Cboe Australia
Multicast TOP Specification

Version 1.0.6

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Contents

1 Introduction

1.1 Overview

This specification is the standard Multicast TOP specification for the Cboe Australia ("CXA") platform.

Clients may use the Multicast TOP protocol to receive real-time top of book quotations directly from CXA. Market data received through Multicast TOP is less timely than receiving the same data from the CXA Multicast PITCH Depth of Book feed. The TOP protocol offers approximately 66% reduction in the number of events and 66% reduction in the number of bytes of application data sent, compared to the CXA Multicast PITCH protocol.

The quotations received via Multicast TOP provide an aggregated size and do not indicate the size or number of individual orders at the best bid or ask. The Multicast TOP protocol also provides last trade price and size and cumulative volume data.

Complete depth of book market data can be received via the CXA Multicast PITCH protocol.

CXA TOP cannot be used to enter orders. For order entry, refer to the appropriate FIX or BOE Specification.

All versions of the Multicast TOP feed will be Gig-shaped and will be available from one or both of CXA's datacentres. Clients may choose to take one or more of the following Multicast TOP feeds depending on their location and connectivity to CXA.

Multicast TOP Feed Descriptions:

Shaping	Served From Data Centre (Primary/Secondary)	Multicast Feed ID
Gig	Primary	AAT
Gig	Primary	ABT
Gig	Secondary	AET

1.2 Feed Connectivity

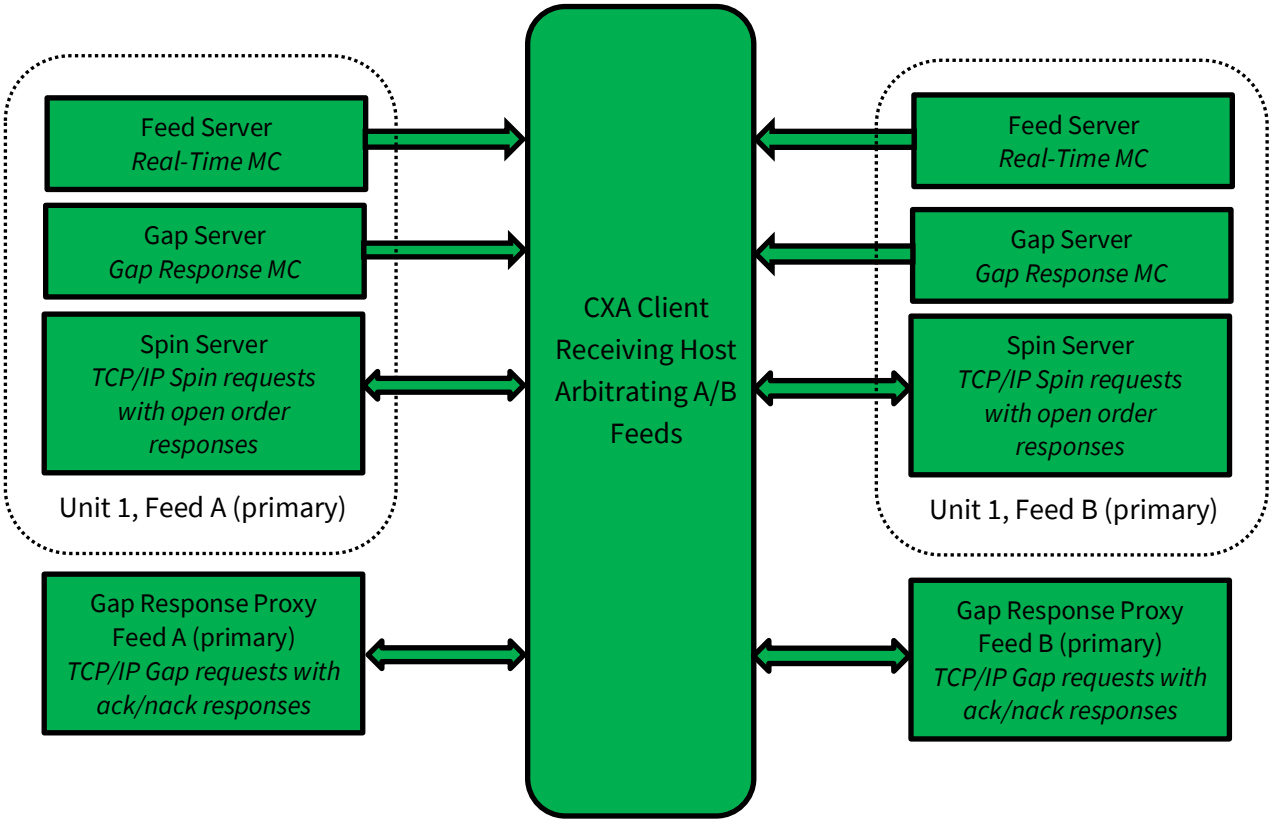
TOP feeds are available to clients who connect to CXA via cross-connect, dedicated circuit, or a supported carrier.

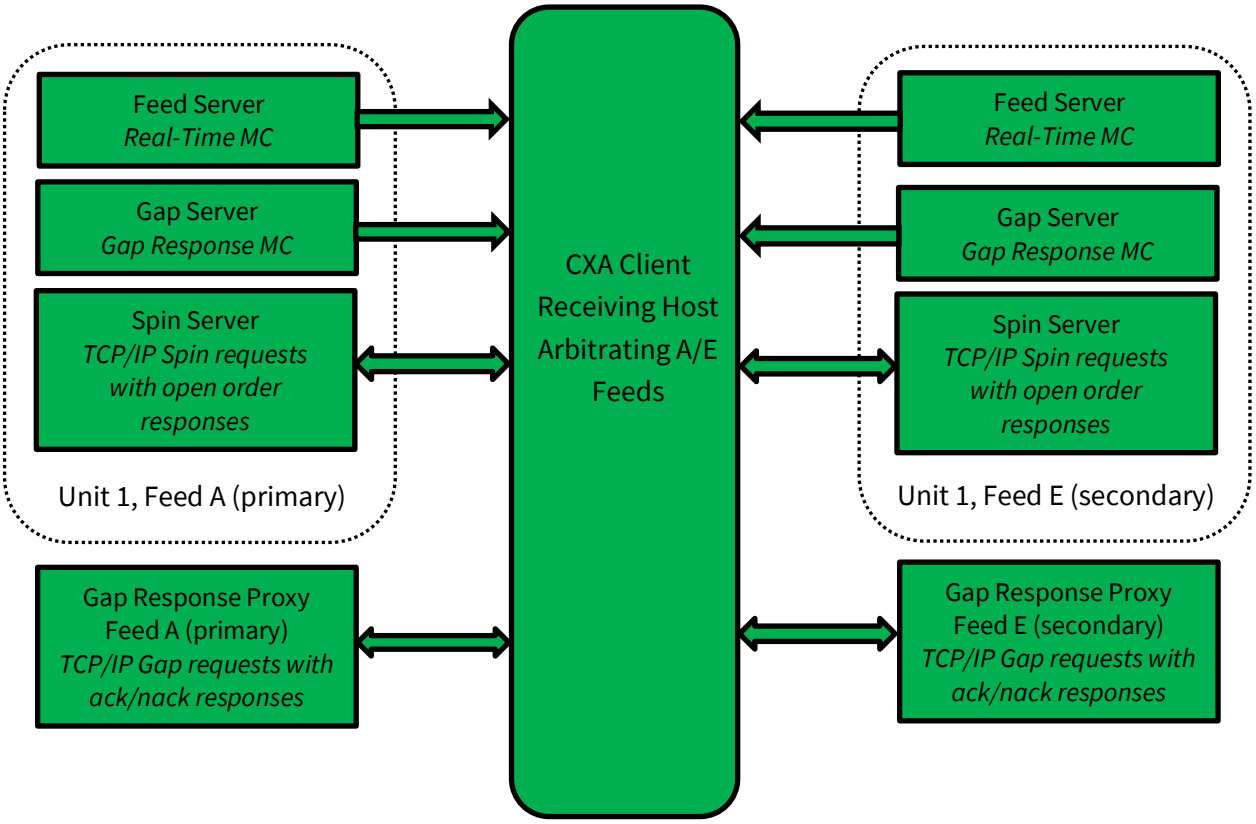
Clients with sufficient connectivity may choose to take both the A and B feeds from CXA's primary datacentre and arbitrate the feeds to recover lost data. Alternatively, clients may choose to arbitrate feeds from both datacentres. It should be noted that feeds from the secondary datacentre will have additional latency compared to those connected with CXA in the primary datacentre due to proximity and business continuity processing.

