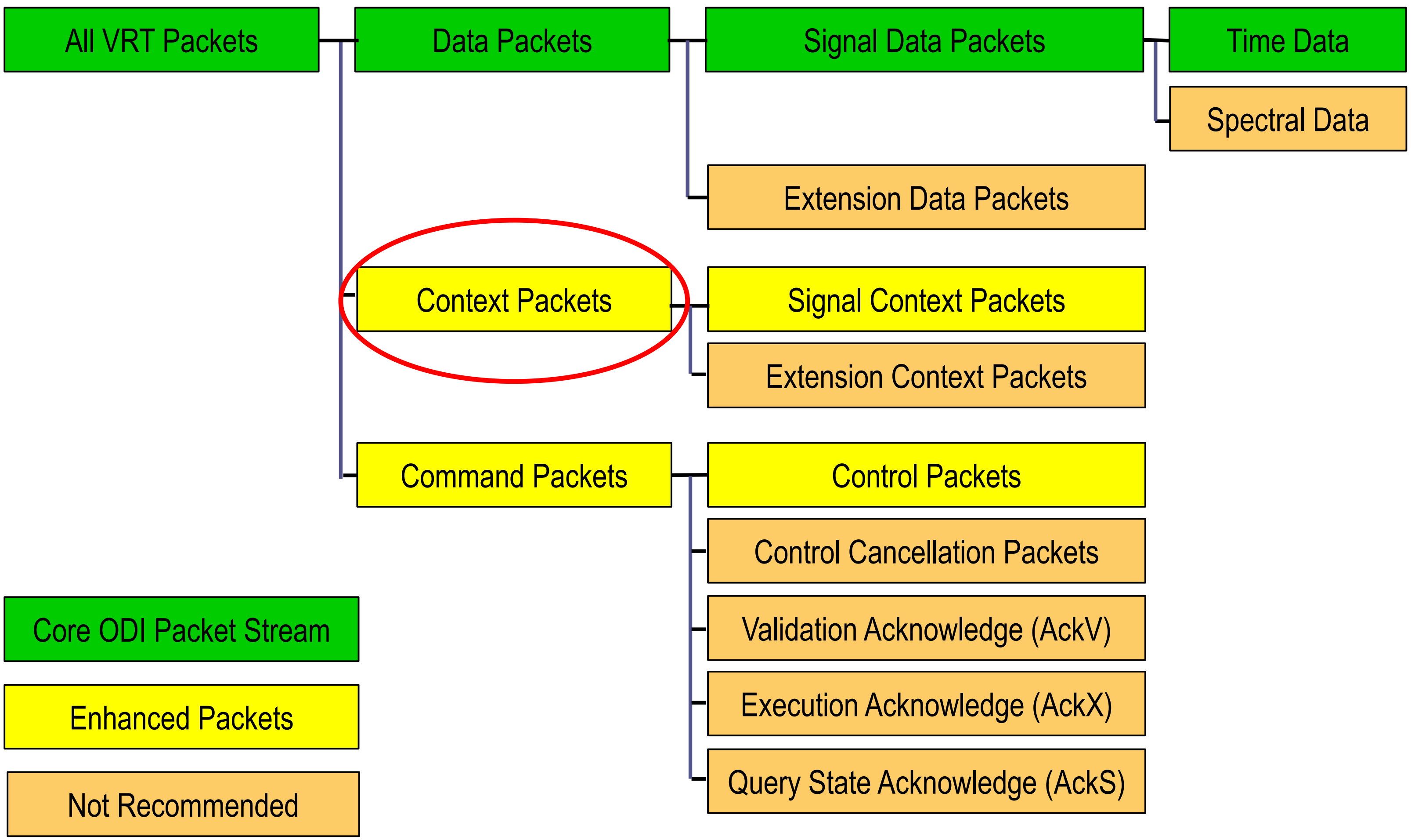
Signal Data Packet Header

Word	31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
1	**Packet Type**				**C**	***Indica-tors***			**TSI**		**TSF**		**Packet Count**				**Packet Size**															
	0 0 1 1				C	T	r	*S*	TSI		TSF		Pkt Count				Packet Size															

Figure 6.1-2: Signal Data Packet Header Bits

ODI-2 Context Packet Specifications

Context Packets



Context Packets

- Adopting the VRT packet definitions allows the use of Context Packets in addition to Data Packets. Context Packets convey metadata related to the signal.
- Handling Context Packets is optional capability of ODI-2 devices. There is no requirement to do so. A producer is NOT required to generate Context Packets, but MAY do so.
- Context Packets and Command Packets have many similarities. Starting with V49.2, VITA has specified Context Packets as the standard way to report metadata related to a signal, and Command Packets as the standard way to control metadata parameters related to the signal. ODI-2 allows consumers to treat Context Packets as commands, allowing recorded data to be played back. However, if a device can execute Context Packets received, it SHALL also execute Command Packets, the preferred method.
- A consumer is NOT required to act on Context Packets received, but MAY do so. A consumer that receives Context Packets that it does not know how to process is required only to continue normal operation. That is, the reception of Context Packets should not interfere with otherwise normal operation.
- Like Data Packets, VRT defines two Context Packet types – Signal Context Packets and Extension Context Packets. The Signal Context Packet is considered the “standard” Context Packet, while Extension Context Packets are used to convey metadata that can’t be communicated using the standard Signal Context Packet.
- Context Packets are compliant with VITA 49.2 standard
- Context Packets have a standard 28 Byte header and no trailer.
- Context Packets, like Data packets, must be a multiple of 32 Bytes in length. This can be achieved by adding null data.

Interlaken Command

VRT Prologue & Trailer

Data

Packet structure - Context

← 8 Bytes → = 1 Interlaken Word

SOP	
Header	Stream ID
Class ID 1	Class ID 2
TSI	TSF 1
TSF 2	CIF0
Context	Context
Context	Context
Context	Context
Context	Context
Context	Context/Pad
Context/Pad	Context/Pad
Context/Pad	Context/Pad
Context/Pad	Context/Pad
EOP	

← Interlaken Start of Packet Command

VRT Context Prologue. 28 Bytes.

Similar to VRT Data Prologue.

Context Fields

Always a multiple of 32 bytes + 4 bytes

Final 32 bytes will include final context fields, plus any "Pad" bytes of null data to insure Context Packets are always a multiple of 32 bytes

← Interlaken End of Packet

Context Packet Prologue

- RULE: An ODI-2 producer that generates Context Packets SHALL include the Prologue fields specified for Context Packets
- Observation: The specified mandated fields are Header, Stream ID, Class ID 1, Class ID 2, TSI, TSF 1, and TSF 2.

Context Packet Structure, Header

- The figure below shows the content of the mandatory header for Context packets, and is reflective of VITA 49.2 Signal Context and Extension Context packets.
- Packet Type (28-31): Packet Type SHALL be the value 010X as shown

  If X=0, the header indicates a Signal Context packet.

  If X=1, the header indicates an Extension Context packet.
- C bit (27) SHALL be set to 1. This indicates a Class ID fields are present
- RR bits (24-25) SHALL be set to 0. These are VITA reserved bits.
- The TSM bit (24) is the TimeStamp Mode bit, indicating whether the TimeStamp in the Context packet is being used to covey timing of Context events with fine or coarse resolution. If TSI is set to 11 (no TimeStamp, but TimeStamp field is present) the TSM bit SHALL be set to 1. Otherwise the TSM bit will be set according to VITA-49.2, Section 7.
- TSI bits (22-23) SHALL be set to either 01, 10, or 11, depending on the VITA timestamp method chosen. These indicate that TimeStamp-Integer field is present. If the device does not support timestamps, then 11 SHALL be used.
- TSF bits (20-21) SHALL be set to either 01, 10, or 11, depending on the VITA timestamp method chosen. These indicate that TimeStamp-Fractional fields are present. If the device does not support timestamps, then 01 SHALL be used.
- When a Context Packet Stream is paired to a Data Packet Stream, the TSI and TSF fields SHALL be the same.
- Packet Count (16-19) is a modulo-16 counter that counts the number of Context packets sent. Bit 16 is the LSB. Packet Count will increment for each packet sent.
- Packet Size (0-15) indicates how many VRT 32-bit (4-Byte) words are present in the entire Context packet, including the mandatory Prologue fields.
- OBSERVATION: The C, TSI, TSF, Packet Count, and Packet Size fields in Context packets function the same way as for Data packets.

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
Packet Type 0	1	0	X	C	R	R	TSM	TSI		TSF		Packet Count				Packet Size															

Context Packet Structure, Stream ID

- Stream ID is an abbreviation for Stream Identifier
- The Stream ID is a 32-bit field, whose value is the same for all data and context packets associated with that stream
- RULE: The Stream ID for a Context packet SHALL match the Stream ID for the related Data Packet Stream.
- OBSERVATION: ODI-2 specifies that Data Packet Stream IDs must be programmable by the user. Since related Context packets must share the same Stream ID, they must also be programmable to the same value.
- OBSERVATION: The default Stream ID is 4096, the same as for Data packets.

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0

Figure shows Stream ID field configured for Stream ID= 4096

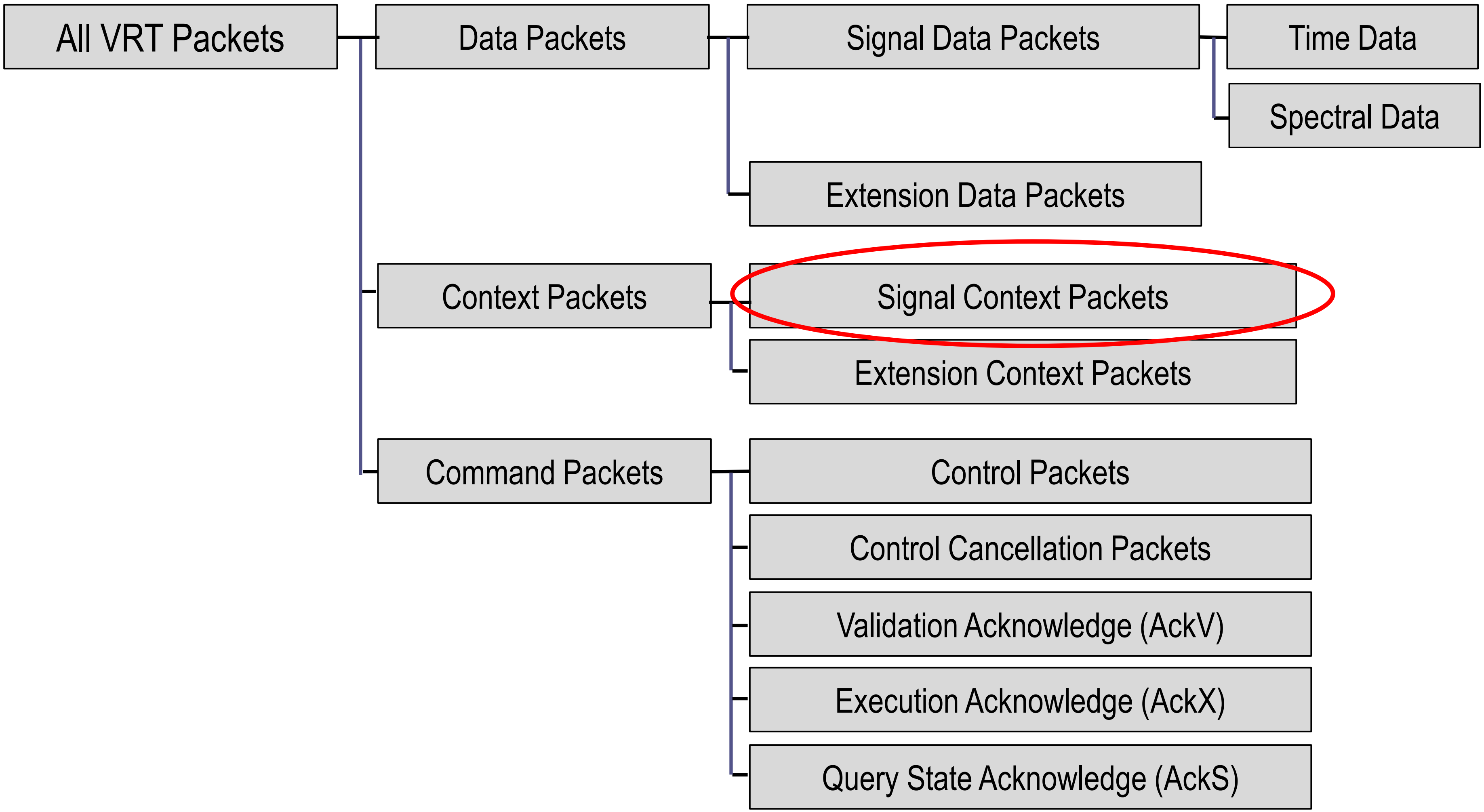
Context Packets, Context Indicator Field

