FIA Market Technology Division Preparing for Leap Second

JUNE 2015

Introduction

A leap second is the addition of an extra second at the end of a day to realign the Coordinated Universal Time (UTC) standard based on International Atomic Time (TAI) with mean solar time. UTC is the accepted standard for international time synchronization, taking the place of Greenwich Mean Time in 1960.

Introducing a leap second periodically corrects for irregularities in the Earth's rate of rotation. This concept was originally introduced in 1972. The decision to introduce a leap second is taken by the International Earth Rotation and Reference Systems Service (IERS), formally the Bureau International de l'Heure. Leap seconds are only introduced on either June 30 or December 31. The last occurrence of a leap second was on Saturday, June 30, 2012.

The majority of computer systems are synchronized using Network Time Protocol (NTP), which encodes time using the UTC system and is used to avoid clock drift between different systems. Such systems form the basis of electronic trading and clearing operations across the globe.

Why is it important?

On Tuesday, June 30, 2015, an additional second will be added to the UTC day to account for variability of the earth's rotation. Theoretically, clocks will change from 23:59:58 UTC to 23:59:59 UTC to 23:59:60 UTC to 00:00:00 UTC.

For reference 23:59:59 UTC is equivalent to the following times around the globe:

New York	19:59:59 EDT (UTC-4)
Chicago	18:59:59 CDT (UTC-5)
London	00:59:59 BST (UTC+1)
Frankfurt	01:59:59 CEST (UTC+2)
Singapore	07:59:59 SGT (UTC+8)
Tokyo	08:59:59 JST (UTC+9)
Sydney	09:59:59 AEST (UTC+10)

This will coincide with several global financial markets opening for trading or already in the process of trading. This is especially true of Asia-Pacific equity and futures markets in Japan, Korea, Singapore and Australia, as well as overnight US futures markets.

This will be the first time that a leap second event has occurred during active trading hours in an environment where electronic and automated trading relies on sub-second precision for communication, execution, clearing, surveillance and audit trails.

During the 2012 leap second event several systems–especially internet servers—encountered issues based on differences in preparedness and implementation, mainly because most computer systems are not prepared to handle a timestamp of 23:59:60 and there are several differences within NTP based time synchronization systems regarding reuse of the timestamp 23:59:59 instead of 23:59:60. There is concern within the financial industry that similar issues could lead to disruption to trading operations across exchanges, clearinghouses, brokers, investors and key service providers.

Executive Summary

The financial services ecosystem exists within the global technology marketplace. The creation of the leap second occurred before electronic trading systems and prior to June 30, 2015, the leap second has never occurred during an electronic trading session. The last leap second impacted a number of technology solutions. Reliability and stability within the futures industry is an expectation of all market participants. The FIA Market Technology Division views this event as a possible disruption that can be avoided by industry collaboration and preparedness.

The FIA Market Technology Division created a working group of member firms, exchanges and vendors to research, share information and make recommendations to the industry. The recommendations focus on environmental knowledge, preparedness, and recovery.

The recommendations include:

- Develop and Implement a Continuity and Recovery Plan
- Implement Enterprise Time Management
- Update Vulnerable Systems
- Actively Monitor Critical Systems
- Consider Adjusting Market Activity

Within these themes, the FIA Market Technology Division has developed high level recommendations to improve the preparedness of industry participants and reduce the likelihood of market disruption.

FIA Market Technology - Recommendations

The FIA Market Technology Division recommendations focus on encouraging each firm to understand their environment and review key areas in order to anticipate the impact of the leap second. Substantial information is available in the public space to aid firms in reviewing the solutions in place and taking corrective action. However, with any action there is uncertainty and risk. A clear plan is required to ensure steps do not destabilize a trading environment.

The working group represents a wide variety of market participants who operate within highly complex, global environments. This paper presents recommendations from a collective group of industry representatives with a diverse range of backgrounds and experience in markets and technology.

The approach and success of testing has been an important topic within the working group due to the reliance on source technologies such as NTP Strata 0 servers which send the leap second flag and the 61st second. While it is difficult to introduce these events into test scenarios, many firms have developed a comprehensive approach and successfully tested their environments to challenge hardware and software vendors to correct vulnerabilities.