When arbitrating, the client can utilise the fact the redundant feeds have messages that are sequenced and process the next expected sequence from whichever feed it's received from first. Any duplicate message sequence can be dropped. Arbitration reduces the chances of losing a message due to packet loss.

Multicast TOP real-time events are delivered using a published range of multicast addresses divided by symbol range units. A TCP/IP connection to one of CXA's Gap Request Proxy ("GRP") servers can be used to request dropped messages. Replayed messages are delivered on a separate set of multicast ranges reserved for packet retransmission. Intraday, a spin of the current top of book may be requested from a Spin Server. This allows a client to become current without requesting a gap for all messages up to that point in the day.

The following diagram is a logical representation Multicast TOP feed message flow between CXA and a client feed handler that is listening to the "A", "B" and "E" instances of a unit:





1.3 Symbol Ranges, Units, and Sequence Numbers

Symbols will be separated into units, and the symbol distribution will not change intra-day. CXA does, however, reserve the right to add multicast addresses or change the symbol distribution. Clients will be notified and provided sufficient time to conform with the changes. Care should be taken to ensure that address changes, address additions, and symbol distribution changes can be supported easily.

Message sequence numbers are incremented by one for every sequenced message within a particular symbol unit. It is important to understand that one *or more* units will be delivered on a single multicast address. As with symbol ranges, unit distribution across multicast addresses will not change intra-day but may change after notice has been given.

Symbol distribution across units as well as unit distribution across multicast addresses are identical for real-time and gap response multicast addresses.

1.4 Gap Request Proxy and Message Retransmission

Requesting delivery of missed sequenced data is achieved by establishing a TCP connection to a CXA Gap Request Proxy ("GRP") port. This GRP port is specific to Multicast TOP and is NOT shared with the Multicast PITCH GRP port. Clients who do not wish to request missed messages do not need to connect to a GRP port for any reason or listen to the multicast addresses reserved for message retransmission. Clients choosing to request missed data will need to connect to their assigned GRP port, log in, and request gap ranges as necessary. All gap requests will be responded to with a `Gap Response` message. A `Gap Response` *Status* code of 'A'ccepted signals that the replayed messages will be delivered via the appropriate gap response multicast address. Any other `Gap Response` *Status* code will indicate the reason that the request cannot be serviced.

Gap requests are limited in message count, frequency, and age by the GRP. Gap requests will only be serviced if they are within a defined sequence range of the current multicast sequence number for the requested unit. Clients will receive a total daily allowance of gap requested messages. In addition, each client is given renewable one-second and one-minute gap request limits. If the gap allowances are exceeded the gap request will be rejected as defined in section 4.5. The client can then wait until the time-based gap request limits reset or perform a spin as defined in section 1.5. If the daily allowance of gap requests is exceeded the client must perform a spin.

If more than one gap request is received for a particular unit/sequence/count combination within a short timeframe, all requests will receive a successful `Gap Response` message from the GRP, but only a single replayed message will be sent on the gap response multicast address.

If overlapping gap requests are received within a short period of time, the gap server will only send the union of the sequence ranges across grouped gap requests. Clients will receive gap responses for their

requested unit/sequence/count, but receivers should be prepared for the gap responses to be delivered via multicast in non-contiguous blocks.

Gap acknowledgements or rejects will be delivered to clients for every gap request received by the GRP. Clients should be prepared to see replayed multicast data before or after the receipt of the gap response acknowledgement from the GRP.

Section 4.6 shows an example flow of messages between a client and CXA's Multicast TOP feed, Gap Server, and Gap Request Proxy.

1.5 Spin Servers

A Spin Server is available for each unit. The server allows clients to connect via TCP and receive a spin of the inside book and symbols with limited trading conditions on that unit. By using the spin, a client can get the current CXA book quickly in the middle of the trading session without worry of gap request limits. The Spin Server for each unit is assigned its own address and/or TCP port.

Upon successful login and periodically thereafter, a `Spin Image Available` message is sent which contains a sequence number indicating the most recent message applied to the book. Using a `Spin Request` message, a client may request a spin for the orders up to a sequence number noted within one of the *last ten* `Spin Image Available` messages distributed. If the `Spin Request` submitted does not present a sequence number that matches one of the last ten `Spin Image Available` messages distributed, the spin will return orders up to the next closest sequence number reported through a `Spin Image Available` message that is greater than the sequence number requested.

In the case a client sends a sequence number in a `Spin Request` that is higher than the sequence number reported by the most recent `Spin Image Available` message, the next spin image to be generated will be returned when it is available. If the requested sequence number is still higher at that time, an "O" (Out of Range) error will be generated.

A spin consists of `Trading Status`, `Single Side Update`, `Two Side Update`, and `Calculated Value` messages. While receiving the spin, the client must buffer multicast messages received. If the `Spin Image Available` message sequence number is the client's reference point, multicast messages with larger sequence numbers should be buffered. If a non-`Spin Image Available` sequence number is the client's reference point which they send in their `Spin Request`, they should buffer from that point on. However, the client should then disregard all messages from the feed server that are not greater than the sequence number in the `Spin Response` . When a `Spin Finished` message is received, the buffered messages must be applied to the spun copy of the book to bring it current.

Section 5.8 shows an example flow of messages between a client and CXA's Multicast TOP feed and Spin Server.

Clients are required to send Heartbeat messages to CXA no less than every 5 seconds, even while a spin response is in progress. Failure to do so is the most common cause of Client difficulties while processing spin responses, especially during periods of high market activity. CXA recommends that Clients send a heartbeat every second to stay well within this heartbeat requirement.

2 Protocol

CXA clients may use the TOP protocol over multicast to receive real-time top of book quotations and execution information direct from CXA.

2.1 Message Format

The messages that make up the TOP protocol are delivered using the CXA `Sequenced Unit Header` which handles sequencing and delivery integrity. All messages delivered via multicast as well as to/from the Gap Request Proxy ("GRP") or Spin Server will use the `Sequenced Unit Header` for handling message integrity.

All UDP delivered events will be self-contained. Developers can assume that UDP delivered data will not cross frame boundaries and a single Ethernet frame will contain only one Sequenced Unit Header with associated data.

TCP/IP delivered events from the GRP may cross frames as the data will be delivered as a stream of data with the TCP/IP stack controlling Ethernet framing.