8 Bytes

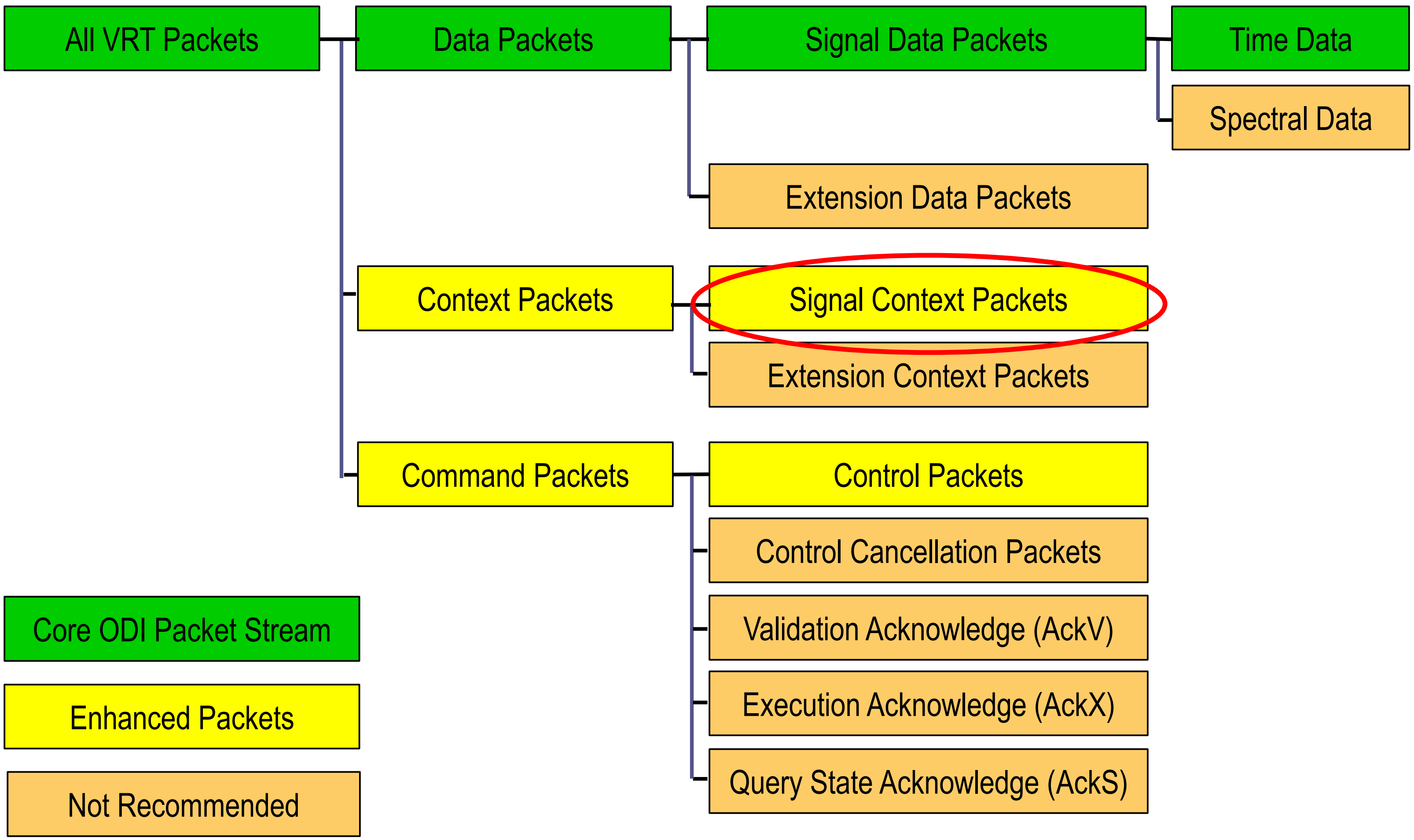
SOP	
Header	Stream ID
Class ID 1	Class ID 2
TSI	TSF 1
TSF 2	CIF0
Context	Context
Context	Context
Context	Context
Context	Context
Context	Context/Pad
Context/Pad	Context/Pad
Context/Pad	Context/Pad
Context/Pad	Context/Pad
EOP	

- CIF is an abbreviation for Context Indicator Field when with Context Packets.
- Several successive CIFs may be used at the beginning of the Context Section, but CIF0 is mandated, and is the first field. Each indicates the presence or absence of specific context data to follow.
- CIF0 is a mandatory field for all ODI-2 Context packets.
- RULE: Context Indicator Field SHALL be present in an ODI-2 Context packet.
- OBSERVATION: Though only one Context Indicator Field is shown, additional Context Indicator Fields may be included, to be placed after CIF0 and before any other Context Data.

Signal Context Packets



Signal Context Packets



Signal Context Packets, Header

- RULE: The Packet Type for a Signal Context Packet SHALL be set to 0100

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
Packet Type 0 1 0 0				C	R	R	TSM	TSI		TSF		Packet Count				Packet Size															

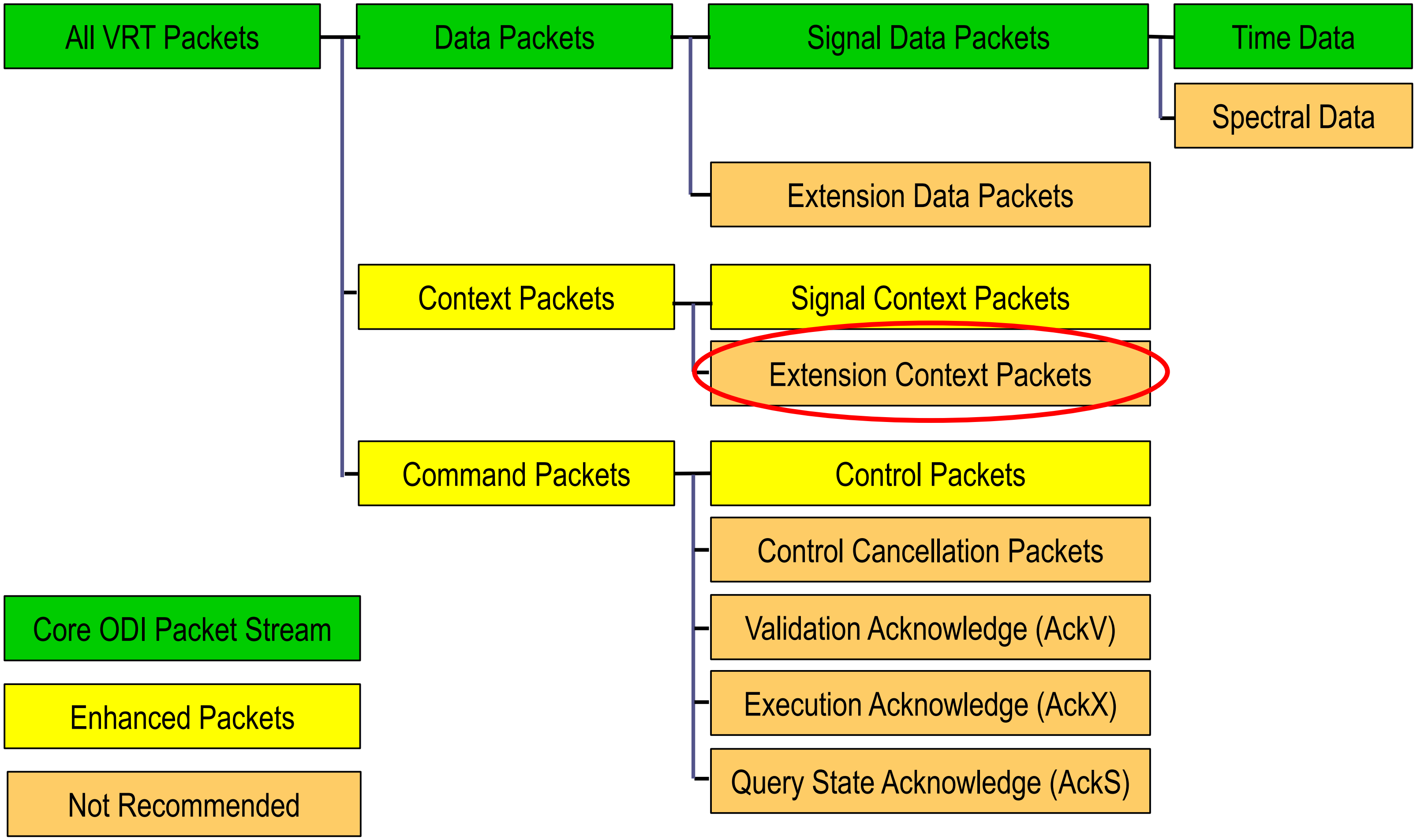
Signal Context Packets, Context Data

← 8 Bytes →

SOP	
Header	Stream ID
Class ID 1	Class ID 2
TSI	TSF 1
TSF 2	CIF0
Context	Context
Context	Context
Context	Context
Context	Context
Context	Context/Pad
Context/Pad	Context/Pad
Context/Pad	Context/Pad
Context/Pad	Context/Pad
EOP	

- Context Data follows the Context Packet Prologue
- RULE: For Signal Context Packets, the Context Data SHALL be the Context Fields indicated by the Context Indicator Field.
- OBSERVATION: If a device uses the AXIe OUI, the definition of the classes and related fields will be specified in an auxiliary specification, such as ODI-2.1.
- PERMISSION: The fields after CIF0 MAY be additional Context Indicator Fields, or they may be other Context Data, as specified in VITA 49.2.
- RECOMMENDATION: Include CIF1 and CIF2 fields, since these fields are required in ODI-2.1. By having two extra null CIF fields, the Context Data begins in the same location within a packet as it does with a Control packet. This allows FPGA-based devices to interpret either one as a Control packet, since the data fields align, which allows recoded data to be played back as commands.
- RULE: All Context packets SHALL be an integer multiple of 32 Bytes.
- PERMISSION: If the Context Data is not naturally a multiple of 32 Bytes in length, pad Bytes may be appended to create a 32 Byte packet before signaling an Interlaken EOP.

Extension Context Packets



Extension Context Packets, Header

- Extension Context Data is used when Signal Context Data is unable to communicate the proper metadata related to the Data Packet stream.
- RULE: The Packet Type for an Extension Context Packet SHALL be set to 0101

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
Packet Type 0 1 0 1				C	R	R	TSM	TSI		TSF		Packet Count				Packet Size															

Extension Context Packets, Context Data

8 Bytes

SOP	
Header	Stream ID
Class ID 1	Class ID 2
TSI	TSF 1
TSF 2	CIF0
Context	Context
Context	Context
Context	Context
Context	Context
Context	Context/Pad
Context/Pad	Context/Pad
Context/Pad	Context/Pad
Context/Pad	Context/Pad
EOP	

- Context Data follows the Context Packet Prologue
- For Extension Context Packets, the Context Data is defined by the vendor.
- RULE: If using Extension Context packets, the vendor SHALL document the behavior of the Context Indicator Field and the Context Data.
- RULE: All Extension Context packets SHALL be an integer multiple of 32 Bytes.
- PERMISSION: If the Extension Context Data is not naturally a multiple of 32 Bytes in length, pad Bytes may be appended to create a 32 Byte packet before signaling an Interlaken EOP.