The overarching recommendations are for all organizations to:

- Take the Event Seriously
- Be Prepared
- Examine Technology Dependencies

1. Develop and Implement a Business Continuity and Recovery Plan

Business continuity over the leap second is critical to avoid disruption, and individual firm preparedness is an important factor to overall industry stability. The leap second event is not specific to the exchanges and potential issues may occur across all segments of the financial industry.

The key points to being prepared include understanding the impact of the leap second on all systems within the firm, addressing known issues, monitoring, and remaining vigilant for anything unexpected.

A recovery plan is an important part of every critical system. A recovery plan will entail a prepared approach for system recovery in the event of interruption. This plan will include prioritization of critical systems, development of recovery time objectives, identification of recovery point objectives, a backup strategy, and a plan for critical human resources.

A recovery plan should be:

- Tailored to the potential vulnerabilities exposed by the leap second.
- Expanded to address unexpected events.
- Validated as systems are being updated with vendor patches.

Leading up to, during and after the leap second event, plan to have resources monitoring systems and subject matter experts available in case of system interruption.

2. Implement Enterprise Network Time Management (NTP or PTP)

Implementing an enterprise time management system to manage the leap second across an organization's systems will minimize the complexity and impact of the leap second.

The leap second will be communicated through the Network Time Protocol (NTP) or the Precision Time Protocols (PTP). For more information on NTP and PTP, please refer to Appendix B.

Computer systems rely on time synchronization to effectively communicate. In electronic trading systems, logging systems and clearing systems, the accurate and consistent time stamp is a critical aspect of record keeping.

Where systems and vendors have identified vulnerabilities, these are often associated with the NTP solution or its implementation. Many systems are unable to process a 61st second and require another system to manage this complexity. In other cases, systems have had defects where the leap second is processed in a vulnerable solution.

Each organization should determine the best enterprise NTP or PTP solution to meet their needs. Additionally, a leap second approach should be defined. There are many alternatives to processing the leap second and these include: repeat the 60th second, stop counting time, increment time on request, slew time preceding the leap second, and slew time following the leap second. By selecting an enterprise solution, each organization can manage their time versus others in the ecosystem and insulate themselves from unknown vulnerabilities.

3. Update Vulnerable Systems

Previous leap second events have caused instability within some systems. In response to these previous impacts, many technology providers have prepared for the 2015 repeat of leap second by releasing versions of their hardware and software that are expected to process the leap second without issue.

Each organization should investigate their systems and determine if their hardware and software vendors have created newer versions (patches) to correct potentially disruptive vulnerabilities within their products. Defining and understanding interdependencies within the environment are also part of the remediation process. Where patches are available, it is recommended that an enterprise patching process be applied to ensure vulnerable systems are up to date.

Understanding how affected systems will respond to the selected enterprise time management process is very important.

Processing the leap second may include the repeat of a second, or non-linear time. Time settings may impact some applications in unpredictable ways. It is important to follow up with critical system vendors and understand how their systems will behave with your approach to enterprise time management.

In some cases, the technology disruptions in 2012 were preventable if the systems had been patched according to the vendor recommendation.

A list of common vendor knowledge base articles compiled by the working group is presented in Appendix D.

4. Actively Monitor Critical Systems

Monitoring systems provide important information regarding the availability, status, capacity, and performance of an organization's systems. Monitoring enterprise systems during the leap second event provides the maximum time to mitigate any issues that arise. Since this is the first time the leap second has occurred during an electronic trading day, it is impossible to anticipate all the ways in which systems may be impacted.

As an example from the 2012 leap second event, a vulnerability made RedHat Linux systems unresponsive by using 100% of the hardware's processing power. By monitoring system availability or CPU utilization, common monitoring events, this issue would be quickly identified and mitigated.

Where monitoring is not already in place, coordinating efforts to patch and monitor critical infrastructure is an effective use of resources.

It is strongly recommended that firms organize their level 1 support staff ("all hands on deck") to monitor critical systems before and after leap second processing to ensure unexpected events don't disrupt the operation. Level 2 and level 3 support staff should be available for escalation in the event that a recovery plan has to be invoked.