The TOP data feed is comprised of a series of dynamic length sequenced messages. Each message begins with *Length* and *Message Type* fields. CXA reserves the right to add message types and grow the length of any message without notice. Clients should develop their decoders to deal with unknown message types and messages that grow beyond the expected length. Messages will only be grown to add additional data to the end of a message.

2.2 Data Types

The following field types are used within the `Sequenced Unit Header`, GRP messages, Spin Server messages, and TOP.

- **Alphanumeric** fields are left justified ASCII fields and space padded on the right.
- **Binary** fields are unsigned and sized to "Length" bytes and ordered using Little Endian convention (least significant byte first).
- **Binary Price** fields are unsigned Little Endian encoded 8 byte binary fields with 7 implied decimal places (denominator = 10,000,000).
- **Bit Field** fields are fixed width fields with each bit representing a Boolean flag (the 0 bit is the lowest significant bit; the 7 bit is the highest significant bit).
- **Printable ASCII** fields are left justified ASCII fields that are space padded on the right that may include ASCII values in the range of 0x20 – 0x7e.
- **Binary UTC Timestamp** are 8 byte unsigned Little Endian values representing the number of nanoseconds since the epoch (00:00:00 UTC on 1 January 1970).

2.3 Message Framing

Top of book update messages will be combined into a single UDP frame where possible to decrease message overhead and total bandwidth. The count of messages in a UDP frame will be communicated using the `Sequenced Unit Header`. Framing will be determined by the server for each unit and site. The content of the multicast across feeds (e.g., A/B) will be identical, but framing will not be consistent across feeds. Receiving processes that receive and arbitrate multiple feeds cannot use frame level arbitration to fill gaps.

2.4 Sequenced Unit Header

The `Sequenced Unit Header` is used for all CXA Multicast TOP messages as well as messages to and from the Gap Request Proxy ("GRP") and Spin Servers.

Sequenced and un-sequenced data may be delivered using the `Sequenced Unit Header`. Un-sequenced headers will have a 0 value for the *Hdr Sequence* field and potentially for the *Hdr Unit* field. All messages sent to and from the GRP and Spin Server are un-sequenced while multicast may contain both sequenced and un-sequenced messages.

Sequenced messages have implied sequences with the first message having the sequence number contained in the header. Each subsequent message will have an implied sequence one greater than the previous message up to a maximum of count messages. Multiple messages can follow a `Sequenced Unit Header`, but a combination of sequenced and un-sequenced messages cannot be sent within one header.

The sequence number for the first message in the next frame can be calculated by adding the *Hdr Count* field to the *Hdr Sequence*. This technique will work for sequenced messages and `Heartbeats`.

Sequenced Unit Header				
Field	**Offset**	**Length**	**Value/Type**	**Description**
Hdr Length	0	2	Binary	Length of entire block of messages. Includes this header and *Hdr Count* messages to follow.
Hdr Count	2	1	Binary	Number of messages to follow this header.
Hdr Unit	3	1	Binary	Unit that applies to messages included in this header.
Hdr Sequence	4	4	Binary	Sequence of first message to follow this header.
Total Length = 8 bytes				

2.5 Heartbeat Messages

The `Sequenced Unit Header` with a count field set to "0" will be used for `Heartbeat` messages. During trading hours `Heartbeat` messages will be sent from the GRP, Spin Server, and all multicast addresses if no data has been delivered within one second. `Heartbeat` messages never increment

the sequence number for a unit but can be used to detect gaps on the real-time multicast channels during low update rate periods.

`Heartbeats` on the real-time multicast addresses during trading hours will have an *Hdr Sequence* value equal to the sequence of the next sequenced message to be sent for the unit. `Heartbeats` on gap multicast addresses will always have the *Hdr Sequence* field set to 0. All `Heartbeat` messages sent to and from the GRP and Spin Server are considered unsequenced and should have sequence and unit fields set to 0.

Outside of trading hours CXA sends `Heartbeat` messages on all real-time and gap channels with a sequence of "0" to help clients validate multicast connectivity. `Heartbeat` messages might not be sent outside of normal trading hours.

CXA expects `Heartbeat` messages to be sent to the GRP and Spin Servers on live connections no less than every 5 seconds. Failure to receive two consecutive `Heartbeat` messages will result in the GRP or Spin Server terminating the client connection. This also applies when the client is receiving a spin from the Spin Server, the `Heartbeat` messages must continue to be sent from the client to the Spin Server.

2.6 Execution IDs

Execution IDs that are reported in TOP may be converted to base 36 and then matched to execution IDs that are received over FIX or BOE acknowledgements. Conversion rules and examples are provided to allow for clients to match these IDs.

2.6.1 Execution IDs

Convert to nine-character, base 36, zero-padded on the left. Binary values represented in Little Endian format.

Binary Value (Hex)	Decimal (base 10)	Cboe Base36 Value
24 45 20 30 15 00 00 00	91001734436	015T02ZOK
8B 0F FF 6E 27 00 00 00	169365933963	025T03ROR

3 TOP Messages

The TOP messages reflect an update of the top of book or execution of an order in the system.

3.1 Unit Clear

The Unit Clear message instructs feed recipients to clear all data for the CXA book in the unit specified in the Sequenced Unit Header. It would be distributed in rare recovery events such as a data centre fail-over.

Unit Clear				
Field Name	**Offset**	**Length**	**Type/(Value)**	**Description**
Length	0	1	Binary	*Length* of this message including this field.
Message Type	1	1	0x97	`Unit Clear` Message
Reserved	2	4	Binary	Reserved (undefined)
Total Length = 6 bytes				

3.2 Trading Status

The Trading Status message is used to indicate the current trading status of a security. A Trading Status message will be sent whenever trading status changes for a security. The following summarises the Trading Status values in the CXA system:

- C = Closed. Not accepting orders or off-exchange trade reports. Implied at system start-up for all symbols.
- A = Pre-market. Not accepting orders, off-exchange trades may be reported.
- T= Trading. Continuous trading session open. Accepting orders and off-exchange trade reports.
- M= MOC Trading. Continuous trading session closed. Accepting only MOC orders and off-exchange trade reports.
- P = Post-market. MOC only trading session closed. Not accepting orders, off-exchange trades may be reported.
- H = Halted. Not accepting orders, only eligible off-exchange trades may be reported. Existing orders may be cancelled.
- S = Trading suspended. Sent in the event trading is suspended for operational reasons. Not accepting orders, only eligible off-exchange trades may be reported. Existing orders may be cancelled.

Halted and Trading suspended are functionally the same, though a halt is considered short term while a suspension occurs for a longer term that can persist over several days.

The Trading Status field will be used to represent the status of the trading session.

Trading Status				
Field Name	**Offset**	**Length**	**Type/(Value)**	**Description**
Length	0	1	Binary	Length of this message including this field
Message Type	1	1	0x3B	`Trading Status` message
Timestamp	2	8	Binary UTC Timestamp	Nanoseconds since epoch
Symbol	10	6	Printable ASCII	Symbol (right padded with spaces).
Trading Status	16	1	Alphanumeric	C = Closed A = Pre-market T = Trading M = MOC Trading P = Post-market H = Halted S = Trading suspended
Market Id Code	17	4	Alphanumeric	Market Identifier Codes (right padded with spaces): XASX = Australian Stock Market CXAW = CXA Warrants CXAE = CXA ETF CXAQ = CXA QMF
Reserved	21	1	Binary	Reserved (undefined)
Total Length = 22 bytes				

3.3 Market Update Messages

Market Update messages reflect real-time events to the current state of the market. These messages are always sequenced and may be recovered via the Gap Request Proxy ("GRP").

