MIAX Pearl Equities Exchange

Top of Market Feed
ToM Interface Specification

Revision Date: 11/05/2020
Version 1.1.a

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1. Overview

MIAX Pearl Equities Top of Market Feed (**ToM**) is a data feed that allows subscribers to receive real-time updates of the following information from the MIAX Pearl Equities Exchange.

- MIAX Pearl Best Bid and Offer (MPBBO): Best Bid and Offer price with aggregated displayed size
- MIAX Pearl Last Sale (trades)
- Trade Cancellations
- Trading Status of symbols traded on MIAX Pearl Equities
- MIAX Pearl Equities System Status

ToM Features:

ToM messaging and the system architecture are designed for low latency and high throughput messaging. Some of the key features of the interface are:

- ToM uses binary message format, binary numeric fields and fixed length ASCII fields in messages in order to utilize bandwidth efficiently and assist in achieving **low latency**.
- Message formats are designed to use **less bandwidth**. Some examples: ToM uses a compact version of the Top of Market message for most quotes with small prices/sizes and uses the larger message only when necessary. ToM disseminates a separate System Time message for the "seconds" part of the timestamp instead of sending this with every message. ToM messages use Symbol IDs in each message in place of a full canonical symbol.
- ToM is offered with redundant multicast feeds (A Feed & B Feed) to provide single point of failure hardware and network fault tolerance and to provide an opportunity for recipients to arbitrate the two feeds to auto-fill gaps.
- ToM real-time messages are disseminated over multicast to achieve a fair delivery mechanism. ToM requires the use of MIAX proprietary ESesM over TCP/IP protocol for retransmission lines in order to provide a **guaranteed delivery** mechanism for gap fills.
- The ToM retransmission service also provides a **Last Value Refresh Service** to facilitate fast intra-day recovery without a full day gap fill.
- ToM notifications provide current **system status** allowing the subscribers to take necessary actions immediately.

This specification is intended to be used by MIAX Pearl Equities ToM subscribers only.

1.1 Exchange related information

1.1.1 Hours of operation for Pearl Equites Exchange

Please refer to MIAX website at http://www.MIAXEquities.com for details about times for each of these events.

Note: Times specified below are in United States Eastern Time zone.

Start of Session: Start of dissemination of messages. After 5:00 a.m.

Regular Trading Session: 9:30 a.m. to 4:00 p.m. (ends at 1:00 p.m. on early closing days).

MIAX Pearl Equities may support Early and After Hours Trading in the future.

MIAX Pearl Equities may send trade related data following the end of trading session due to the issuance of manual trades, trade cancels, or trade corrections for various operational reasons as needed.

1.1.2 Obtaining more information

Information such as (but not limited to) membership, rules, data feeds, fees and support can be obtained by sending an email to TradingOperations@MIAXEquities.com or by referring to MIAX website at http://www.MIAXEquities.com.

1.2 Testing of ToM Subscription

MIAX Pearl can provide testing assistance on the MIAX Pearl Equities testing area for the ToM Feed and the ToM retransmission interface.

Please contact MIAX Trading Operations at TradingOperations@MIAXEquities.com or (609) 897-7302 to obtain more information about the aforementioned.

1.3 Answers to FAQs

Subscription: Please contact Trading Operations for details about subscribing to ToM.

Symbol management: Subscribers to the data feed will get a list of all securities symbols that will be traded and sourced on the feed at the start of every session. If firms cannot start listening to the feed in time for the normal symbol broadcast, they can connect to the ToM Retransmission service and request for a Last Value Refresh Service (see section 3.2.2) or request all messages published and then subsequently process only the symbol messages to build their symbol list. The MIAX Pearl Equities assigned Symbol ID of each security will be sent in every message so that firms can tie each message to a symbol.

Retransmission: Gap-fill packets generated as a response to retransmission requests are only disseminated on the retransmission TCP channels and not on the real-time multicast feeds.

