PUMA TRADING SYSTEM TIMESTAMPS

Version 1.1.0

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SUMMARY

1 CONTACTS

- Trading Support Department (GSN): provides real-time connectivity, monitoring and troubleshooting.
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2 CHANGE LOG

Date	Version	Description	Author
Jul. 24th, 2024	1.0.1	- Initial version.	RNKH
Aug. 8th, 2024	1.0.2	- Some minor adjustments.	RNKH
Oct. 8th, 2024	1.0.3.1	- The resolution of *sendingTime* field for outbound messages is now fixed to nanoseconds from milliseconds and synchronized with PTP. - *packetHeader.sendingTime* field adjusted to reflect the new **T11** measure point that is the instant just before the market data packet will be published in the UDP multicast.	RNKH
Dec. 10th, 2024	1.0.4	- *receivedTime* field has been published in *ExecutionRepor_New*, *ExecutionRepor_Modify*, *ExecutionRepor_Cancel* and *ExecutionRepor_Reject* messages with the T6 point in time since December 9th, 2024, in the production environment.	RNKH
Jun., 13th, 2025	1.1.0	- *mDEntryTimestamp* field replaced by *transactTime* field with **T5** point of measure in *Order_MBO*, *DeleteOrder_MBO*, *MassDeleteOrders*, *ExecutionSummary*, *Trade*, *ForwardTrade* and *TradeBust* messages. - **T10** point of measure as the value of *mDEntryTimestamp* field is now only applied to market data statistics messages. - Value of *aggressorTime* field changed to **T4** point of measure of the origin of cascaded stop orders executions and outright executions related to an implied execution.	RNKH

3 TIME AND TIMESTAMPS IN PUMA TRADING SYSTEM

3.1 Introduction

This document highlights details of timestamp fields for private and public messages, providing guidance on how clients may better track latency of these messages and identify missed opportunities.

3.2 Glossary

This section provides some high-level definitions of commonly used terms in this document. Please note that some of these terms are described in more detail in the dedicated sections within this document or in the associated specifications documents (*Binary Entrypoint* and *Binary UMDF* guidelines documents):

- **Timestamps**: a device (a representation) for recording the time of day, and in some cases date, on which an event has occurred, a message was received or sent out. Technical format of the timestamp used in various fields may represent this value differently and is specified for each field associated with timestamps in the message specifications.
- **Timescale**: span of time within which events occur, in comparison to any broader period of time. Timescale is used to identify granularity of the time protocol used for synchronization between computer networked systems, and definition of timestamps.
- **Hardstamps**: timestamps captured in the wire or in dedicated device.
- **Softstamps**: timestamps captured in the application software.
- **Resolution:** the fineness to which the time can be read.
- **Precision:** the fineness to which the time can be read *repeatably and reliably*.
- **Accuracy:** the correctness of the measured time.
- **Precision Time Protocol (PTP)**: is a protocol (documented by IEEE in 1588) used to synchronize clocks in the computing infrastructure, using computer network. PTP is used in critical mission applications as it has higher level of granularity (compared to NTP) and has built in provisions to eliminate network and equipment jitter. PTP timescale is defined in seconds and nanoseconds, with common assumption that it uses POSIX timescale with origin January 1, 1970.