There may be cases where the only size at a given top of book price level is made up of one or more undisclosed orders. In this case, the an update message will have a zero size and a non-zero price. This is a valid price level. In the case where there is no valid price level on the book a zero size and zero price update will be sent.

3.3.1 Single Side Update

`Single Side Update` messages provide an updated price and size for a single side of a *Symbol*. The side is denoted by the *Side* field. One `Single Side Update` message may reflect one or more updates to the inside book that were processed at the same time but will only be done so in a way that can be arbitrated between A/B feeds.

Single Side Update				
Field Name	**Offset**	**Length**	**Type/(Value)**	**Description**
Length	0	1	Binary	*Length* of this message including this field.
Message Type	1	1	0xE4	`Single Side Update` Message
Timestamp	2	8	Binary UTC Timestamp	Nanoseconds since epoch

Symbol	10	6	Printable ASCII	Symbol (right padded with spaces).
Side	16	1	Alphanumeric	B = Bid side S = Ask side
Price	17	8	Binary Price	Price
Quantity	25	4	Binary	Number of shares on the inside book. May be zero if only undisclosed orders exist on the inside book.
Reserved	29	1	Binary	Reserved (undefined)
Total Length = 30 bytes				

3.3.2 Two Side Update

`Two Side Update` messages provide an updated price and size for both sides of a *Symbol*. One `Two Side Update` message may reflect one or more updates to the inside book that were processed at the same time but will only be done so in a way that can be arbitrated between A/B feeds.

Two Side Update				
Field Name	**Offset**	**Length**	**Type/(Value)**	**Description**
Length	0	1	Binary	*Length* of this message including this field.
Message Type	1	1	0xE5	`Two Side Update` Message
Timestamp	2	8	Binary UTC Timestamp	Nanoseconds since epoch
Symbol	10	6	Printable ASCII	Symbol (right padded with spaces).
Bid Price	16	8	Binary Price	Bid Price
Bid Quantity	24	4	Binary	Number of shares on the bid side of the inside book. May be zero if only undisclosed orders exist on the inside book.
Reserved	28	1	Binary	Reserved (undefined)
Ask Price	29	8	Binary Price	Ask Price
Ask Quantity	37	4	Binary	Number of shares on the ask side of the inside book. May be zero if only undisclosed orders exist on the inside book.
Reserved	41	1	Binary	Reserved (undefined)
Total Length = 42 bytes				

3.3.3 TOP Trade

The `TOP Trade` message provides information about executions of orders on the CXA book or executions that occur off-exchange and reported to CXA. `TOP Trade` messages for on-exchange electronic executions are necessary to calculate CXA execution-based data. `TOP Trade` messages do not alter the book. For on-exchange electronic executions one or more `Single Side Update` or `Two Side Update` messages may follow a `TOP Trade` message to reflect the updated book (for example, an aggressive order may take out one or more price levels and establish a new level on the opposite side).

Any order may be executed in parts. A complete view of all CXA executions can be built from all `TOP Trade` messages for on-exchange electronic executions.

The `TOP Trade` message is sent for each execution on the CXA book or for executions that occur off-exchange and reported to CXA. A `TOP Trade` message is also sent whenever an execution or trade report is broken with the *Flags* field value indicating trade break. Trade breaks are rare and only affect applications that rely upon CXA execution-based data. Trade breaks will contain the *Symbol*, *Quantity*, *Price,* and *Execution Id* of the original trade. The *Total Volume* field will be reduced by the number of shares reported in the *Quantity* field.

TOP Trade				
Field Name	**Offset**	**Length**	**Type/(Value)**	**Description**
Length	0	1	Binary	*Length* of this message including this field.
Message Type	1	1	0xE6	`TOP Trade` Message
Timestamp	2	8	Binary UTC Timestamp	Nanoseconds since epoch
Symbol	10	6	Printable ASCII	Symbol (right padded with spaces).
Quantity	16	4	Binary	Incremental number of shares executed, reported, or corrected (see *Flags*).
Price	20	8	Binary Price	The price of the trade.
Execution Id	28	8	Binary	CXA generated day-unique execution identifier of this trade. *Execution Id* is also referenced in trade breaks.
Total Volume	36	4	Binary	Total number of shares executed on the CXA book, or off-exchange reported trades, for the symbol on the current business day (may decrease if the *Flags* field indicates a trade break).
PID	40	4	Alphanumeric	Participant ID (right padded with spaces). Blank (spaces) if not attributed.
Contra PID	44	4	Alphanumeric	Contra Participant ID (right padded with spaces). Blank (spaces) if not attributed.
Trade Type	48	1	Alphanumeric	B = Broker Preferenced Trade N = Trade resulting from normal matching logic <space> = Off-exchange trade report

Trade Designation	49	1	Alphanumeric	C = CXAC (Limit) P = CXAP (Mid Point) N = CXAN (Near Point) F = CXAF (Far Point) M = CXAM (MOC) B = CXAB (BIDS Block Size) I = CXAI (BIDS Price Improved) Valid only for on-exchange executions, space otherwise.
Trade Report Type	50	1	Alphanumeric	B = Block Trade P = Large Portfolio Trade T = Large Principal Transaction S = Trades with Price Improvement L = Permitted Trade During Post Trading Hours Period M = Permitted Trade During Pre Trading Hours Period E = Out of Hours Trade F = ETF Trade Report for unit creations or redemptions Valid only for off-exchange trade reports, space otherwise.
Trade Transaction Time	51	8	Binary UTC Timestamp	Nanosecond timestamp of the off-exchange trade as specified in the Trade Report submitted by the trading participant. Valid only for off-exchange trade reports, zero otherwise.
Flags	59	1	Bit Field	Bit 0 – Trade Condition 0 = Normal trade 1 = Trade break Bits 1-7 Reserved
Total Length = 60 bytes				

3.3.4 Calculated Value

The `Calculated Value` message is sent when CXA calculates market values for a specified symbol or when a calculated market value is reported to CXA. The specified symbol may not trade on CXA, but instead could represent index or iNAV values reported to CXA from third parties as indicated by the *Value Category* field. The index values will be reported on each of the unitised CXA TOP feeds and are not specific to an individual unit.

`Calculated Value` messages will be included in a spin response.

Calculated Value				
Field Name	**Offset**	**Length**	**Type/(Value)**	**Description**
Length	0	1	Binary	*Length* of this message including this field
Message Type	1	1	0xE3	`Calculated Value` Message
Timestamp	2	8	Binary UTC Timestamp	Nanoseconds since epoch
Symbol	10	6	Printable ASCII	Symbol of the calculated value (right padded with spaces).
Value Category	16	1	Alphanumeric	1 = Closing price 2 = iNAV values (ETF) 3 = Index values 4 = EOD NAV from issuer
Value	17	8	Binary Price	The calculated value.
Value Timestamp	25	8	Binary UTC Timestamp	Timestamp when the calculated value was generated in nanoseconds since epoch.
Total Length = 33 bytes				

3.4 End of Session

The `End of Session` message is sent for each unit when the unit shuts down. No more sequenced messages will be delivered for this unit, but heartbeats from the unit may be received.