Redundant Feeds: In order to achieve higher availability, MIAX Pearl Equities offers the real-time ToM feed in two separate redundant and identical feeds named “A Feed” and “B Feed”. Firms are advised to arbitrate between the two feeds in order to mitigate gaps and achieve higher availability. “A Feed” is the primary feed from the primary data center and “B Feed” is the secondary feed from the secondary data center.

Refresh Service: Refresh service is provided only on the retransmission TCP channels and does not affect the real-time ToM feed.

1.4 Data Types

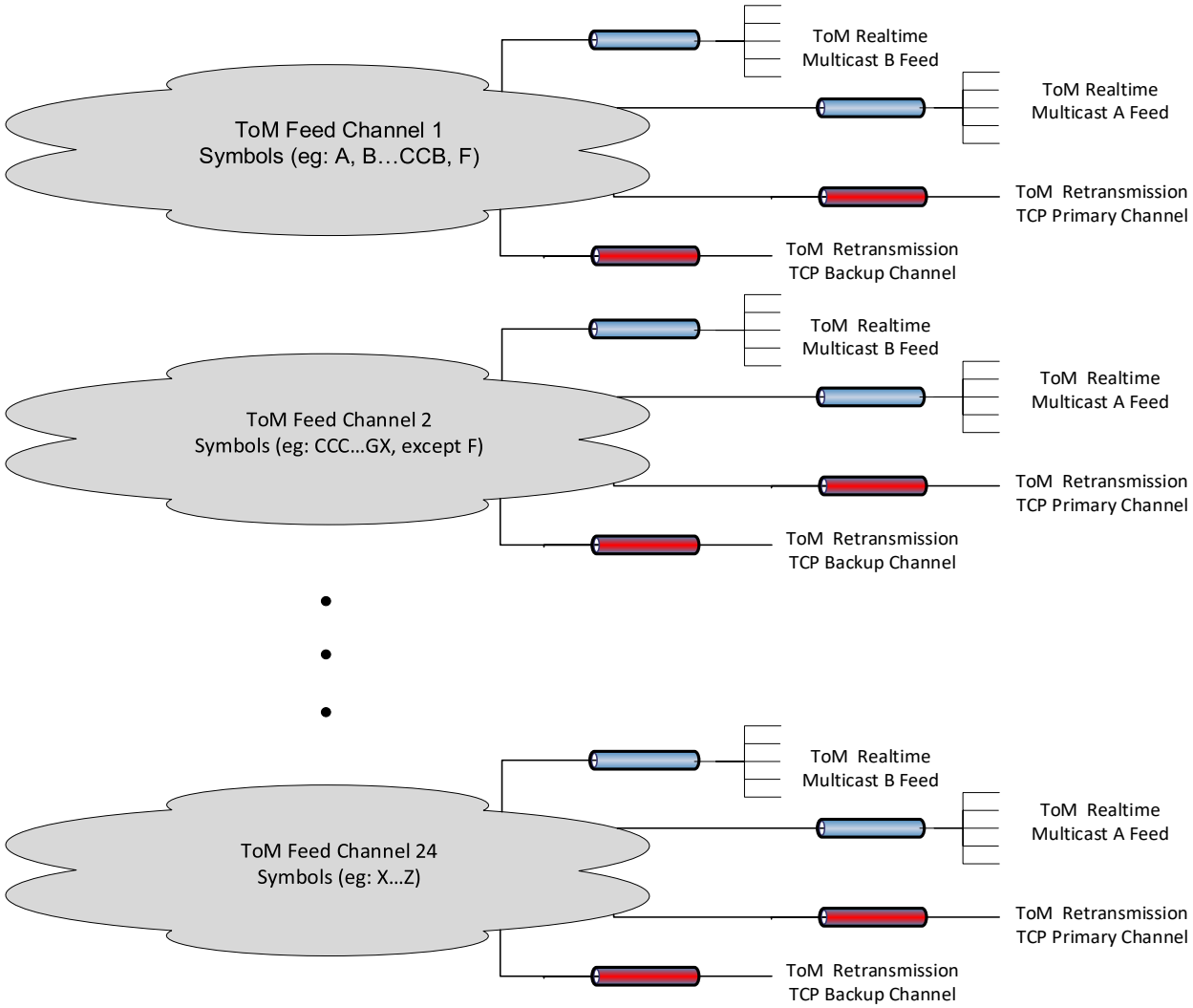
The following table describes the data types used in ToM messaging:

Note: Time fields in all messages are as per timings of United States Eastern Time zone unless specified otherwise.