ODI-2 Command Packet Specifications

Command Packets -1

- Adopting the VRT packet definitions allows the use of Command Packets in addition to Data Packets and Context Packets.
- While devices may be controlled through a separate interface to the system controller, command packets enable an in-stream method for sending meta-data to be executed quickly and synchronously with the signal data.
- ODI-2 specifies the general packet structure requirements for Command Packets. ODI-2.1 will specify specific Command Packets for interoperability.
- Command Packets are analogous to Context Packets in that they convey metadata related to the signal. While Context Packets describe metadata about a digitized or recorded signal, Command Packets enable control of similar parameters to an exciter, such as a signal generator.
- If an exciter, such as a signal generator, can accept control information over its ODI port, it MUST be able to do so through Command Packets. It MAY also be controlled, via a software command, to execute Context Packets. This last permission allows a signal generator to execute recorded signals, including the associated Context Packets.
- Handling Command Packets is optional capability of ODI-2.1 devices. There is no requirement to do so. A producer is NOT required to generate Command Packets, but MAY do so.
- A consumer is NOT required to act on Command Packets received, but MAY do so. A consumer that receives Command Packets that it does not know how to process is required only to continue normal operation. That is, the reception of Command Packets should not interfere with otherwise normal operation.
- Command Packets have a standard 36 Byte Prologue and no Trailer.
- Command Packets, like other packets, must be a multiple of 32 Bytes in length
- Command Packets MUST comply with the rules in VITA 49.2, Section 8.

Command Packets -2

- The diagram below shows the five Command Packet subtypes. The minimum Command Packet functionality is the Control Packet, which sends control fields in an analogous method to Context Packets. It is the only recommended Command Packet subtype in ODI-2.

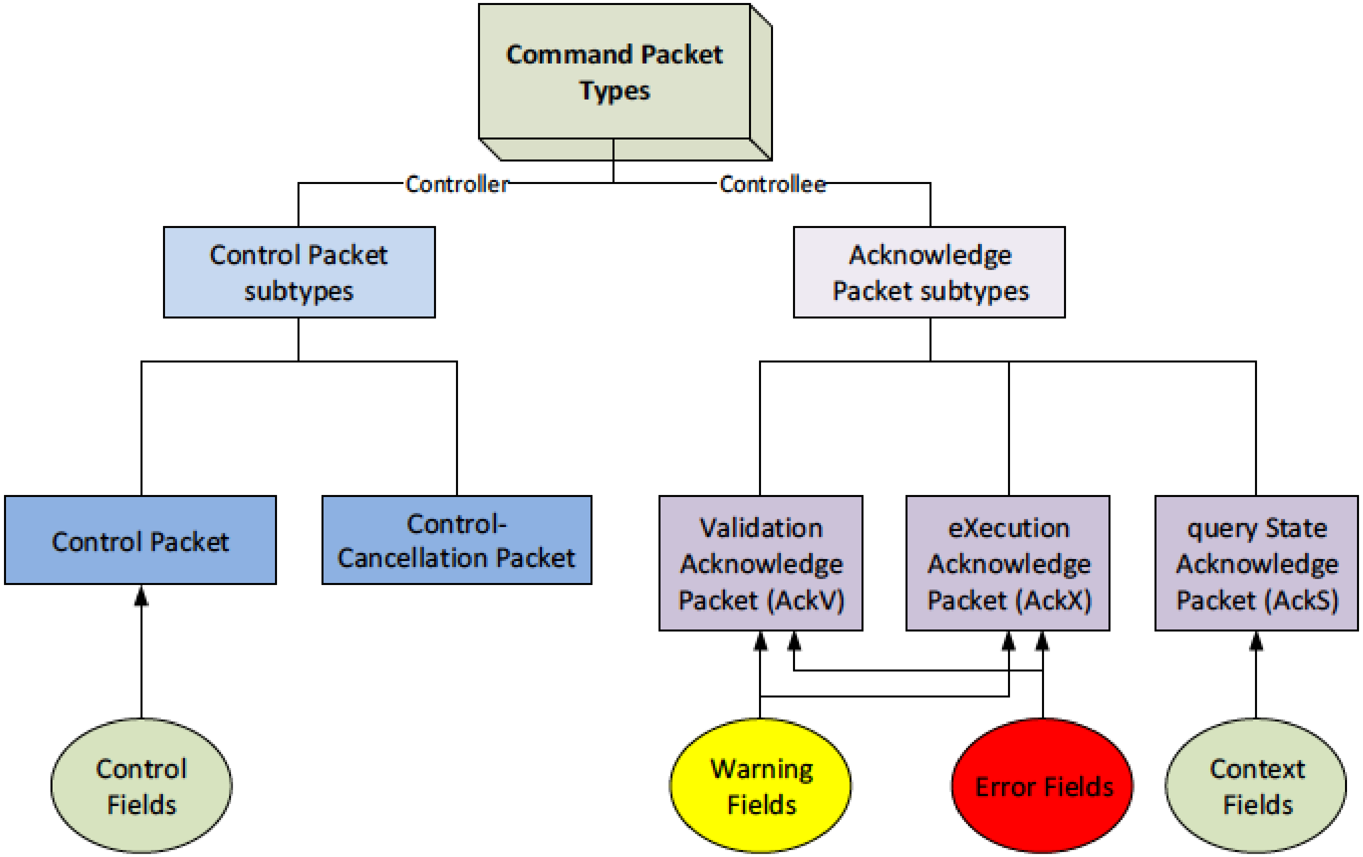
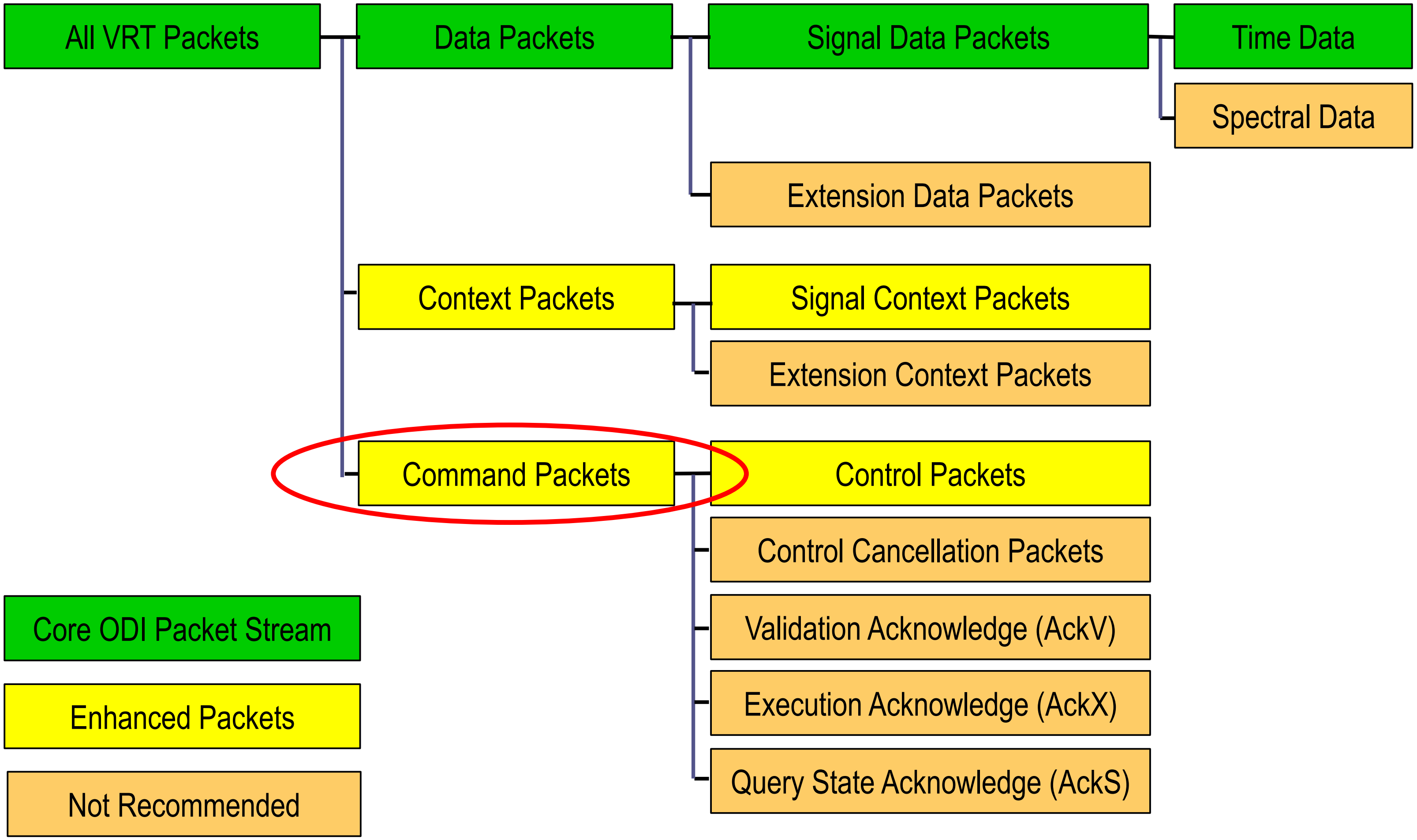


Figure 8.1-1: Command Packet Class Taxonomy showing Packet Subtypes

Command Packets



Command Packet structure

Interlaken Command

VRT Prologue & Trailer

Data

← 8 Bytes → = 1 Interlaken Word

SOP	
Header	Stream ID
Class ID 1	Class ID 2
TSI	TSF 1
TSF 2	CAM
Message ID	CIF0
Context	Context
Context	Context
Context	Context
Context	Context/Pad
Context/Pad	Context/Pad
Context/Pad	Context/Pad
Context/Pad	Context/Pad
EOP	

Interlaken Start of Packet Command

VRT Command Prologue. 36 Bytes.

Similar to VRT Context Prologue, with two additional fields, CAM and Message ID.

Command Fields

Always a multiple of 32 bytes - 4 bytes

Final 32 bytes will include final command fields, plus any “Pad” bytes of null data to insure Command Packets are always a multiple of 32 bytes.

Interlaken End of Packet

Command Packet - Prologue

Legend
Interlaken Command
VRT Prologue & Trailer
Data

← 8 Bytes → = 1 Interlaken Word

SOP	
Header	Stream ID
Class ID 1	Class ID 2
TSI	TSF 1
TSF 2	CAM
Message ID	CIF0
Context	Context
Context	Context
Context	Context
Context	Context/Pad
Context/Pad	Context/Pad
Context/Pad	Context/Pad
Context/Pad	Context/Pad
EOP	

← Interlaken Start of Packet Command

VRT Command Prologue. 36 Bytes.

Note that Controlee/Controller ID/UUID is not included in the Prologue, as ODI is a point-to-point bus without ambiguity of which device sent a message or received a message.

← Interlaken End of Packet

Command Packet Structure, Header

<table>
<tr><td>31</td><td>30</td><td>29</td><td>28</td><td>27</td><td>26</td><td>25</td><td>24</td><td>23</td><td>22</td><td>21</td><td>20</td><td>19</td><td>18</td><td>17</td><td>16</td><td>15</td><td>14</td><td>13</td><td>12</td><td>11</td><td>10</td><td>9</td><td>8</td><td>7</td><td>6</td><td>5</td><td>4</td><td>3</td><td>2</td><td>1</td><td>0</td></tr>
<tr><td colspan="4">Packet Type</td><td>C</td><td colspan="3">Indica-tors</td><td colspan="2">TSI</td><td colspan="2">TSF</td><td colspan="4">Packet Count</td><td colspan="16">Packet Size</td></tr>
<tr><td>0</td><td>1</td><td>1</td><td>0</td><td>C</td><td>A</td><td>R</td><td>L</td><td colspan="2">TSI</td><td colspan="2">TSF</td><td colspan="4">Pkt Count</td><td colspan="16">Packet Size</td></tr>
<tr><td></td><td></td><td></td><td></td><td>1</td><td></td><td>0</td><td></td><td colspan="2"></td><td colspan="2"></td><td colspan="4"></td><td colspan="16"></td></tr>
</table>

vita49d2-drawings_20170315.vsd

Figure 8.2-2: Command Packet Header

- Packet Type (28-31): Packet Type SHALL be the value 0110 as shown
- C bit (27) SHALL be set to 1. This indicates a Class ID fields are present
- A bit (26) SHALL be set to 0 for Control Packets, and 1 for Acknowledgement Packets
- R bit (25) is reserved and SHALL be set to 0 for all Command Packets
- L bit (24) SHALL be set to 1 to indicate a Control-Cancellation packet, and set to 0 otherwise
- TSI bits (22-23) SHALL be set to either 01, 10, or 11, depending on the VITA timestamp method chosen. These indicate that TimeStamp-Integer field is present. If the device does not support timestamps, then 11 SHALL be used.
- TSF bits (20-21) SHALL be set to either 01, 10, or 11, depending on the VITA timestamp method chosen. These indicate that TimeStamp-Fractional fields are present. If the device does not support timestamps, then 01 SHALL be used.
- When a Command Packet Stream is paired to a Data Packet Stream, the TSI and TSF fields SHALL be the same.
- Packet Count (16-19) is a modulo-16 counter that counts the number of Command packets sent. Bit 16 is the LSB. Packet Count will increment for each packet sent.
- Packet Size (0-15) indicates how many VRT 32-bit (4-Byte) words are present in the entire Command packet, including the mandatory Prologue fields.