End of Session				
Field Name	**Offset**	**Length**	**Type/(Value)**	**Description**
Length	0	1	Binary	*Length* of this message including this field.
Message Type	1	1	0x2D	`End of Session` Message
Reserved	2	4	Binary	Reserved (undefined)
Total Length = 6 bytes				

4 Gap Request Proxy Messages

The following messages are used for initialising a TCP/IP connection to the Gap Request Proxy ("GRP") and to request message retransmissions. Clients only need to implement the following messages if gap requests will be made. Each of the following message types must be wrapped by an unsequenced Sequenced Unit Header as described in section 2.4. The following messages will not be delivered using multicast.

4.1 Login

The `Login` message is the first message sent to the GRP by a client's process after the connection to the GRP is established. Failure to login before sending any other message type will result in the connection being dropped by the GRP.

Login				
Field	**Offset**	**Length**	**Value/Type**	**Description**
Length	0	1	Binary	*Length* of this message including this field.
Message Type	1	1	0x01	`Login` Message
SessionSubId	2	4	Alphanumeric	*SessionSubId* supplied by CXA.
Username	6	4	Alphanumeric	*Username* supplied by CXA.
Filler	10	2	Alphanumeric	(space filled)
Password	12	10	Alphanumeric	*Password* supplied by CXA.
Total Length = 22 bytes				

4.2 Login Response

The `Login Response` message is sent by the GRP to the client process in response to a `Login` message. The *Status* field is used to reflect an accepted login or the reason the session was not accepted. If login fails, the connection will be dropped after the `Login Response` message is sent.

Login Response				
Field	**Offset**	**Length**	**Value/Type**	**Description**
Length	0	1	Binary	*Length* of this message including this field.
Message Type	1	1	0x02	`Login Response` Message
Status	2	1	Alphanumeric	Accepted or reason for reject.
Total Length = 3 bytes				

Login Response – Status Codes	
'A'	Login Accepted
'N'	Not authorised (Invalid Username/Password)
'B'	Session in use
'S'	Invalid Session

4.3 Heartbeat

Heartbeat messages must be sent once every five seconds in order to keep the client's connection to the GRP server alive. Heartbeat messages are sent using the `Sequenced Unit Header` as described in sections 2.4 and 2.5.

4.4 Gap Request

The `Gap Request` message is used by a client's process to request retransmission of a sequenced message (or messages) by one of CXA's gap servers.

Gap Request				
Field	**Offset**	**Length**	**Value/Type**	**Description**
Length	0	1	Binary	*Length* of this message including this field.
Message Type	1	1	0x03	`Gap Request` Message
Unit	2	1	Binary	*Unit* that the gap is requested for.
Sequence	3	4	Binary	*Sequence* of first message (Lowest sequence in range).
Count	7	2	Binary	*Count* of messages requested.
Total Length = 9 bytes				

4.5 Gap Response

The `Gap Response` message is sent by the GRP in response to a `Gap Request` message. The *Unit* and *Sequence* fields will match the values supplied in the `Gap Request` message. A `Gap Response` message, with a *Status* of Accepted or reason for failure, will be sent for each `Gap Request` message received by the GRP.

Gap Response				
Field	**Offset**	**Length**	**Value/Type**	**Description**
Length	0	1	Binary	*Length* of this message including this field.
Message Type	1	1	0x04	`Gap Response` Message.
Unit	2	1	Binary	*Unit* the gap was requested for.
Sequence	3	4	Binary	*Sequence* of first message in request.
Count	7	2	Binary	*Count* of messages requested.
Status	9	1	Alphanumeric	Accepted or reason for reject*.
Total Length = 10 bytes				

Gap Response – Status Codes	
'A'	Accepted
'O'	Out of range (ahead of sequence or too far behind)
'D'	Daily gap request allocation exhausted
'M'	Minute gap request allocation exhausted
'S'	Second gap request allocation exhausted
'C'	Count request limit for one gap request exceeded
'I'	Invalid Unit specified in request
'U'	Unit is currently unavailable

* - All non-'A' status codes should be interpreted as a reject.

4.6 Gap Server Usage Example

The following diagram shows the exchange of messages over time between a client and CXA's Multicast TOP feed, Gap Request Proxy, and Gap Server.

At time 0 assume the client state of the book is current through sequence 310170, and the next expected sequence is 310171.

At time 1 the client sends a `Login` message to the Gap Request Proxy (GRP) server and at time 2 receives a `Login Response` message indicating the login has been accepted. The client is now successfully logged into the GRP and able to request gaps. Note this is just for example purposes and in practice the client is encouraged to log into the GRP at the start of the trading day.

At time 3 and 4, the client receives sequences 310171 and 310172. These messages are in sequence and the client applies these messages to their book. The state of the book is current through sequence 310172 and the next expected sequence is 310173.

At time 5 and 6, the client receives sequences 310176 and 310177 and determines sequences 310173 through 310175 are missing (i.e., a gap was detected). Sequences 310176 and 310177 are then cached for later use.

At time 7 a `Gap Request` message is sent to the GRP to request the missing messages, starting at sequence 310173 for a total of 3 messages.

At time 8, the client receives sequence 310178. Since there are still missing sequences, it cannot apply this message to the book and sequence 310178 is cached for later use.

At time 9, the client receives a `Gap Response` message from the GRP indicating the gap request was successful and it can expect the requested messages to be sent from the Gap Server.

At time 10, the client receives sequence 310179. Since there are still missing sequences, it cannot apply this message to the book and sequence 310179 is cached for later use.

At time 11, the client receives sequence 310173 from the Gap Server. Since the last sequence applied was 310172, the client can apply this message to the book. The state of the book is current through sequence 310173 and the next expected sequence is 310174.

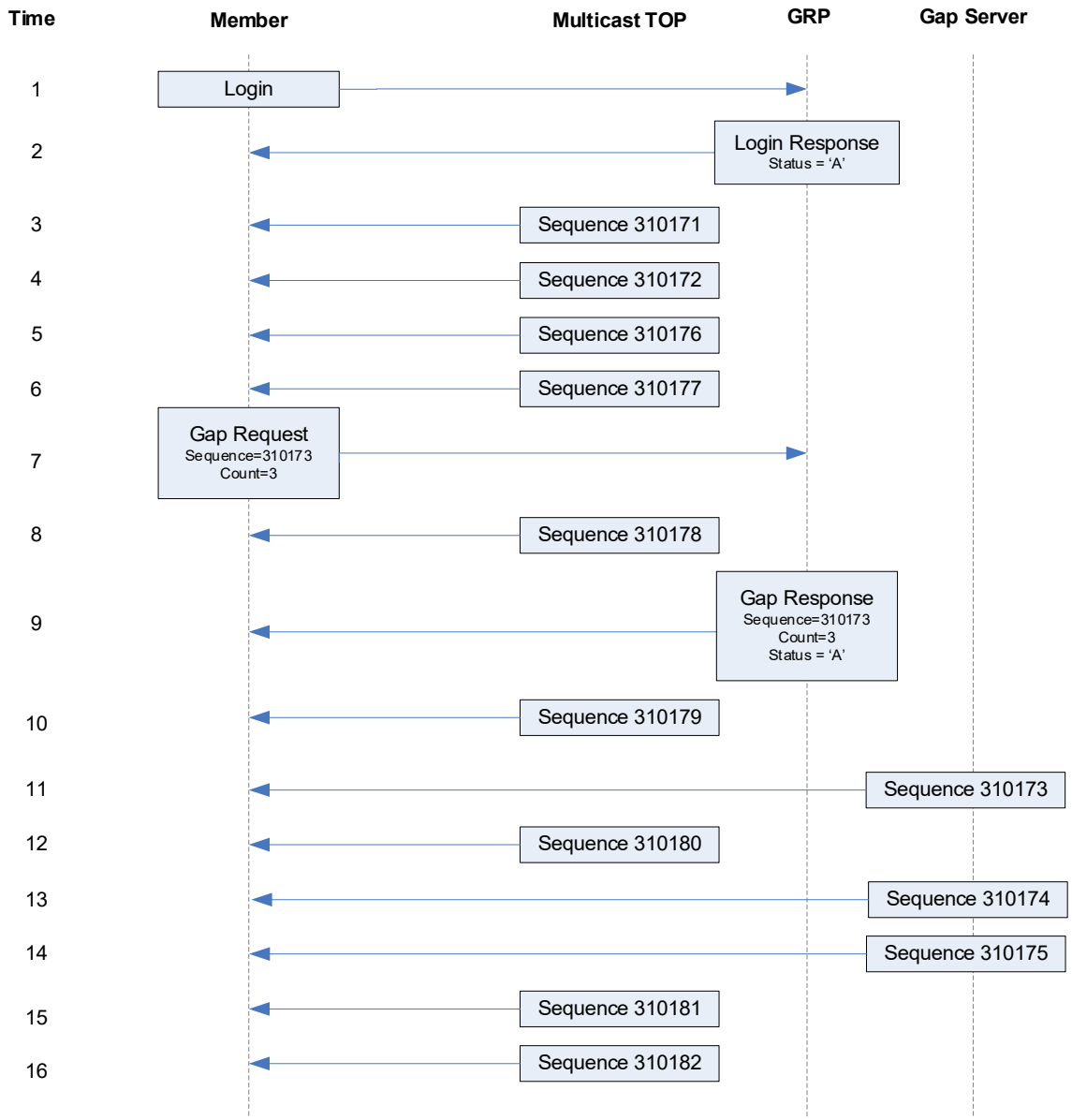
At time 12, the client receives sequence 310180. Since there are still missing sequences, it cannot apply this message to the book and sequence 310180 is cached for later use.