Data Type	Description
BinaryU	Unsigned, Intel x86 byte-ordered (**little-endian**), binary encoded numbers
BinaryS	Signed, Intel x86 byte-ordered (**little-endian**), binary encoded numbers
BinaryPrc2U	BinaryU Field with the last 2 (right most) digit places being decimal places
BinaryPrc6U	BinaryU Field with the last 6 (right most) digit places being decimal places
Flags	A special BinaryU type where a bit mask must be used to extract different values. The least significant bit is bit 0.
SecTime	BinaryU field that contains the Matching Engine transaction time in seconds since Epoch (January 1, 1970, 00:00:00 **UTC**)
NanoTime	BinaryU field that contains the Matching Engine transaction time in nanoseconds since past second
Alphanumeric	Each place can contain characters or numbers. Left justified and space-padded on the right

2. ToM Architecture

Top of Market Feed (ToM) Architecture



Highlights:

- Real-time dissemination is separated out on to 24 separate Feed channels.
- A Feed channel will contain sourced data for a discrete set of symbols.
- A discrete set of symbols will only be sourced by a single feed channel on any given day.
- Each Feed channel sources independently from the other groups and hence has independent sequence numbers.
- All the messages on each feed channel will be published in FIFO sequence.
- High availability is achieved by disseminating identical data on an “A Feed” and “B Feed” for each Feed channel
- Symbols may not be contiguously distributed according to symbol ranges in each Feed channel.

- Two separate TCP based retransmission channels for each Feed channel supply ToM retransmission via the ToM Retransmission interface.

3. Session Level Protocol

3.1 Real-time ToM Feed

ToM real-time feed uses MIAX's proprietary **MACH protocol**. Each ToM Packet may have multiple application messages and each application message is encapsulated in a MACH protocol packet. Hence a single ToM packet may contain 1 or more sequenced MACH protocol packets.
Please refer to MACH document (available at MIAX website) for details about MACH protocol. This protocol layer offers low latency application messaging over multicast, sequencing of messages and heartbeats.

3.2 ToM Retransmission Interface

ToM Retransmission Interface uses MIAX's proprietary **ESesM – TCP Session Management Protocol**. Please refer to the latest ESesM TCP Session Management document (available at the MIAX website) for details about ESesM session management protocol. This protocol layer offers session management capabilities such as authentication, application messaging over TCP/IP, sequencing of messages, heartbeats and gap fills.

Firms must first use the `Login Request` with a requested sequence number of **zero** to login to the Interface. After receiving a successful `Login Response`, the firm can choose either the ESesM Gap Fill Service or Last Value Refresh Service.

3.2.1 ESesM Gap Fill Service

Firms can use the **Retransmission Request** session management message, available in the ESesM protocol, to request retransmission of a specific range of packets, identified by sequence numbers.

3.2.2 Last Value Refresh Service

3.2.2.1 Request Message to MIAX Pearl Equities

Firms can use the **Unsequenced Data Packet,** available in the ESesM protocol, to request a last value refresh of various market data and status information. The Refresh Request has the following format:

Field Name	Length	Data Type	Notes
ESesM Packet Length	2	Binary	
ESesM Packet Type	1	Alphanumeric	*'U' – ESesM Unsequenced Packet*
Request Type	1	Alphanumeric	'R' – Refresh
Refresh Message Type	1	Alphanumeric	'S' - Symbol Update Refresh 't' – Security Trading Status Refresh 's' – System State Refresh 'Q' – Top of Market Refresh

3.2.2.2 Response Message from MIAX Pearl Equities

The Retransmission feed will respond to the Refresh request with a series of ESesM-TCP **Unsequenced Data Packets** based on the Refresh Message Type. Each response message will have the *following format:*

Field Name	Length	Data Type	Notes
ESesM Packet Length	2	Binary	
ESesM Packet Type	1	Alphanumeric	*'U' – ESesM Unsequenced Packet*
Response Type	1	Alphanumeric	'r' –Refresh
Sequence Number	8	BinaryU	Original sequence number from live feed.
Application Message	varies	See section 4	Based on the message type requested.