3.3 How the timestamps are set

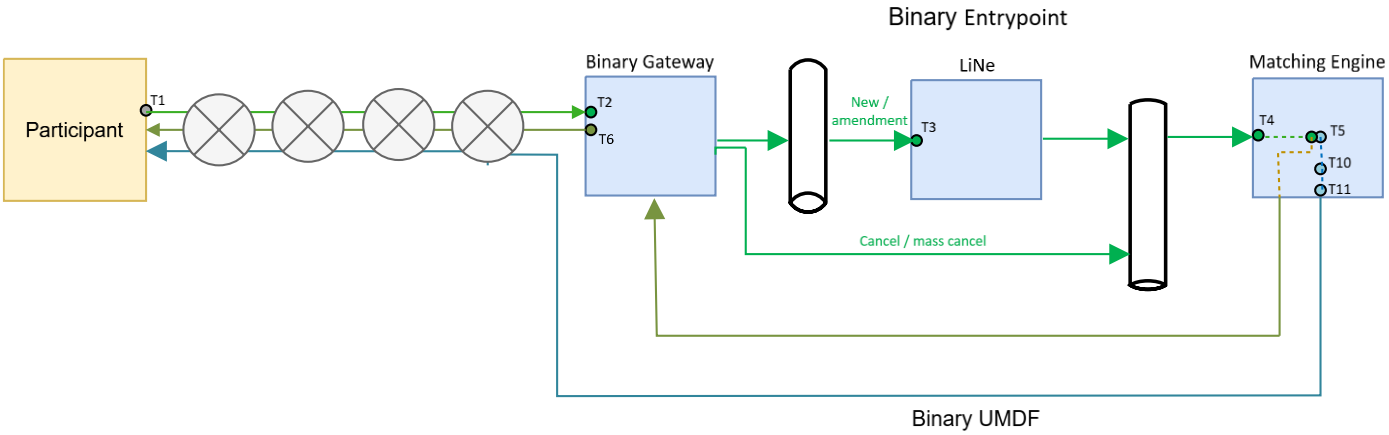
Currently, all timestamps published in outbound messages (order entry and market data) are *softstamps* generated by the related PUMA components (binary gateway or matching engine). Those components gathered timestamps using default API for the purpose of getting system clock from the machines that is synchronized by PTP protocol with our

own stratum-3 atomic master clock using a dedicated network interface for this purpose. Currently, the standard deviation for the offset from the master clock (accuracy of our timestamps) is up to one microsecond.

3.4 Timestamp fields in the current platform configuration (Oct. 2024)

Inbound and outbound messages in private (order entry) and public (market data) data in PUMA carry external timestamps provided by the clients and internal timestamps provided by PUMA components, allowing clients to monitor the arrival or processing time on each system and compare them at different levels.

The following diagram and table represent the different timestamps provided in the outbound messages (order entry and market data). The default resolution of all those metrics is in nanoseconds. Exceptions are described in the notes section.



Measure point	Feed type	SBE field name	Component	Notes
T1	Private	InboundBusinessHeader.sendingTime	Client	Provided by the client.
T2	Private	receivedTime	Gateway	Assigned by the gateway after the message is received from the client's socket.
T3	Private	**<NONE>**	LiNe	Assigned by LiNe after the message is received from the internal bus, in the beginning of the market segment processing for new/amendment orders.
T4	Private	marketSegmentReceivedTime	Matching Engine	Assigned by the matching engine when the message is received from the internal bus.
	Public	aggressorTime	Matching Engine	Assigned when the **entering aggressor** order is received from the internal bus and triggered a match event. Field present only in *ExecutionSummary* message. In the case of cascading STOP orders triggered by an execution, the value of the *aggressorTime* field in subsequent *ExecutionSummary* messages will have