Command Packet Structure, Stream ID

- Stream ID is an abbreviation for Stream Identifier
- The Stream ID is a 32-bit field, whose value is the same for all data and command packets associated with that stream
- RULE: The Stream ID for a Command Packet SHALL match the Stream ID for the related Data Packet Stream.
- OBSERVATION: ODI-2 specifies that Data Packet Stream IDs must be programmable by the user. Since related Command Packets must share the same Stream ID, they must also be programmable to the same value.
- OBSERVATION: The default Stream ID is 4096, the same as for Data packets.

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0

Figure shows Stream ID field configured for Stream ID= 4096

Interlaken Command
VRT Prologue & Trailer
Data

Command Packet – Class ID

8 Bytes = 1 Interlaken Word

SOP	
Header	Stream ID
Class ID 1	Class ID 2
TSI	TSF 1
TSF 2	CAM
Message ID	CIF0
Context	Context
Context	Context
Context	Context
Context	Context/Pad
Context/Pad	Context/Pad
Context/Pad	Context/Pad
Context/Pad	Context/Pad
EOP	

SOP: Interlaken Start of Packet Command

Class ID

RECOMMENDATION: The Class ID in the Acknowledgment Packet SHOULD match that used in the corresponding Control Packet.

OBSERVATION: The Recommendation above is the same in V49.2 Recommendation 8.2-1.

EOP: Interlaken End of Packet

Command Packet – CAM

Legend
Interlaken Command
VRT Prologue & Trailer
Data

← 8 Bytes → = 1 Interlaken Word

SOP	
Header	Stream ID
Class ID 1	Class ID 2
TSI	TSF 1
TSF 2	CAM
Message ID	CIF0
Context	Context
Context	Context
Context	Context
Context	Context/Pad
Context/Pad	Context/Pad
Context/Pad	Context/Pad
Context/Pad	Context/Pad
EOP	

← Interlaken Start of Packet Command (SOP)

← **Control/Acknowledge Mode** (CAM)

The CAM field will be set as required by each packet type.

← Interlaken End of Packet (EOP)

Command Packet – Message ID

Legend:
- Interlaken Command
- VRT Prologue & Trailer
- Data

← 8 Bytes → = 1 Interlaken Word

SOP	
Header	Stream ID
Class ID 1	Class ID 2
TSI	TSF 1
TSF 2	CAM
Message ID	CIF0
Context	Context
Context	Context
Context	Context
Context	Context/Pad
Context/Pad	Context/Pad
Context/Pad	Context/Pad
Context/Pad	Context/Pad
EOP	

← Interlaken Start of Packet Command (SOP)

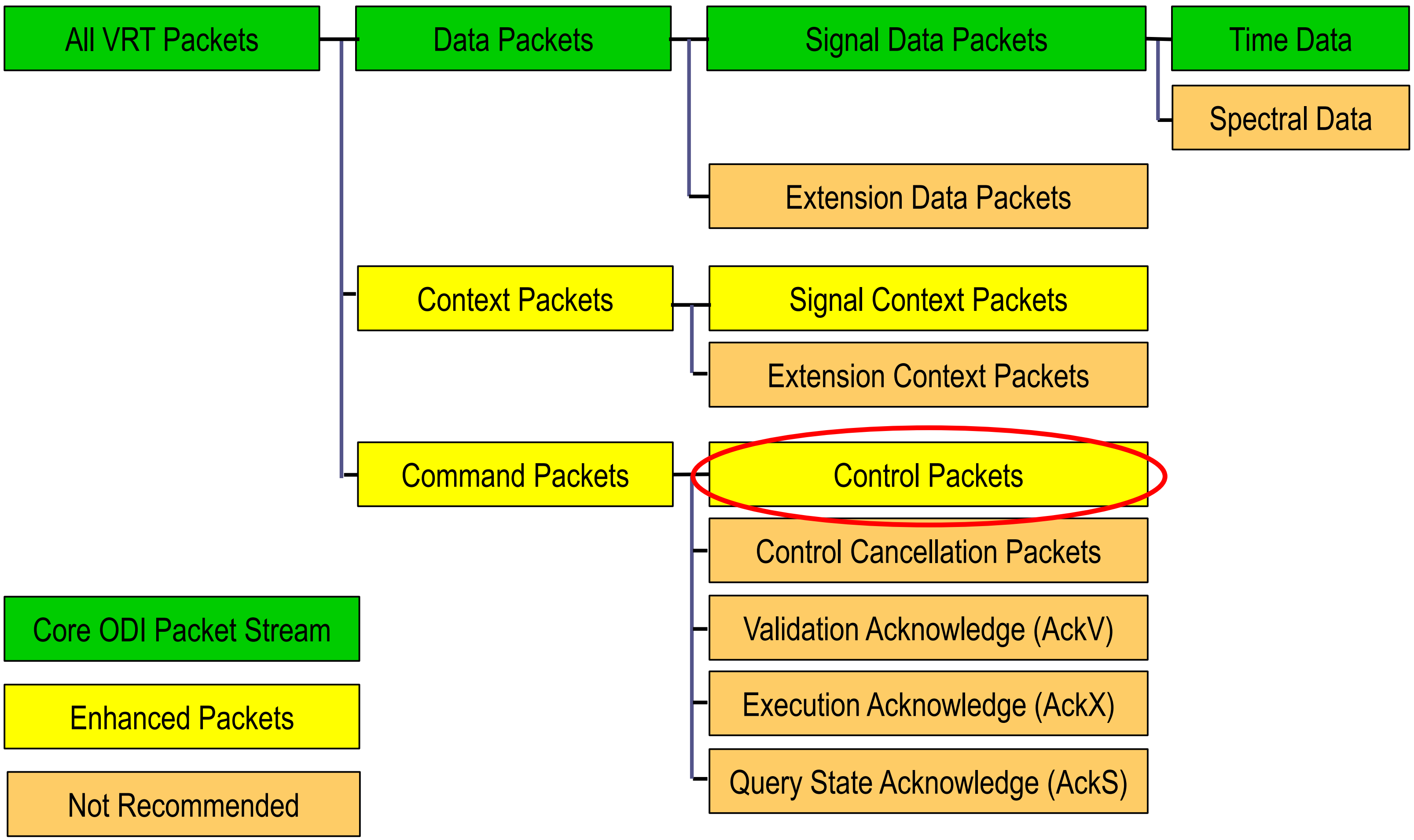
← **Message ID** (Message ID)

RULE: Each new Control Packet SHALL have a unique Message ID.

OBSERVATION: This Rule can be met with a counter that is incremented for each Control Packet.

← Interlaken End of Packet (EOP)

Control Packet Subtype



Control Packet Subtype

- The Control Packet is the most basic of Command Packet subtypes. It may be used in a system as the only Command Packet, or along with the other Command Packet subtypes.
- Like the Context packet, the Control packet adds indicator fields (designated "Control Indicator Field(s)") to the packet body to indicate which data fields are present in the packet.
- The Control Packet uses the Control/Acknowledge Mode (CAM) field to designate how and when a Controllee is to put Controls into effect, and how a Controllee is to acknowledge the Controller. Through the mode field, a Controller can specify that a Controllee merely evaluate the Control packet for correctness, without putting the controls into effect. It can also choose from multiple types of acknowledge: validation, execution, and query-state.
- The timestamp can be used to specify an exact time for execution of the controls in the packet. The Control packet features the ability to cancel a scheduled control or set of controls before they are executed by a device.

Control Packet Subtype – CAM field

	31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
	Ctrl											Ctrl & Ack									Ack Only				Reserved							
	CE	IE	CR	IR	P	W	Er	A1	A0	Nack	Res	ReqV	ReqX	ReqS	ReqW	ReqEr	Res	Ctrl T2	Ctrl T1	CtRl T0	0	0	0	0								
RULE:	0	0	0	0	x	x	x	x	x	x	0	x	x	x	x	x	0	x	x	x	0	0	0	0	0	0	0	0	0	0	0	0
RECOMMEND:	0	0	0	0	1	1	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

- The diagram above shows the values of the bits within the CAM field for ODI-2
- P (partial execution) will be set as in V49.2. RECOMMENDATION: Set P to 1.
- W (Warnings) will be set as in V49.2. RECOMMENDATION: Set W to 1.
- Er (Errors) will be set as in V49.2. RECOMMENDATION: Set Er to 1.
- A1 and A0 (Actions) will be set as in V49.2. RECOMMENDATION: Set A1/A0 to 10.
- NACK (Not Acknowledge Only) will be set as in V49.2. RECOMMENDATION: Set NACK to 0
- ReqV (Request Validation Ack. packet) will be set as in V49.2. RECOMMENDATION: Set ReqV to 0
- ReqX (Request Ack. Execution packet) will be set as in V49.2. RECOMMENDATION: Set ReqX to 0
- ReqS (Request Ack. Query State packet) will be set as in V49.2. RECOMMENDATION: Set ReqS to 0
- ReqW (Request Warning Ack. packet) will be set as in V49.2. RECOMMENDATION: Set ReqW to 0
- ReqEr (Request Warning Ack. packet) will be set as in V49.2. RECOMMENDATION: Set ReqEr to 0
- Ctrl T0-T2 (Timing Control) will be set as in V49.2. RECOMMENDATION: Set Ctrl T0-T2 to 000

Control Packet – Context

- Interlaken Command
- VRT Prologue & Trailer
- Data

← 8 Bytes → = 1 Interlaken Word

SOP	
Header	Stream ID
Class ID 1	Class ID 2
TSI	TSF 1
TSF 2	CAM
Message ID	CIF0
Context	Context
Context	Context
Context	Context
Context	Context/Pad
Context/Pad	Context/Pad
Context/Pad	Context/Pad
Context/Pad	Context/Pad
EOP	