The first ESesM TCP packet to be received by the firms will be the System Time Message (See section 4.1). The timestamp (combined with the nanosecond part in the subsequent messages) represents the most recent MIAX Pearl Equities Matching Engine transaction time. It is ***not*** the original timestamp from the MACH sequenced messages in the live feed. *The sequence number in the refresh messages may be used to arbitrate with the sequenced packets from live feed (eg: data with higher sequence number from either the refresh or the live feed represents latest information).*

3.2.2.3 End of Refresh Notification from MIAX Pearl Equities

When the refresh is complete MIAX Pearl Equities will send the following message.

Field Name	Length	Data Type	Notes
ESesM Packet Length	2	Binary	
ESesM Packet Type	1	Alphanumeric	*'U' – ESesM Unsequenced Packet*
Response Type	1	Alphanumeric	'E' – End of Request.
Refresh Message Type	1	Alphanumeric	from Refresh Request.

3.2.3 Session Termination

After satisfying the retransmission request, ToM Retransmission Interface will send a Goodbye Packet and disconnect the TCP connection.

Note: Upon receipt of an unknown, malformed or illegal session message, MIAX Pearl Equities will send a ESesM "Goodbye Packet" with a human readable reason text string and MIAX Pearl Equities will disconnect the line.

4. Application Message Formats

This section consists of format of messages sent over the ToM feed.

The time specified in the *Timestamp* field in all the messages below is the time at which the MIAX Pearl Equities Matching Engine associated with that symbol group published the message. This is the same timestamp that will get included in the messages transmitted on the retransmission interface.

4.1 System Time Message

This is the message format that will be used to disseminate the "seconds" part of the timestamp that is applicable to all messages that are sent in the current second.

Field Name	Length	Data Type	Notes
MACH Protocol Data			*Refer to MACH Protocol Specification*
Message Type	1	BinaryU	49
Time Stamp	4	SecTime	Seconds part of the time that applies to all messages that gets disseminated until this message gets sent again.

Points to note:

- Note that this message is only sent when there are any application messages that are going to be sent during any second. Firms are advised to not assume that there will be a message for every second of the day.

4.2 Symbol Update

This is the message format that will be used to disseminate all security symbols traded on MIAX Pearl Equities for the current trading session. The Symbol ID sent in this message will be disseminated in Top of Market and Last Sale messages.

Field Name	Length	Data Type	Notes
MACH Protocol Data			*Refer to MACH Protocol Specification*
Message Type	1	BinaryU	1
Timestamp	4	NanoTime	Nanosecond part of Matching Engine time.
Symbol ID	4	BinaryU	Symbol ID mapped to a given symbol. It is assigned per trading session and is valid for that session. Firms are advised to download and use Symbol IDs for the current trading session as Symbols IDs could change across trading sessions.
Ticker Symbol	11	Alphanumeric	Ticker symbol for the security in NASDAQ Integrated Platform format.
Reserved	1	BinaryU	Reserved for future use.
Test Security Indicator	1	Alphanumeric	'Y' – Yes

Field Name	Length	Data Type	Notes
			'N' – No
Reserved	1	BinaryU	Reserved for future use.
Lot Size	2	BinaryU	Round Lot size in shares.
Opening Time	8	Alphanumeric	Expressed in HH:MM:SS format. Eg: 09:30:00
Closing Time	8	Alphanumeric	Expressed in HH:MM:SS format. Eg: 16:00:00
Primary Market Code	1	Alphanumeric	'A' - NYSE American 'B' - NASDAQ BX 'C' – NYSE National 'H' – MIAX Pearl Equities 'I' – NASDAQ ISE 'J' - CBOE EDGA Exchange 'K' - CBOE EDGX Exchange 'L' - Long-Term Stock Exchange 'M' - NYSE Chicago 'N' - New York Stock Exchange 'P' - NYSE Arca 'Q' - NASDAQ 'U' – Members Exchange 'V' - Investors' Exchange 'W' - CBOE Stock Exchange 'X' - NASDAQ PHLX 'Y' - CBOE BYX Exchange 'Z' - CBOE BZX Exchange