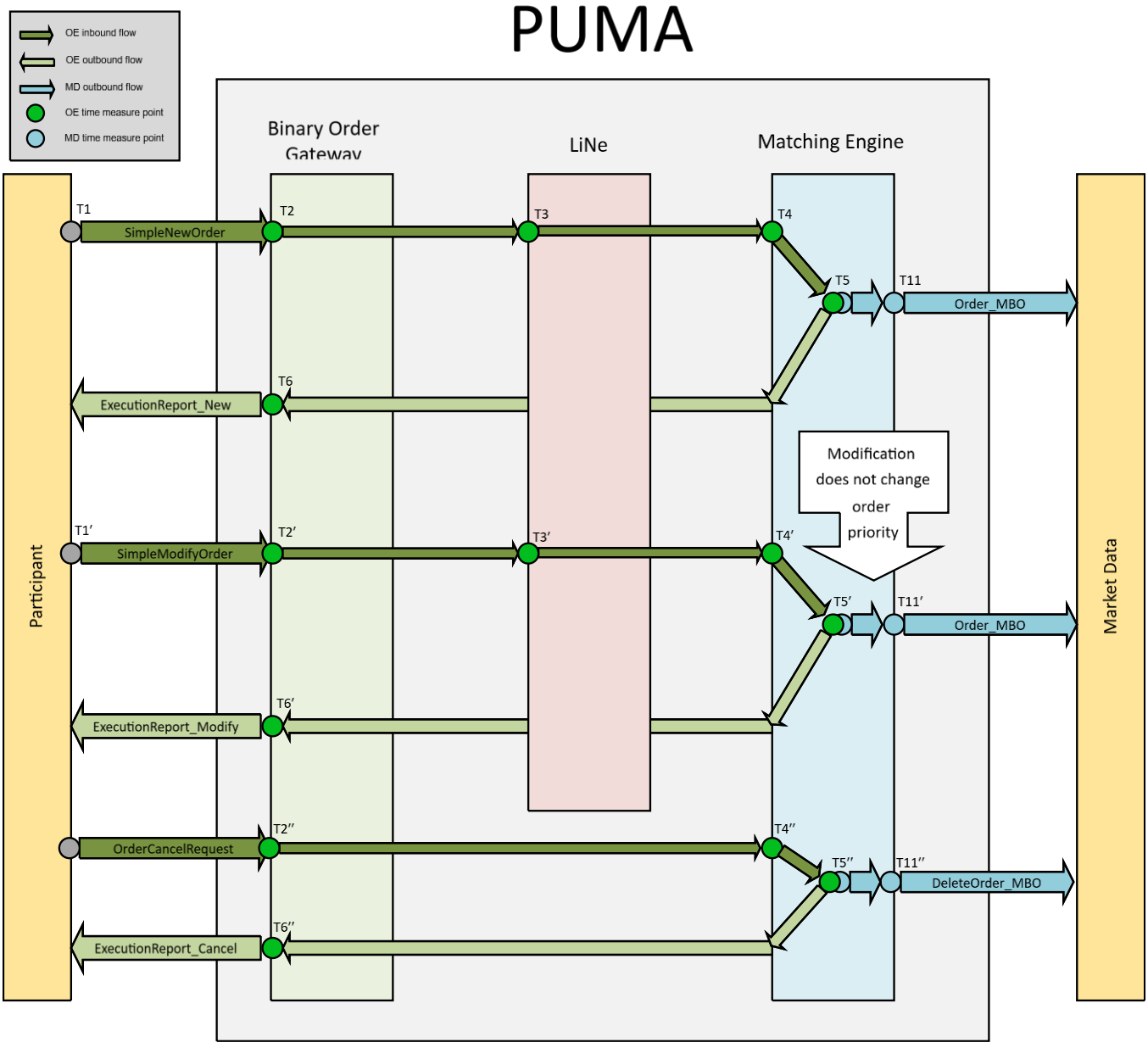
Measure point	Feed type	SBE field name	Component	Notes
				the same value as the **T4** of the initial execution that triggered this cascade. For the execution of an implied order, the value of the *aggressorTime* field for the execution of the *outrights* related to that implied will have the same value as the **T4** of the execution of the implied order.
T5 Assigned by the matching engine when the transaction happens (book updates / matching).	Private	transactTime	Matching Engine	Timestamp of execution/order creation for all sub-types of *ExecutionReport* messages.
	Public	transactTime	Matching Engine	Timestamp of when the order, trade or trade bust occurred in *Order_MBO*, *DeleteOrder_MBO*, *MassDeleteOrders*, *ExecutionSummary*, *Trade*, *ForwardTrade* and *TradeBust* messages. It has the same value as the value of *transactTime* field of the related *ExecutionReport* message in the Order Entry flow. Timestamp when status of the security/group phase changed in *SecurityStatus* and *SecurityGroupPhase* messages.
	Public	mDInsertTimestamp	Matching Engine	Timestamp when the order was inserted or re-inserted into the order book in *Order_MBO* message.
T6	Private	OutboundBusinessHeader.sendingTime	Gateway	Assigned by the gateway just before the gateway queuing the message to the client's socket.
T10	Public	mDEntryTimestamp	Matching Engine	Assigned by the matching engine during the assembly of the market data messages to be published. It has the same value for all **statistics** messages inside a single packet.
T11	Public	packetHeader.sendingTime	Matching Engine	Assigned by the matching engine just before the market data packet will be published in the UDP multicast.