← Interlaken Start of Packet Command

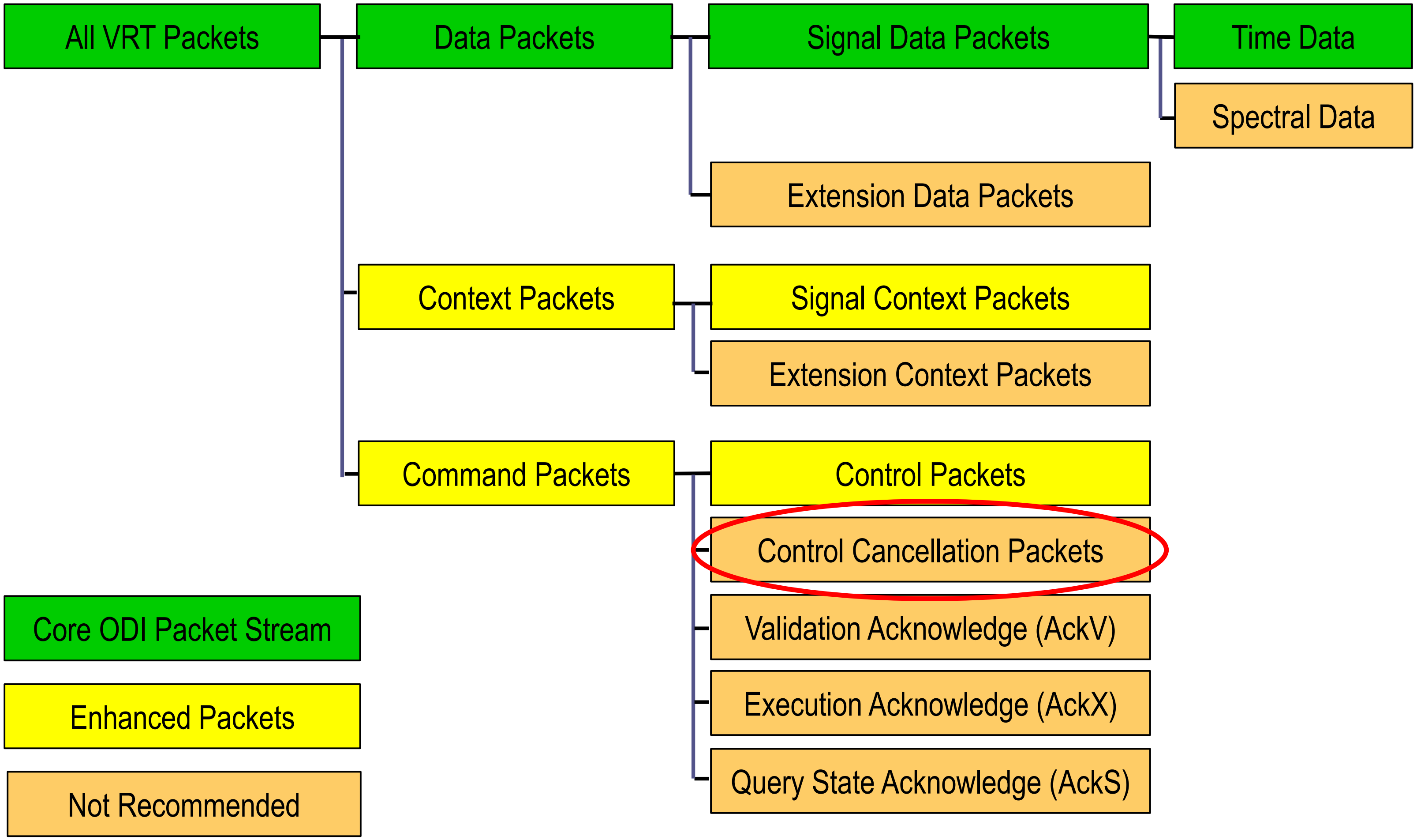
← **Context/Command Fields**

RULE: CIF0 field SHALL be Included

OBSERVATION: The Context/Command Fields will be an integer multiple of 32 Bytes -4 to comply with the Rule that all packets be a multiple of 32 Bytes.

← Interlaken End of Packet

Control Cancellation Packet Subtype



Control Cancellation Packet Subtype

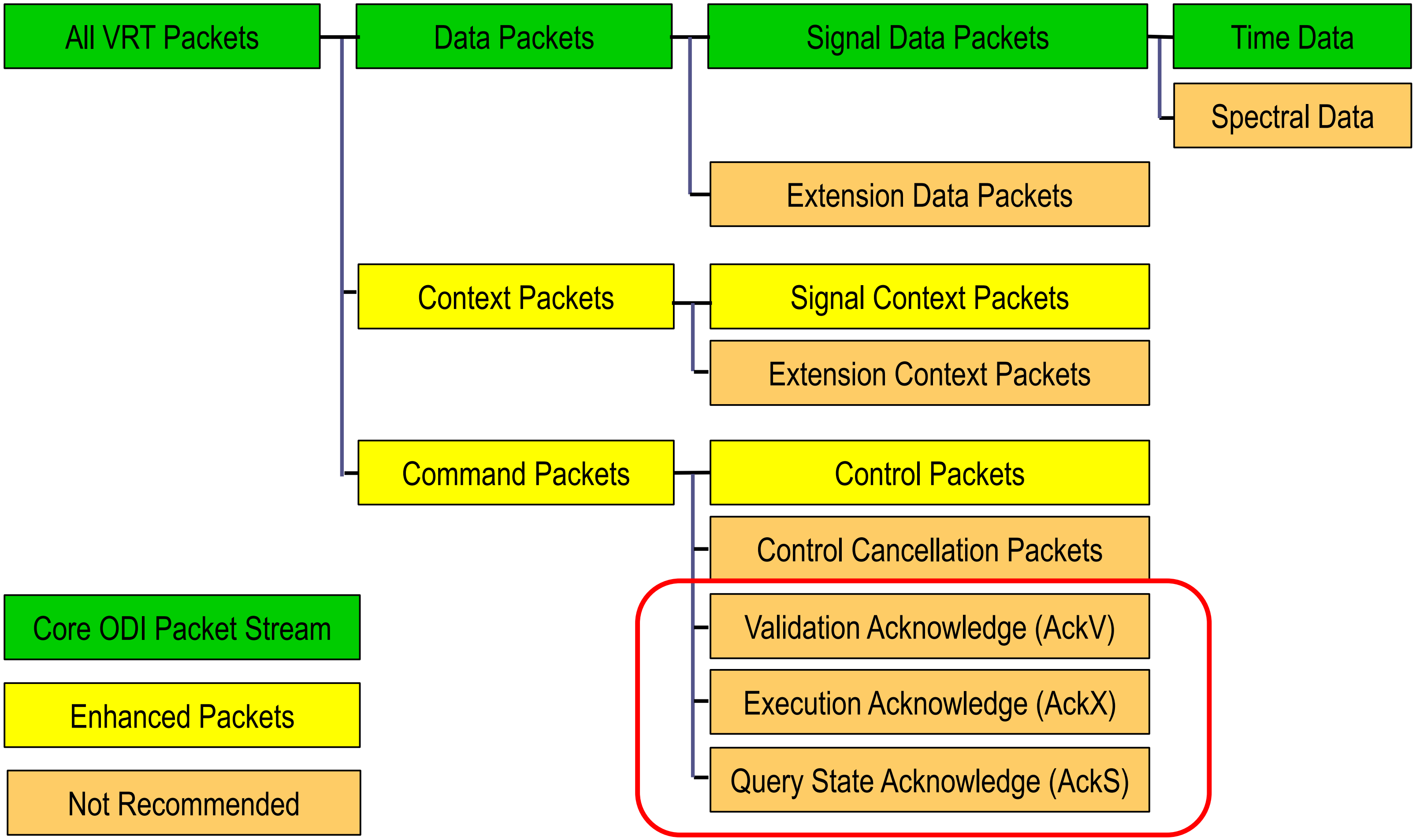
- Due to the speeds involved, Control Cancellation is not recommended.
- A Control-Cancellation packet is issued when the packet-header packet-specific Indicators cmdH-L is set to 1. This will interrupt the implementation of scheduled but not yet executed controls. They will be cancelled and removed from a device's command queue.

SOP	
Header	Stream ID
Class ID 1	Class ID 2
TSI	TSF 1
TSF 2	CAM
Message ID	CIF0
CIF1	CIF2
CIFx…	Pad
Pad	Pad
EOP	

- The Control Cancellation Packet is the same as the Control Packet EXCEPT it does NOT have fields after the CIFs.

- In the diagram to the left this means only CIFX fields are in the Context portion, and any remaining fields will be null to meet the 32 Byte multiple length requirement.

Acknowledge Packet Subtype



Acknowledge Packets

- Due to the speeds involved, Acknowledge Packets are not recommended.
- An Acknowledge Packet shall be of only one subtype- a Validation Acknowledge, an Execution Acknowledge, or a Query-State Acknowledge
- To meet the above rule, it SHALL have only one bit out of three AckV, AckX, and AckS bits set to one.
- Acknowledge Packets SHALL comply to the rules set out for the Acknowledge Packet Subtype in Section 8.4 of V49.2

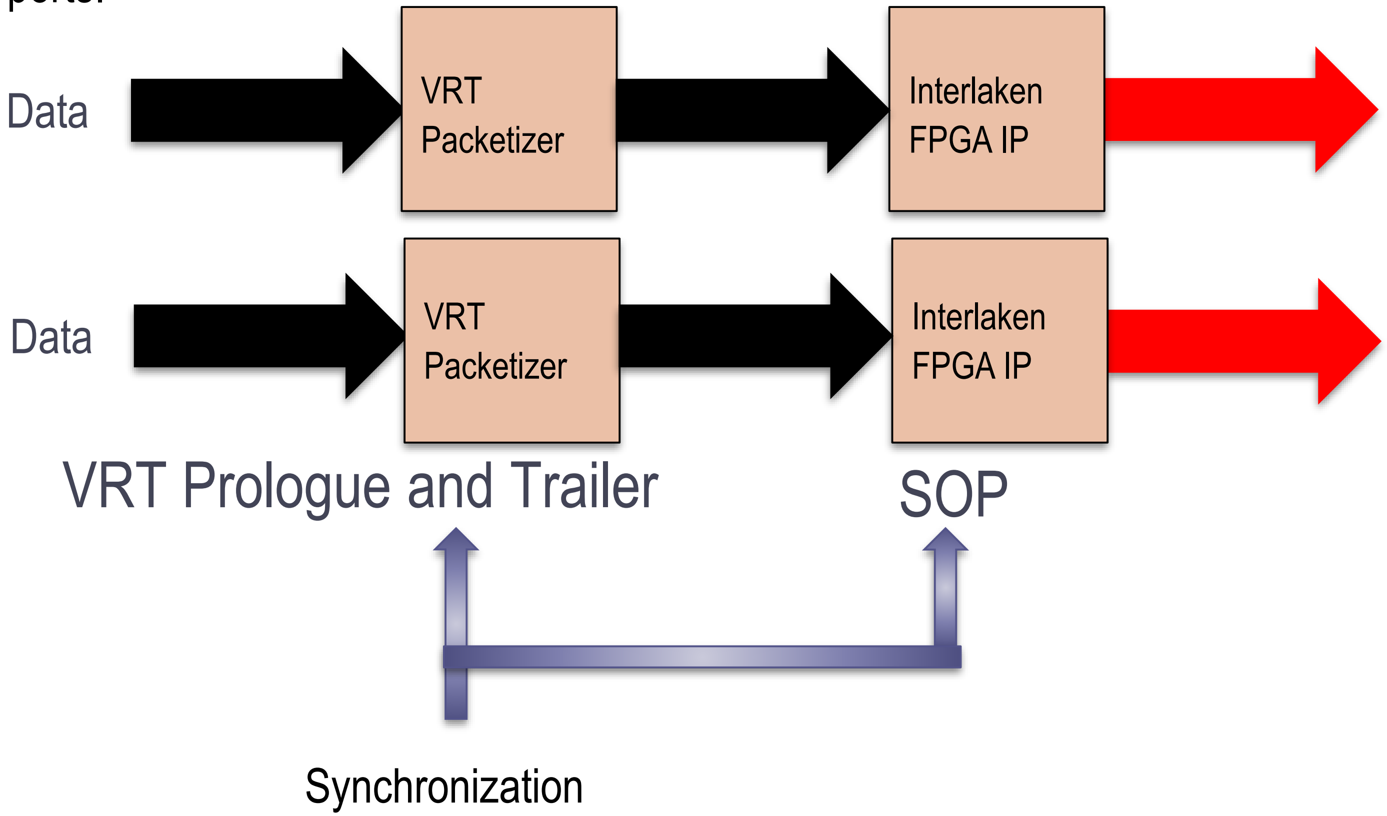
ODI-2 Port Aggregation

ODI-2 Port Aggregation

- ODI-2 Port Aggregation a method to use multiple ports to send a synchronous data at higher speeds than can be achieved with a single port.
- Port aggregation is an optional capability.
- Port Aggregation does NOT include using multiple ports to send simultaneous asynchronous data streams. That ability is already allowed in ODI-1, and does not need any further specification.
- The two use cases for port aggregation are:
  - Transporting multi-channel data whose aggregate bandwidth is beyond the single port bandwidth
  - Transporting single channel data whose aggregate bandwidth is beyond the single port bandwidth
- ODI-2 uses the VRT packet structure, coupled with Interlaken SOP (Start of Packet commands) to synchronize data across multiple ports.
- There is no theoretical limit to the number of ports that can be aggregated, but four ports is a feasible number.
- ODI-2 uses a per-port method of flow control over aggregated ports.