Points to note:

- Entire Symbol list for the channel will be disseminated at the start of day.
- In each channel, firms will only receive the symbols associated with the Matching Engine that is servicing that channel.
- Intra-day updates will also be published as they occur.
- In case of an intra-day reconnection, users can request all symbols data from the ToM retransmission line.

4.3 System State

This is the message format that will be used to notify firms of the state changes of the system. This is a notification that applies to all symbols on the feed. Firms can use notifications as triggers in their system to ensure electronic synchronization of systems.

Field Name	Length	Data Type	Notes
MACH Protocol Data			*Refer to MACH Protocol Specification*
Message Type	1	BinaryU	83
Timestamp	4	NanoTime	Nanosecond part of Matching Engine time.
ToM Version	8	Alphanumeric	Eg: ToM1.0
Session ID	1	BinaryU	Current trading session identifier.

Field Name	Length	Data Type	Notes
System Status	1	Alphanumeric	'S' = Start of System hours 'C' = End of System hours '1' = Start of Test Session (sent before tests) '2' = End of Test Session

Points to note:

- Firms must ensure that messages sent on the ToM Feed from the beginning of "start of test session" to the end of "end of test session" will not affect their production session while allowing the firms to still be involved in production tests and dry runs.
- A change in Session ID will mean a restart at MACH sequence number 1 for that symbol group. Refer to MACH protocol specification for details about this. Firms must be able to handle more than one trading session in a single trading day.

4.4 Security Trading Status Notification

This is the message format that will be used to notify firms of changes to the trading status of a particular security.

Field Name	Length	Data Type	Notes
MACH Protocol Data			*Refer to MACH Protocol Specification*
Message Type	1	BinaryU	4
Timestamp	4	NanoTime	Nanosecond part of Matching Engine time.
Symbol ID	4	BinaryU	Symbol ID mapped to a given symbol.
Trading Status	1	BinaryU	1 - Pre-Open 2 - Trading 3 - Halt 4 - Operational Halt 5 - Closed
Market State	1	BinaryU	1 - Pre-Opening 2 - Early Trading Session (Future Implementation) 3 - Regular Trading Session 4 - After-Hours Trading Session (Future Implementation)
Short Sale Restriction	1	Alphanumeric	Current state of short sale restriction. 'Y' – Short Sale Restriction is in effect 'N' – Short Sale Restriction is not in effect

4.5 Top of Market (Best Bid and Offer) Message – Compact Format

This is the message format that will be used to publish MIAX Pearl Best Bid and Offer (MPBBO) of a security with MPBBO values that can fit in this compact format. In the compact format both bid and offer prices have 2 decimal places and are limited to a maximum value of $655.35. Bid and Offer sizes are limited to 65,535 shares.

Field Name	Length	Data Type	Notes
MACH Protocol Data			*Refer to MACH Protocol Specification*
Message Type	1	BinaryU	2
Timestamp	4	NanoTime	Nanosecond part of Matching Engine time.
Symbol ID	4	BinaryU	Symbol ID mapped to a given symbol.
Bid Price	2	BinaryPrc2U	Displayed bid price.
Bid Size	2	BinaryU	Aggregate size in shares at the displayed bid price.
Offer Price	2	BinaryPrc2U	Displayed offer price.
Offer Size	2	BinaryU	Aggregate size in shares at the displayed offer price.

Points to note:

- Refresh: The sequence number in the refresh messages may be used to arbitrate with the sequenced packets from live feed (eg: data with higher sequence number from either the refresh or the live feed represents latest information).