At time 13 and 14, the client receives sequences 310174 and 310175 from the Gap Server. Since the last sequence applied was 310173, the client can apply these messages to the book.

Now that all the missing sequences have been received from the Gap Server, the client can apply the cached sequence messages 310176 through 310180. At this point the book should be current with the TOP feed. The state of the book is current through sequence 310180 and the next expected sequence is 310181.

At times 15 and 16, sequences 310181 and 310182 are received. Since there are no missing sequences, and these messages are in sequence, the client applies these messages to their book. The state of the book is current through sequence 310182 and the next expected sequence is 310183.

It should be noted that other clients may also request gaps, and the clients should be prepared to ignore any message from the Gap Server it is not expecting or does not need.



5 Spin Messages

5.1 Login

The `Login` message is the first message sent to the Spin Server by a client's process after the connection to the Spin Server is established. Failure to login before sending any other message type will result in the connection being dropped by the Spin Server.

The format of the `Login` message for the Spin Server is identical to that of the GRP described previously in section 4.1.

5.2 Login Response

The `Login Response` message is sent by the Spin Server to a client's process in response to a `Login` message. The status field is used to reflect an accepted login or the reason the session was not accepted. If login fails, the connection will be dropped after the `Login Response` message is sent.

The format of the `Login Response` message for the Spin Server is identical to that of the GRP described previously in section 4.2.

5.3 Heartbeat

Heartbeat messages must be sent once every five seconds in order to keep the client's connection to the spin server alive. Heartbeat messages are sent using the `Sequenced Unit Header` as described in sections 2.4 and 2.5.

5.4 Spin Image Available

The `Spin Image Available` message is sent once per second and indicates through what sequence number a spin is available.

Spin Image Available				
Field Name	**Offset**	**Length**	**Type/(Value)**	**Description**
Length	0	1	Binary	*Length* of this message including this field.
Message Type	1	1	0x80	`Spin Image Available` Message
Sequence	2	4	Binary	Spin is available which is current through this sequence number.
Total Length = 6 bytes				

5.5 Spin Request

The `Spin Request` message is used by a client's process to request transmission of a spin of the unit's order book. Refer to section 1.5 or more complete details regarding *Sequence* specification as well as buffering requirements.

Spin Request				
Field Name	**Offset**	**Length**	**Type/(Value)**	**Description**
Length	0	1	Binary	*Length* of this message including this field.
Message Type	1	1	0x81	`Spin Request` Message
Sequence	2	4	Binary	Sequence number from a `Spin Image Available` message received by the client.
Total Length = 6 bytes				

5.6 Spin Response

The `Spin Response` message is sent in response to a client's `Spin Request` message indicating whether a spin will be sent.

Spin Response				
Field Name	**Offset**	**Length**	**Type/(Value)**	**Description**
Length	0	1	Binary	*Length* of this message including this field.
Message Type	1	1	0x82	`Spin Response` Message
Sequence	2	4	Binary	Sequence number from a `Spin Image Available` message.
Order Count	6	4	Binary	For TOP this is always zero.
Status	10	1	Alphanumeric	Accepted or reason for reject*.
Total Length = 11 bytes				

Spin Response - Status Codes	
'A'	Accepted
'O'	Out of Range (*Sequence* requested is greater than *Sequence* available by the next spin)
'S'	Spin already in progress (only one spin can be running at a time).

* - All non-'A' status codes should be interpreted as a reject.

5.7 Spin Finished

The `Spin Finished` message is sent to indicate that all messages for the spin requested have been sent. A `Spin Finished` message is only sent if a `Spin Request` was not rejected. Upon receipt of a `Spin Finished` message, any buffered multicast messages should be applied to the client's copy of the book to make it current.

Spin Finished				
Field Name	**Offset**	**Length**	**Type/(Value)**	**Description**
Length	0	1	Binary	*Length* of this message including this field.
Message Type	1	1	0x83	`Spin Finished` Message
Sequence	2	4	Binary	Sequence number from the `Spin Response` message.
Total Length = 6 bytes				

5.8 Spin Server Usage Example

The following diagram (see next page) shows the exchange of messages over time between a client and CXA's Multicast TOP feed and Spin Server. The spin will consist of `Trading Status`, `Calculated Value`, `Single Side Update` and `Two Side Update` messages.

At time 1, the client has no state of the book and desires to become current. The client caches the received Multicast TOP messages (sequences 310172 and 310173) for later use. Since the client has no book, they cannot yet be applied.

At time 5, the client has successfully logged into the Spin Server and has cached another message, sequence 310174.

At time 7, the client receives a `Spin Image Available` message which indicates that the spin server can give them a spin of all books as of sequence 310169. The client does not have all messages cached after 310169 (they are missing 310170 and 310171), so this spin is not useful to the client.

At time 10, the client receives a `Spin Image Available` message which is useful since it would be a spin of all books up to and including sequence 310175 and the client has all messages after 310175 cached.