Port Aggregation – Synchronizing Packets

Synchronization occurs by sending equal-sample-length VRT packets simultaneously. The beginning of all packets start at the same time, indicated by an Interlaken SOP signal. Using this method, EOP may not occur on all ports simultaneously, but often does. The VRT packetizer consists of inserting 28 Byte Prologue and 4 Byte Trailer around the block data, as defined earlier in ODI-2. This method guarantees that sample data from the same period of time is transported across all ports.



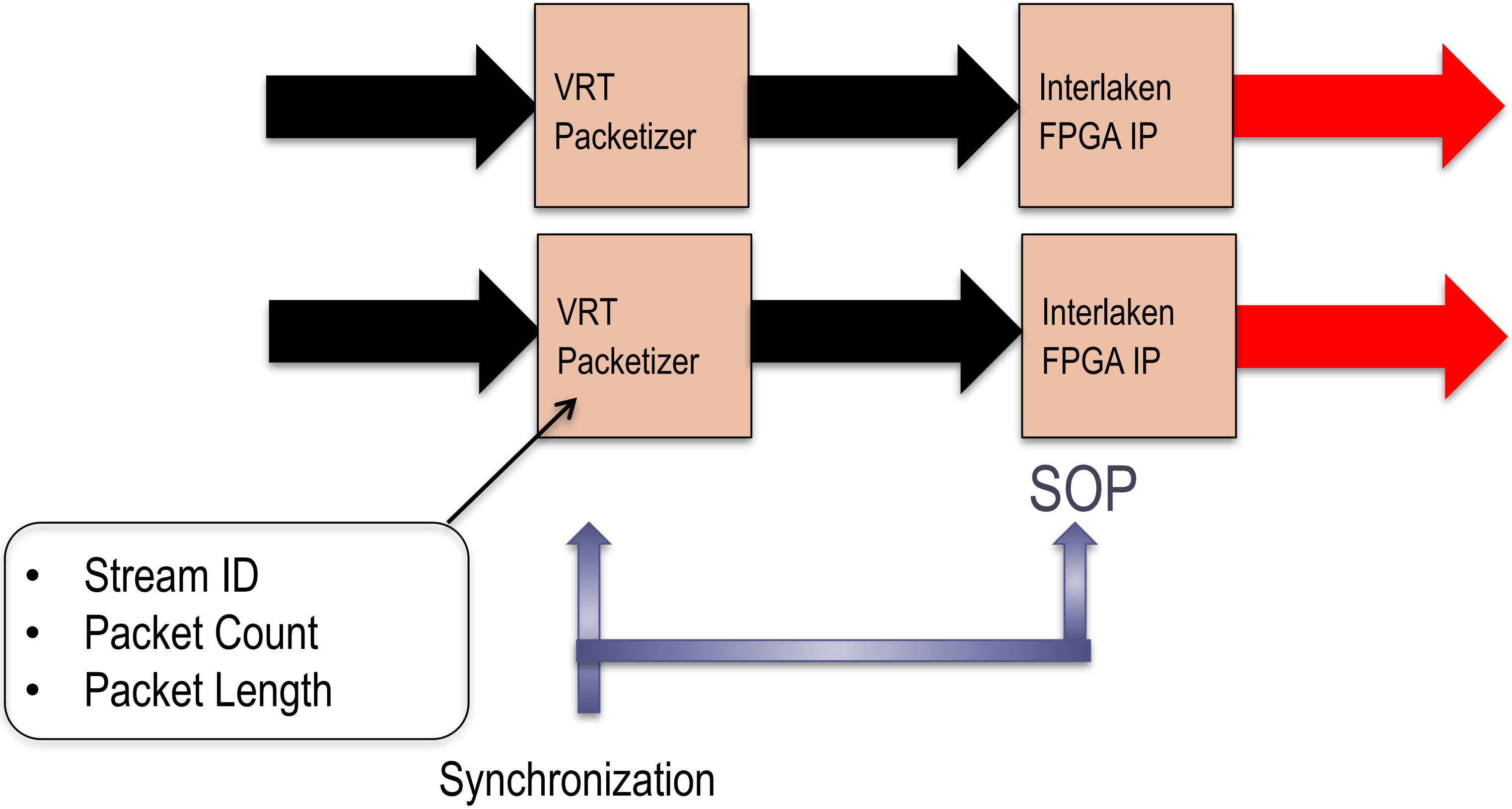
ODI-2 Port Aggregation – Synchronization 1

- RULE: ODI-2 producers that implement port aggregation SHALL send Interlaken SOP signals to the FPGA IP on all aggregated ports within 5 ns of each other.
- OBSERVATION: This is a rule on the internal method of sending simultaneous SOP to each port. Feasible implementations will use hardware signals sent to all ODI ports simultaneously, which will be well under the 5ns limit. Due to the differential latency of each port, the actual SOPs may occur on the ODI port outputs more than 5ns apart.

Port Aggregation – Synchronizing Packets (2)

Stream ID: A separate Stream ID SHALL be assigned to each stream. This allows stored data to distinguish between ports.

Packet Count in the header SHALL begin with zero for the first packet, and is incremented after each packet is sent. This allows the consumer to align packets correctly.

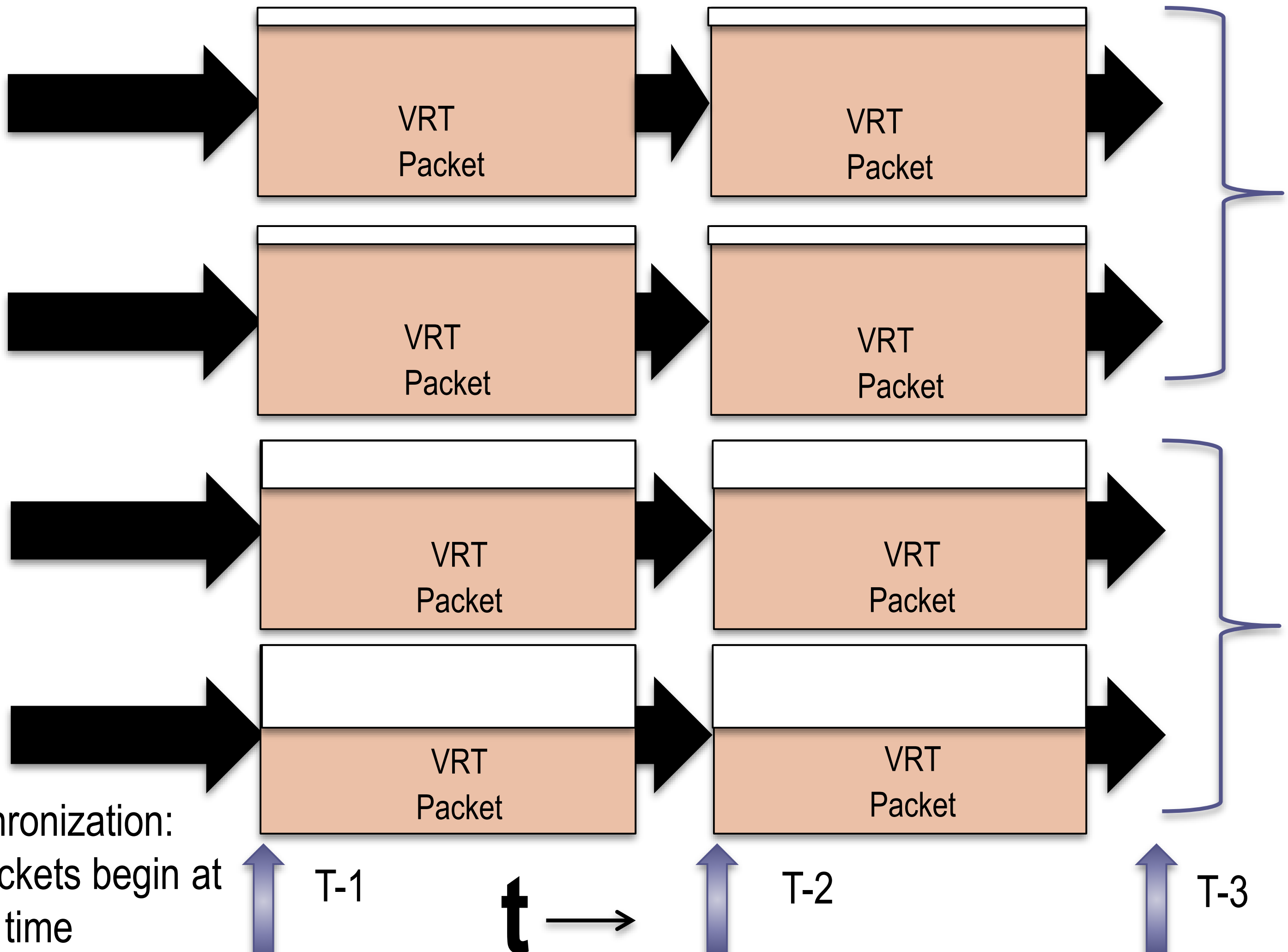


Stream ID and Packet Count

- RULE: In a multi-port device where the ports are to be aggregated, each additional port's Stream ID SHALL be incremented by 1024.
- OBSERVATION: In a 4-port aggregation, the default Stream IDs are
  - Port 1: 4096
  - Port 2: 5120
  - Port 3: 6144
  - Port 4: 7168
- OBSERVATION: By incrementing by 1024 for each additional port, each port can be identified by the Stream ID. Incrementing by 1024 still allows downstream devices processing the data to increment the Stream ID by 1, as envisioned by VITA 49A, without causing duplication of Stream ID.
- RULE: Packet Count in the header SHALL begin with zero for the first packet, and is incremented after each packet is sent.
- OBSERVATION: This rule allows the consumer to align packets correctly.
- RULE: ALL ports being aggregated SHALL send the same Packet Count for each synchronized packet across all ports
- OBSERVATION: the above rule allows recovery from a line outage, perhaps caused by an Electrostatic Discharge event. Since Packet Count is a modulo-16 counter, it unambiguously aligns the beginning of a packet with the correct packet.

Port Aggregation – Single and Multi-channel Data

Complete packets are not buffered, just enough for an Interlaken burst of 2K bytes. Max packet size is <256K bytes, implying 127 Interlaken bursts. Brown area indicates duty cycle.