3.5 Timestamp dynamics

Diagrams below provide dynamics of timestamp use in PUMA and correspond to the various cases described in this document.

3.5.1 New order entry and cancellation

This scenario consists in a participant sending a new order, then modifying it without changing the priority of the order, and finally cancelling it.



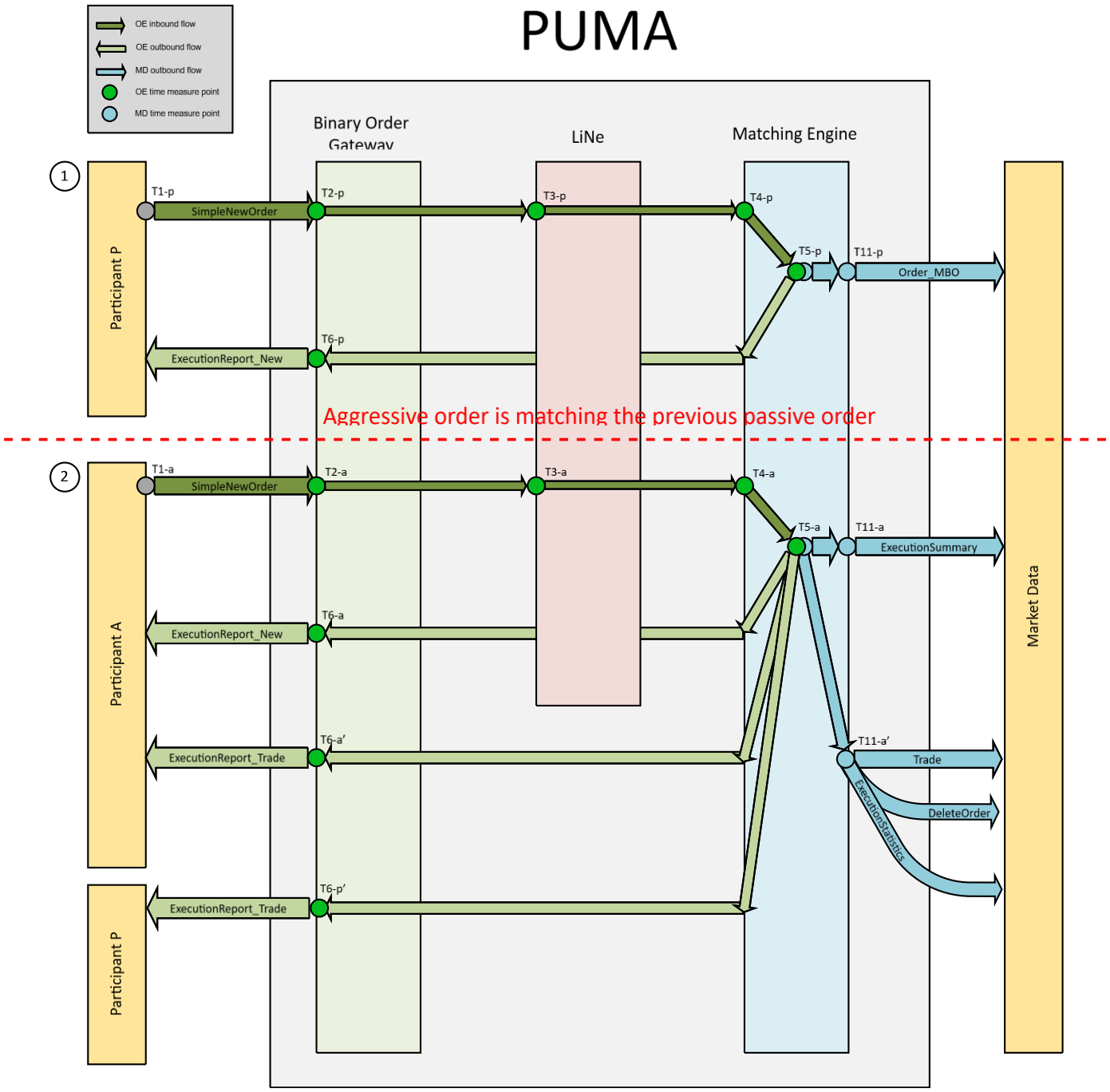
Timestamps in the messages above:

Order Entry		Market Data	
Message	**Timestamp fields**	**Message**	**Timestamp Fields**
SimpleNewOrder	InboundBusinessHeader: T1		
ExecutionReport_New	OutboundBusinessHeader.sendingTime: T6 transactTime: T5 marketSegmentReceivedTime: T4 receivedTime: T2	**Order_MBO**	packetHeader.sendingTime: T11 mDInsertTimestamp: **T5** mDEntryTimestamp: T10
SimpleModifyOrder (modification that does not change order priority => reduce orderQty)	InboundBusinessHeader: T1'		
ExecutionReport_Modify	OutboundBusinessHeader.sendingTime: T6' transactTime: T5' marketSegmentReceivedTime: T4' receivedTime: T2'	**Order_MBO**	packetHeader.sendingTime: T11' mDInsertTimestamp: **T5** (same value published previously in the ExecutionReport_New) mDEntryTimestamp: T10'
OrderCancelRequest	InboundBusinessHeader: T1''		
ExecutionReport_Cancel	OutboundBusinessHeader.sendingTime: T6'' transactTime: T5'' marketSegmentReceivedTime: T4'' receivedTime: T2''	**DeleteOrder_MBO**	packetHeader.sendingTime: T11'' mDEntryTimestamp: T10''

3.5.2 Order in the book is aggressed

This scenario consists in a participant P (passive) sending a new order, then another participant A (aggressor), receiving that event from the market data, successfully sending an aggressor order that matches completely that passive order.

The value of *aggressorTime* field in the *ExecutionSummary* market data message is the same value of *marketSegmentReceivedTime* field in the *ExecutionReport_New* order entry message of the aggressor order that triggered the match event.



	Order Entry		Market Data	
Pariticipant	**Message**	**Timestamp fields**	**Message**	**Timestamp Fields**
P	SimpleNewOrder	InboundBusinessHeader: T1-p		
	ExecutionReport_New	OutboundBusinessHeader.sendingTime: T6-p transactTime: T5-p marketSegmentReceivedTime: T4-p	**Order_MBO**	packetHeader.sendingTime: T11-p mDEntryTimestamp: T10-p mDInsertTimestamp: T5-p

		receivedTime: T2-p		
A	SimpleNewOrder	InboundBusinessHeader: T1-a		
	ExecutionReport_New	OutboundBusinessHeader.sendingTime: T6-a transactTime: T5-a marketSegmentReceivedTime: T4-a receivedTime: T2-a	**ExecutionSummary**	packetHeader.sendingTime: T11-a mDEntryTimestamp: T10-a aggressorTime: T4-a
	ExecutionReport_Trade	OutboundBusinessHeader.sendingTime: T6-a' transactTime: T5-a	**Trade** **DeleteOrder_MBO** **ExecutionStatistics** (in the same packet)	packetHeader.sendingTime: T11-a' Trade.mDEntryTimestamp: T10-a' DeleteOrder_MBO.mDEntryTimestamp: T10-a' ExecutionStatistics.mDEntryTimestamp: T10-a'
P	ExecutionReport_Trade	OutboundBusinessHeader.sendingTime: T6-p' transactTime: T5-a		