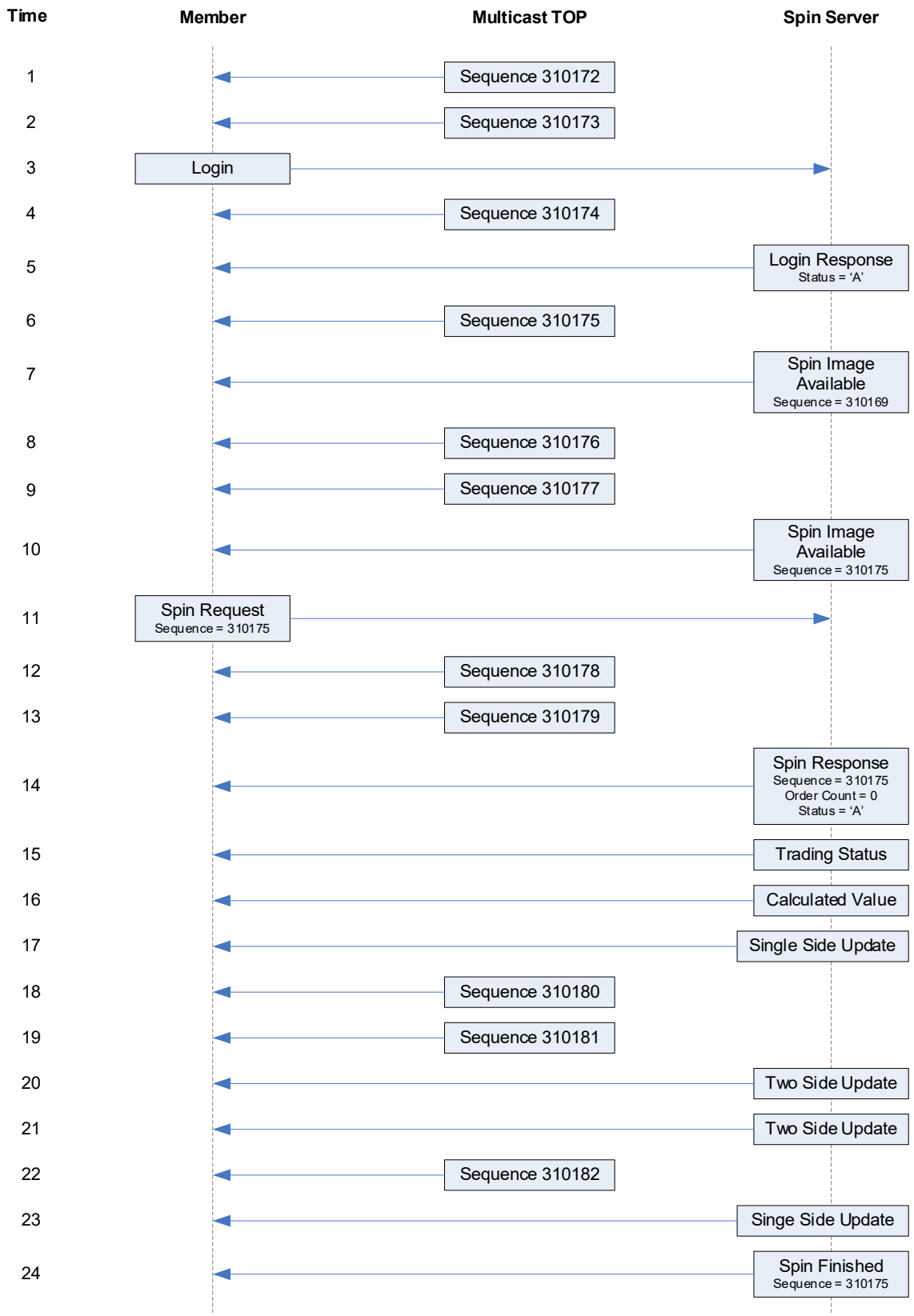
At time 11, the client sends a `Spin Request` for all messages up to and including 310175 and continues to cache Multicast TOP messages received.

At time 14, the Spin Server acknowledges the `Spin Request`.

At time 24, the spin server indicates that it has finished the spin of all books. The client must then apply the cached messages from sequence number 310176 through current.

Notes:

- Spin Servers are available for each unit. Clients may need to employ multiple Spin Servers depending upon their architecture.



6 Message Types

6.1 Gap Request Proxy Messages

0x01	Login
0x02	Login Response
0x03	Gap Request
0x04	Gap Response

6.2 Spin Server Messages

0x01	Login
0x02	Login Response
0x80	Spin Image Available
0x81	Spin Request
0x82	Spin Response
0x83	Spin Finished

6.3 TOP Messages

0x97	Unit Clear
0x3B	Trading Status
0xE4	Single Side Update
0xE5	Two Side Update
0xE6	TOP Trade
0xE3	Calculated Value
0x2D	End of Session

7 Example Messages

Each of the following message types must be wrapped by a sequenced or un-sequenced unit header as described here. Note that in the following examples, each byte is represented by two hexadecimal digits.

7.1 Login

Length	16	22 bytes
Type	01	Login
SessionSubId	30 30 30 31	"0001"
Username	46 49 52 4D	"FIRM"
Filler	20 20	" "
Password	41 42 43 44 30 30 20 20 20 20	"ABCD00 "

7.2 Login Response

Length	03	3 bytes
Type	02	Login Response
Status	41	Login accepted

7.3 Gap Request

Length	09	9 bytes
Type	03	Gap Request
Unit	01	Unit 1
Sequence	3B 10 00 00	First message: 4155
Count	32 00	50 messages

7.4 Gap Response

Length	08	8 bytes
Type	04	Gap Response
Unit	01	Unit 1
Sequence	3B 10 00 00	First message: 4155
Status	41	Accepted

7.5 Spin Image Available

Length	06	6 bytes
Type	80	Spin Image Available
Sequence	3B 10 00 00	Sequence: 4155

7.6 Spin Request

Length	06	6 bytes
Type	81	Spin Request
Sequence	3B 10 00 00	Sequence: 4155

7.7 Spin Response

Length	0B	11 bytes
Type	82	Spin Request
Sequence	3B 10 00 00	Sequence: 4155
Order Count	42 00 00 00	66 orders
Status	41	Accepted

7.8 Spin Finished

Length	06	6 bytes
Type	83	Spin Finished
Sequence	3B 10 00 00	Sequence: 4155

7.9 Unit Clear

Length	06	6 bytes
Type	97	Unit Clear
Reserved	20 20 20 20	(Reserved)

7.10 Trading Status

Length	16	22 bytes
Type	3B	Trading Status
Timestamp	F0 77 BB CE 2A 6A 62 16	1612968348641622000 ns since epoch
Symbol	5A 56 5A 54 20 20	"ZVZT "
Trading Status	54	T = Trading
Market Id Code	41 55 53 20	"AUS "
Reserved	00	(Reserved)

7.11 Single Side Update

Length	1E	30 bytes
Type	E4	Single Side Update
Timestamp	F0 77 BB CE 2A 6A 62 16	1612968348641622000 ns since epoch
Symbol	5A 56 5A 54 20 20	"ZVZT "
Side	42	B (Buy)
Price	15 CD 5B 07 00 00 00 00	12.3456789
Quantity	BC 02 00 00	700 shares
Reserved	00	(Reserved)

7.12 Two Side Update

Length	2A	42 bytes
Type	E5	Two Side Update
Timestamp	F0 77 BB CE 2A 6A 62 16	1612968348641622000 ns since epoch

Symbol	5A 56 5A 54 20 20	"ZVZT "
Bid Price	15 CD 5B 07 00 00 00 00	12.3456789
Bid Quantity	BC 02 00 00	700 shares
Reserved	00	(Reserved)
Ask Price	95 63 F4 07 00 00 00 00	13.3456789
Ask Quantity	F4 01 00 00	500 shares
Reserved	00	(Reserved)