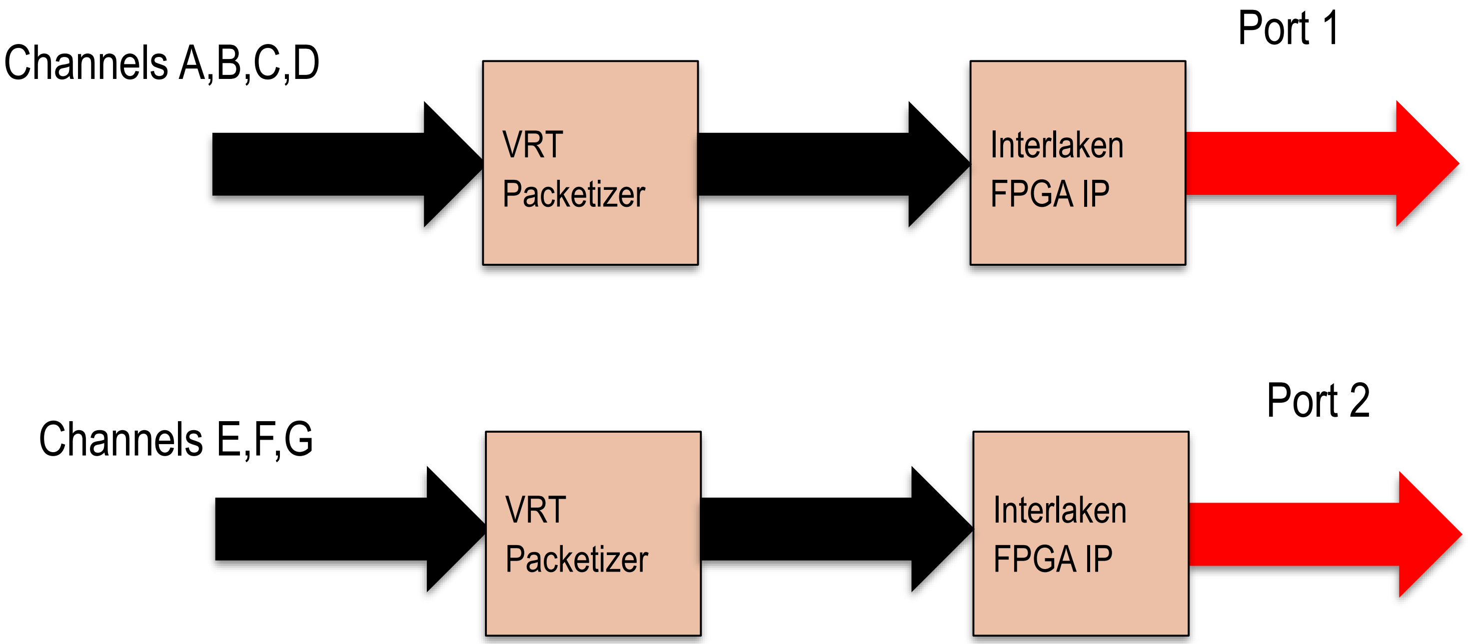
Example of very high speed single channel data split into two port

Example of multi-channel data on two ports, where one port has more channels than the other

Synchronization: All packets begin at same time

Port Aggregation – Multiple channels

Synchronization occurs by sending equal-sample-length VRT packets simultaneously. The beginning of all packets will start at the same time, indicated by an Interlaken SOP signal. EOP may not occur simultaneously, but must occur before the next SOP.



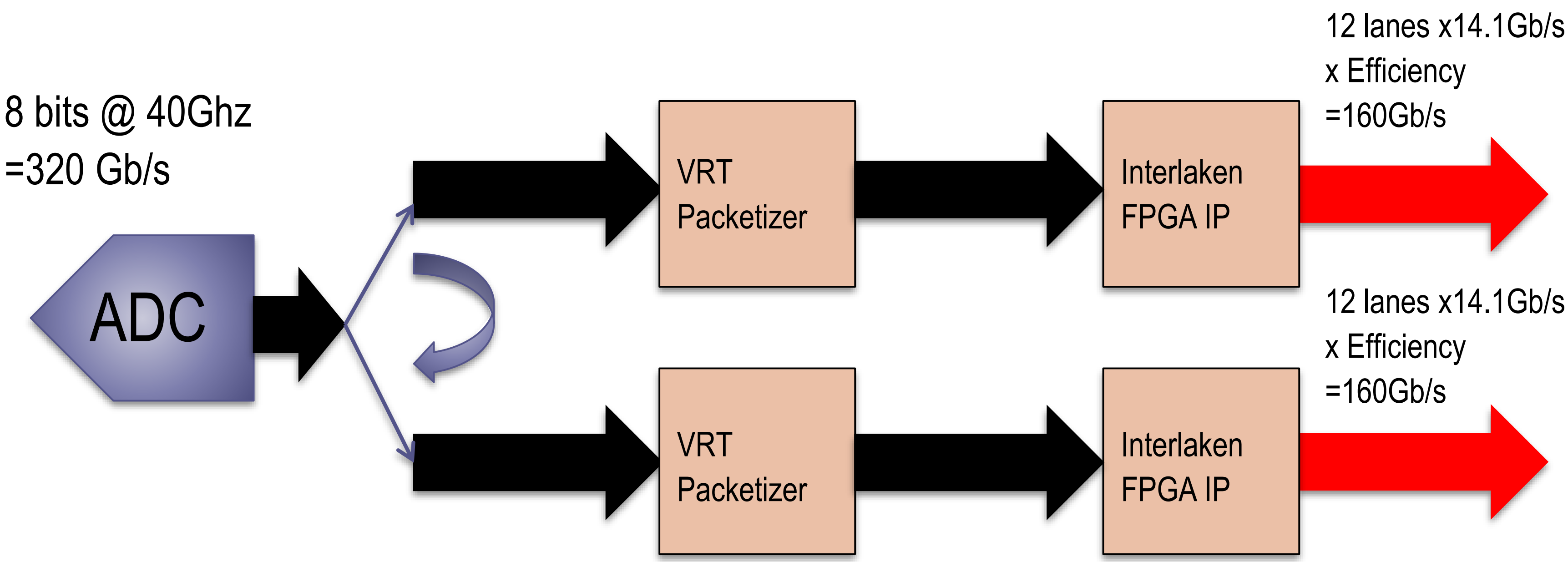
In the example above, all channels send the same number of samples per packet. Therefore, the packet size of Port 1 will be 1.33 that of Port 2.

ODI-2 Port Aggregation – Multiple Channels

- RULE: ODI-2 devices that implement port aggregation SHALL send the same number of samples per channel per packet across all ports
- OBSERVATION: The above rule ensures that the number of samples for each channel will be the same across all packets being sent simultaneously. By definition, it also ensures that each packet covers the same time period.
- PERMISSION: For multi-channel data, a device MAY include more channels on one port than another.
- OBSERVATION: The above permission reflects the fact that the number of channels may not be cleanly divisible by the number of ports.
- RECOMMENDATION: A device SHOULD NOT include more than one channel on any given port than it includes on another given port.
- OBSERVATION: The above recommendation minimizes differences in packet sizes between aggregated ports.

Port Aggregation – Single channel, Transmission

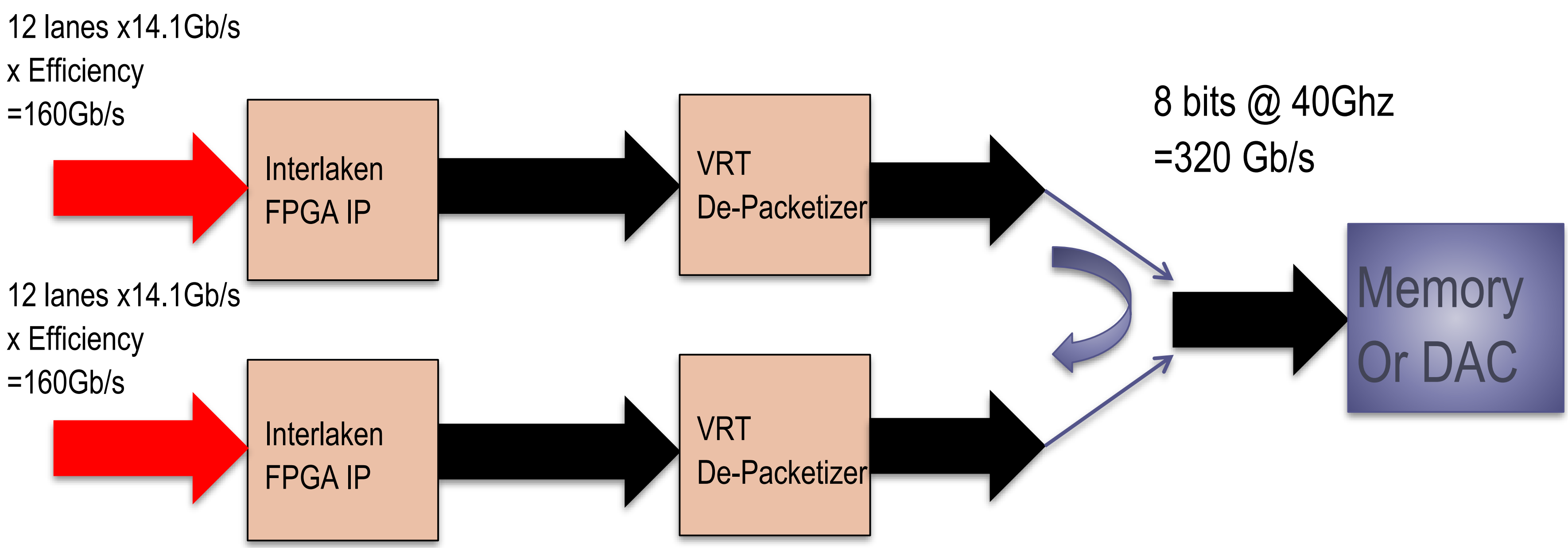
Samples of a single channel are sent in a round robin fashion to each port, packaged in a VRT packet. Here is an example:



- Consecutive samples are transmitted in a round robin technique to each port.
- Interlaken SOP bit is set on each port at beginning of VRT packet. This allows port alignment.
- The example shows 2 port aggregation. Any number of ports my be aggregated.

Port Aggregation – Single channel, Reception

VRT Packets are extracted from each port, and the data interleaved again to form the original stream. Example:



- Interleaved data in a round robin technique to create original stream
- Interlaken SOP bit set on each port at beginning of VRT packet. This allows port alignment.
- The example shows 2 port aggregation. Any number of ports my be aggregated

ODI-2 Port Aggregation – Single Channel

- RULE: ODI-2 devices that implement port aggregation for a single channel SHALL send the same number of samples per packet across all ports
- OBSERVATION: The above rule ensures straight forward interleaving of packets.

Port Aggregation – Flow control

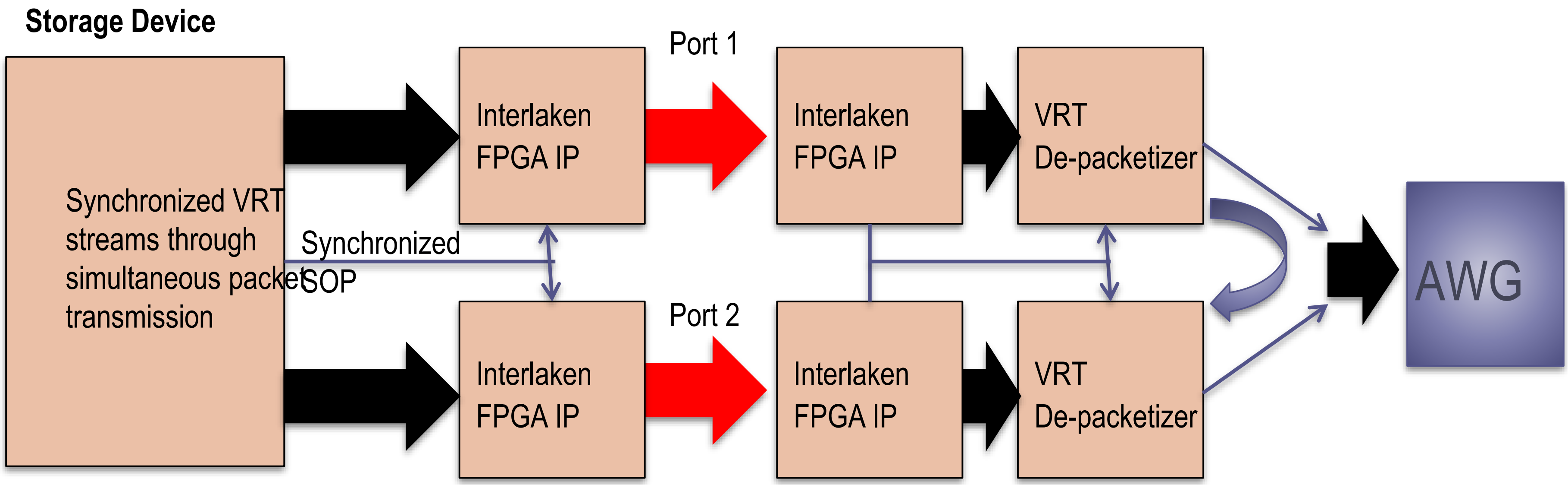
- Flow control is needed in any application where the consumer is pacing the timing of the samples. This is most common when an AWG (arbitrary waveform generator) or other type of signal generator uses flow control to keep the average rate of data from the producer, which could be a storage device, to match its own sampling rate.
- Flow control has been defined earlier in ODI-1 on a per port basis. There are two methods, In-Band and Out of Band. Both rely on XON/XOFF signals being sent from the consumer to the producer, either by a reverse Interlaken link, or an explicit electrical signal.
- Port Aggregation uses a per-port method of flow control. That is, each port is controlled with separate XON/XOFF signals as with the single port flow control model.