4.6 Top of Market (Best Bid and Offer) Message – Wide Format

This is the message format that will be used to publish MIAX Pearl Best Bid and Offer (MPBBO) of a security with MPBBO values that will not fit in the compact format.

Field Name		Length	Data Type	Notes
MACH Protocol Data				*Refer to MACH Protocol Specification*
Message Type		1	BinaryU	3
Timestamp		4	NanoTime	Nanosecond part of Matching Engine time.
Symbol ID		4	BinaryU	Symbol ID mapped to a given symbol.
Bid Price		8	BinaryPrc6U	Displayed bid price.
Bid Size		4	BinaryU	Aggregate size in shares at the displayed bid price.
Offer Price		8	BinaryPrc6U	Displayed offer price.
Offer Size		4	BinaryU	Aggregate size in shares at the displayed offer price.

Points to note:

- Refresh: The sequence number in the refresh messages may be used to arbitrate with the sequenced packets from live feed (eg: data with higher sequence number from either the refresh or the live feed represents latest information).

4.7 Last Sale (Trade) Message

This is the message format that will be used to disseminate Trades that are resulting from executions on MIAX Pearl Equities during the current trading session. It includes a Trade ID that is unique to the trade across the exchange for the trading day. Trade corrections will also be disseminated using the same message format.

Field Name	Length	Data Type	Notes
MACH Protocol Data			*Refer to MACH Protocol Specification*
Message Type	1	BinaryU	10
Timestamp	4	NanoTime	Nanosecond part of Matching Engine time.
Symbol ID	4	BinaryU	Symbol ID mapped to a given symbol.

Field Name	Length	Data Type	Notes
Trade ID	8	BinaryU	Unique ID assigned by the Matching Engine.
Correction Number	1	BinaryU	Trade correction number. Set to zero for new trades. Increments by 1 for each subsequent correction.
Price	8	BinaryPrc6U	Execution price.
Size	4	BinaryU	Number of shares executed.
Flags	1	Flags	**Bit 0:** 0 – Not reportable to the SIP 1 – Reportable to the SIP **Bits 1-7:** undefined

Points to Note:

- Only SIP reportable trades are disseminated
- Trade ID assigned to a trade is used in subsequent Trade Cancel message if the trade is cancelled.
- Trade corrections will have the same Trade ID as the original trade, the Correction Number will be incremented for each subsequent correction.

4.8 Trade Cancel Message

This is the message format that will be used to disseminate canceled trades that are resulting from Trade cancellations on MIAX Pearl Equities during the current trading session.

Field Name	Length	Data Type	Notes
MACH Protocol Data			*Refer to MACH Protocol Specification*
Message Type	1	BinaryU	11
Timestamp	4	NanoTime	Nanosecond part of Matching Engine time.
Symbol ID	4	BinaryU	Symbol ID mapped to a given symbol.
Trade ID	8	BinaryU	Unique ID assigned by the Matching Engine to the original trade being cancelled.
Correction Number	1	BinaryU	The latest correction number of the given Trade ID.
Price	8	BinaryPrc6U	The latest price of the given Trade ID.
Size	4	BinaryU	The latest size of the given Trade ID.

Appendix A: ToM Subscription/ Connectivity Information

Please visit MIAX website at http://www.MIAXEquities.com to obtain the most up-to-date information about the following:

- Real-time Feed multicast groups, ports for A feed and B Feed
- Retransmission IP addresses and ports for primary and backup channels.

Appendix B: Contact List

Please visit MIAX website at http://www.MIAXEquities.com to obtain the most up-to-date contact list and other such information.

Appendix C: Revision History

Revision Date	Version	Description
Jan 22, 2020	1.0	First official release
Feb 06, 2020	1.0.a	Minor update to clarify that only SIP reportable trades are disseminated over ToM
Apr 02, 2020	1.1	Removed Tradable field from Symbol Update message. It is now replaced with a reserved field
Nov 05, 2020	1.1.a	Removed Security Type field from Symbol Update message, it is now replaced with a reserved field. Added clarification in Symbol Update message for Symbol ID field that it could change across trading sessions and firms are advised to download and use it for the current trading session.

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