7.13 TOP Trade (On-Exchange Electronic Execution)

Length	3C	60 bytes
Type	E6	TOP Trade
Timestamp	F0 77 BB CE 2A 6A 62 16	1612968348641622000 ns since epoch
Symbol	5A 56 5A 54 20 20	"ZVZT "
Quantity	BC 02 00 00	700 shares
Price	15 CD 5B 07 00 00 00 00	12.3456789
Execution Id	34 2B 46 E0 BB 00 00 00	
Total Volume	40 42 0F 00	1,000,000 shares
PID	31 32 33 34	"1234"
Contra PID	35 36 37 38	"5678"
Trade Type	4E	N = Normal matching
Trade Designation	43	C = CXAC (Limit)
Trade Report Type	20	" " (space)
Trade Transaction Time	00 00 00 00 00 00 00 00	zero
Flags	00	0 = Normal trade

7.14 TOP Trade (Off-Exchange Trade Report)

Length	3C	60 bytes
Type	E6	TOP Trade
Timestamp	F0 77 BB CE 2A 6A 62 16	1612968348641622000 ns since epoch
Symbol	5A 56 5A 54 20 20	"ZVZT "
Quantity	BC 02 00 00	700 shares
Price	15 CD 5B 07 00 00 00 00	12.3456789
Execution Id	34 2B 46 E0 BB 00 00 00	

Total Volume	40 42 0F 00	1,000,000 shares
PID	31 32 33 34	"1234"
Contra PID	35 36 37 38	"5678"
Trade Type	20	" " (off-exchange)
Trade Designation	20	" " (space)
Trade Report Type	50	P = Large Portfolio Trade
Trade Transaction Time	F0 77 BB CE 2A 6A 62 16	1612968348641622000 ns since epoch
Flags	00	0 = Normal trade

7.15 Calculated Value

Length	21	33 bytes
Type	E3	Calculated Value
Timestamp	F0 77 BB CE 2A 6A 62 16	1612968348641622000 ns since epoch
Symbol	5A 56 5A 54 20 20	"ZVZT "
Value Category	31	1 = Closing price
Value	15 CD 5B 07 00 00 00 00	12.3456789
Value Timestamp	F0 77 BB CE 2A 6A 62 16	1612968348641622000 ns since epoch

7.16 End of Session

Length	06	6 bytes
Type	2D	End of Session
Reserved	00 00 00 00	(Reserved)

8 Multicast Configuration

8.1 Production Environment Configuration

8.1.1 Limitations/Configurations

The following table defines the configuration for network and gap request limitations. These limitations are session based. CXA reserves the right to adjust the gap request limitations to improve the effectiveness of the gap request infrastructure.

Period/Type	Limit/Setting	Notes
MTU	1500	CXA will send UDP messages up to 1500 bytes. Clients should ensure that their infrastructure is configured accordingly.
Gig-Shaped Throttle	1 Gb/s	The real-time and gap multicast head ends are configured to shape their output to this level to minimise packet loss.
Gap Response Delay	2 ms	The Gap Server will delay resending sequenced messages via multicast for the specified limit to satisfy multiple GRP gap requests with one multicast response.
Count	100	Any single gap request may not be for more than this number of dropped messages.
1 Second	320 Requests	This is the maximum number of retransmission requests allowed per second for each session. This is renewed every clock second.
1 Minute	1,500 Requests	This is the maximum number of retransmission requests allowed per minute for each session. This is renewed every clock minute.
Day	100,000 Requests	This is the maximum number of retransmission requests allowed per day for each session.
Within Range	1,000,000 Messages	Clients' retransmission requests must be within this many messages of the most recent sequence sent by the real-time feed per session.

8.1.2 Unit/Symbol Distribution

The following table describes the CXA symbol distribution across units.

Unit	CXA Symbol Range
1	Zero – M~~~~~
2	N – Z~~~~~

Note - CXA reserves the right to add units and/or change symbol distribution with 48 hours of notice and no migration period. Notice will be given that the distribution will change on a certain date. Care should be taken to support mappings in these tables via software configuration.

8.1.3 Multicast Routing Parameters

Data Centre	Rendezvous Point
Primary Data Centre A feed	74.115.128.10/32
Primary Data Centre B feed	74.115.128.11/32
Secondary Data Centre E feed	74.115.128.13/32

8.1.4 Address/Unit Distribution

The following tables describe the unit distribution across the CXA Multicast TOP feeds.

Primary Data Centre		Gig-Shaped [AAT] 170.137.217.64/28		Gig-Shaped [ABT] 170.137.217.80/28	
Unit	IP Port	Real-time MC	Gap Resp. MC	Real-time MC	Gap Resp. MC
1	30601	233.218.133.82	233.218.133.83	233.218.133.98	233.218.133.99
2	30602				

Note - CXA reserves the right to add multicast addresses with prior notice, but no migration period. Notice will be given that the distribution will change on a certain date. Care should be taken to support mappings in these tables via software configuration.

Secondary Data Centre		Gig-Shaped [AET] 170.137.214.16/28	
Unit	IP Port	Real-time MC	Gap Resp. MC
1	31601	233.218.133.114	233.218.133.115
2	31602		

Note - CXA reserves the right to add multicast addresses with prior notice, but no migration period. Notice will be given that the distribution will change on a certain date. Care should be taken to support mappings in these tables via software configuration.

8.2 Certification Environment Configuration

8.2.1 Unit/Symbol Distribution

The following table describes the CXA symbol distribution across units.

Unit	CXA Symbol Range
1	Zero – M~~~~~
2	N – Z~~~~~

Note - CXA reserves the right to add units and/or change symbol distribution with 48 hours of notice and no migration period. Notice will be given that the distribution will change on a certain date. Care should be taken to support mappings in these tables via software configuration.

8.2.2 Certification Multicast Routing Parameters

Data Centre	Rendezvous Point
Primary Data Centre feed	74.115.128.12/32

8.2.3 Address/Unit Distribution

The following tables describe the unit distribution across the certification CXA Multicast TOP feeds.

Primary Data Centre		Gig-Shaped [Cert] 170.137.217.16/28	
Unit	IP Port	Real-time MC	Gap Resp. MC
1	32601	233.218.133.106	233.218.133.107
2	32602		

Note - CXA reserves the right to add multicast addresses with prior notice, but no migration period. Notice will be given that the distribution will change on a certain date. Care should be taken to support mappings in these tables via software configuration.

9 Connectivity

9.1 Supported Extranet Carriers

The Gig-Shaped feed will be made available to clients through extranet carriers that have completed their multicast implementation and certified with CXA on a per-market basis. CXA may certify a number of carriers defined in the CXA Connectivity Manual with respect to redistribution of CXA Multicast data feeds. For more information on receiving Multicast TOP through any of these providers, reach out to the vendor contact noted in the Extranet Providers section of the Connectivity Manual.

9.2 Bandwidth Recommendation

The Gig-shaped feeds require 1 Gbps of bandwidth. CXA will use 90% of these respective bandwidths for Multicast TOP to allow clients to use the same physical connection for order entry if desired.

10 Support

Please direct questions or comments regarding this specification to TradeDeskAU@cboe.com.

Revision History

Document Version	Date	Description
1.0.0	08/04/22	Initial version.
1.0.1	15/08/22	Minor grammatical changes.
1.0.2	26/08/22	Updated symbol distribution ranges to be simple alpha ranges.
1.0.3	31/08/22	Populated TOP feed addresses in section 8.
1.0.4	01/09/22	Updated symbol range.
1.0.5	28/10/22	Updated *Length* and *Type* values in `Single Side Update` example message.
1.0.6	07/11/22	Updated *Trade Designation* values "B" and "I" for BIDS MIC codes.