Port Aggregation – Flow control

- RULE: During port aggregation all ports using flow control SHALL use either In-Band flow control or Out-of-Band flow control, but not a mixture of the two.
- OBSERVATION: Out-of-Band flow control requires an electrical signal for each port. Therefore a 4-port device would require four electrical signals. PXI and AXIe support 8 and 12 trigger lines respectively, and these lines can be designated to be the OOB flow control lines. It is possible to define an ODI system that requires more flow control lines than the number of backplane trigger lines in a modular instrument system.
- RECOMMENDATION: Devices that support OOB flow control SHOULD include an explicit OOB signal for each port.
- OBSERVATION: The above recommendation allows direct connections between devices without the use of modular backplane signals. This is useful for connecting non-modular devices together, or for expanding the OOB flow control capacity of a modular system.

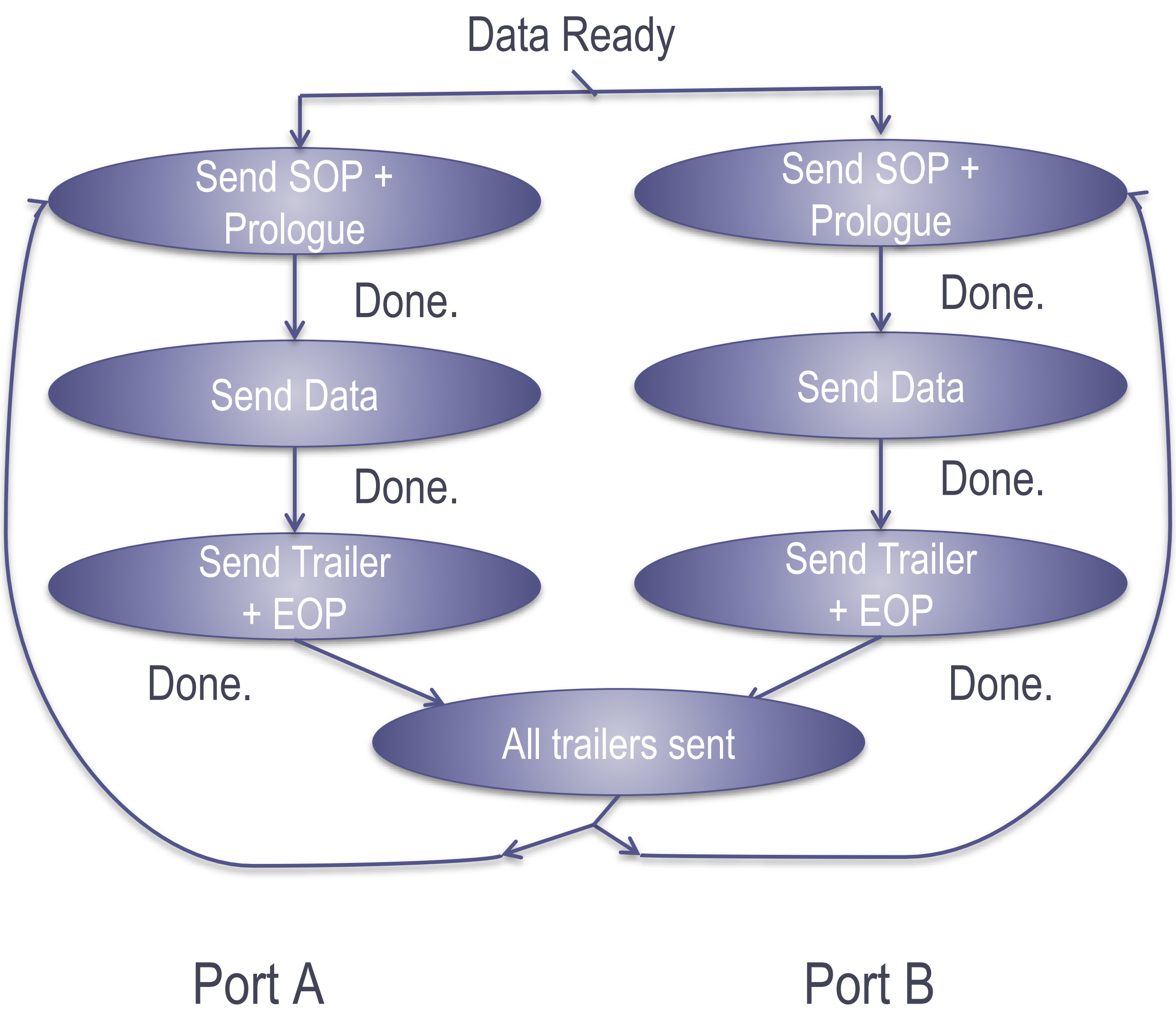
Port Aggregation – Flow control

With port aggregation, the producer forces parallel synchronous packet transmission, with SOP on all streams occurring within a defined window. **Shown without flow control**



The consumer aligns the incoming packets so the VRT Data Payload (raw sample data) is perfectly aligned across all ports. These samples are either interwoven (as shown, which is the case of fast single channel data) or sent synchronously to multiple channels.

State diagram: Xmit Train Packets Producer



For port aggregation, the SOP and Prologue are sent nearly simultaneously on all ports.

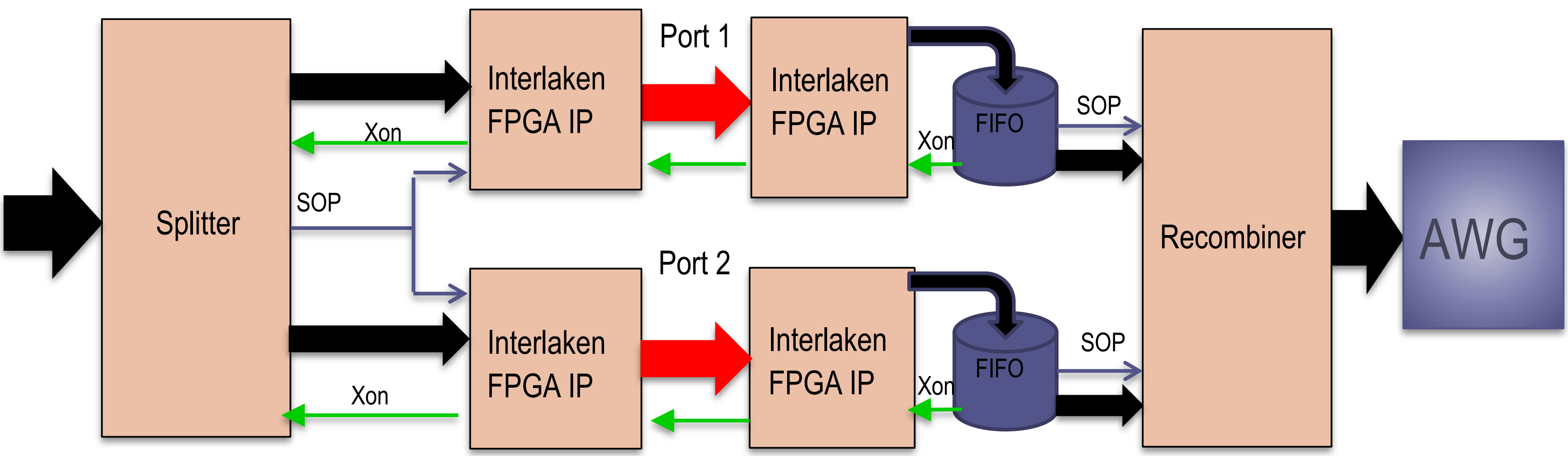
This is done by initializing the FPGA IP within 5ns on all ports to start SOP and the Prologue.

The producer waits until EOP is sent on all ports before starting the process again.

Note: The Modulo-16 counter in the Prologue of each port is the same. This allows time matching of packets after an outage.

Aggregating Ports – Flow control per port

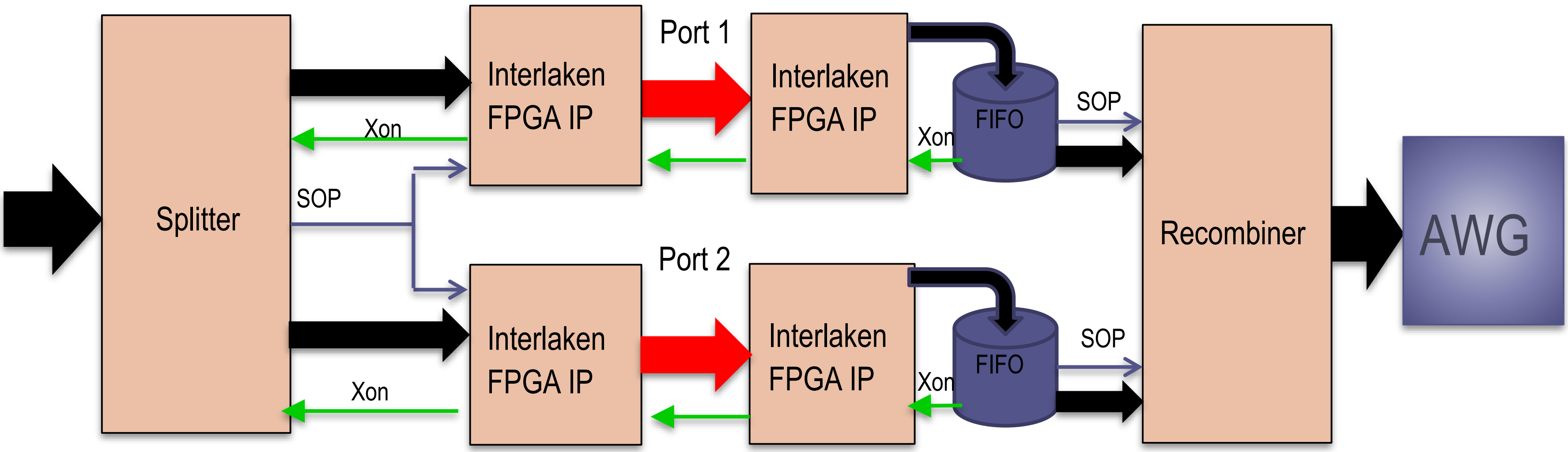
With per port flow control, each port is controlled independently from the consumer.
Here is the previous example shown with per port flow control and the FIFO buffer.
Flow control is shown in green.



Since the packets are aligned at SOP, they will each be transported before the next SOP.
This allows uneven packet lengths, such as when there are more channels on one port than another, to be handled appropriately by the consumer.

Aggregating Ports – Packet Alignment

Receivers use SOP to re-align packets.



Splitter:

1. Before sending a set of packets, wait for Xon from all ports.
2. Start sending on all ports (with SOP) simultaneously.
3. Wait for all ports to finish sending packets.
4. Go to 1.

Recombiner: Note FIFO directly controls Xon. Timeout T1, is greater than worst-case latency variation.

1. On all ports, read and discard FIFO words until next word on all ports has SOP.
   a) Discard any unexpected words without SOP.
   b) After SOP is on any port, allow up to T1 seconds for SOP to appear on all ports. If SOP on all ports go to 2, if not read and discard SOP word and go back to 1.
2. Read SOP word from all ports. Verify Packet Count field in the VITA-49 header is the same for each port. If not, discard and go to 1.
3. Continue reading words from all ports, recombining data, until EOP is received on all ports. If any port reports error (CRC) or SOP appears before EOP, then mark packet as bad.
4. Go to 1.

Note: T1 constraints will be defined in more detail, but is typically shorter than a Data Packet length.

Documentation requirements

- RULE: All ODI-2 devices SHALL document the VRT packet structures and classes that they support.
- OBSERVATION: The above rule aligns with the VITA 49.2 rule of documenting all packet structures. Following the VITA rules will meet the above ODI-2 rule.
- RULE: All ODI-2 devices SHALL document their port aggregation capabilities, including:
  - -Number of ports capable of being aggregated
  - -Single port bandwidth requirements or capability when in port aggregation mode
  - -In Band and Out of Band flow control modes supported
  - -Per port and en banc flow control modes supported.