5. Consider Adjusting Market Activity

The global financial industry is now a 24x6 marketplace with limited windows within the trading week where any or all exchanges are inactive. There is no convenient window mid-week that provides a convenient time for the industry to implement technology changes.

This will be the first time that the leap second has occurred during active trading hours in an environment where electronic and automated trading rely on sub-second precision for communication, execution, clearing, surveillance and audit trails. The leap second event will coincide with several global financial markets opening for trading or already in the process of trading, including Asia-Pacific equity and futures markets in Japan, Korea, Singapore and Australia, as well as overnight US and European futures markets and late trading on some US equity markets.

The 2012 leap second event revealed vulnerabilities across numerous platforms. There is concern within the financial industry that similar issues could lead to disruption to trading operations across exchanges, clearinghouses, brokers, investors and key service providers – potentially introducing systemic risk to the financial industry.

To address this risk, US futures exchanges will postpone their open on June 30, for trade date July 1, and late trading on US equity markets will halt earlier than usual.

Exchanges in Asia have announced that they will maintain normal trading hours and have provided details regarding how their systems will adjust their clocks before or after the leap second.

The different approaches taken will have an impact on all market participants.

Most notably clocks within the global marketplace will handle the leap second differently, and for a few hours (or days) before and after the leap second event, time will become relative, based on what your system clock does in comparison with other system clocks. Depending on how your system clock adjusts for the leap second, your systems will always be slightly out-of-sync with at least one of the exchanges in the Asia-Pacific region until all systems are resynchronized with International Atomic Time.

Even where an exchange has delayed their open until after the leap second there may still be issues with timestamps in administrative messages (such as heartbeats) sent via the exchange API, depending on the enterprise time management system employed by the exchange.

A matrix of exchange status during the leap second is presented in Appendix A.

Each organization will need to evaluate the impact of the leap second within their environment and determine what steps should be taken. Firms may want to consider:

- adjusting market activity, particularly with regard to automated trading around the leap second event; and
- employing additional vigilance around all aspects of trading (execution, operations, risk management, etc.) before, during and after the leap second event.

FIA Market Technology Division – Next Steps

Preparation is a critical part of stability during the leap second. The recommendations can be applied across market participants to enhance an organization's understanding of their environment. Open communication and collaboration has been a success factor in the collection and dissemination of knowledge and the development of recommendations. FIA has scheduled a conference bridge around the leap second event to continue this effort:

Tuesday, June 30 at 7:00pm EDT (6:00pm CDT)

United States: (805) 309-2350
United Kingdom: +44.20.7043.5048
Tokyo: +81.3.4579.9748
Singapore: +65.3158.3519
Australia: +61.2.8014.4647
Seoul: +82.2.6022.2315
Passcode: 8236757#
Additional locations: http://www.turbobridge.com/international.html

Following July 1, a post mortem will be scheduled to collect the experiences across industry participants and compile a document presenting recommendations for future industry events.

Appendix A: Global Exchange Matrix

All market participants will be impacted by the choices that global exchanges have taken with regard to how they will manage the leap second event.

Since exchanges have chosen many differing approaches, FIA Market Technology Division has attempted to represent this within a Global Exchange Matrix that presents the state of major global exchanges at the time of leap second, how their systems will process the leap second, and any modified trading schedules where they exist.

Note that this matrix is has been collated on a best efforts basis. FIA acknowledges that it cannot ensure that every market participant, vendor or trading venue has taken steps to reduce the risk of an issue occurring before, during or after the leap second event. All market participants should be aware that any issues that occur due to the leap second event are likely to be viewed by local regulatory authorities under existing regulations which may or may not take into account the impact of the leap second event. We strongly encourage all market participants to understand how different jurisdictions are approaching the leap second event, and take action appropriately.

FIA recommends verifying all information directly with the exchange as appropriate.

See next page for FIA Leap Second Preparedness - Global Exchange Matrix Table.

FIA Leap Second Preparedness - Global Exchange Matrix

Version 1.3

City	Sydney	Tokyo	Seoul	Singapore	Hong Kong	Delhi	Dubai	Frankfurt	Paris	London	Sao Paulo	Montreal	New York	Chicago	City
Time	9:59:59	8:59:59	8:59:59	7:59:00	7:59:59	5:29:59	3:59:59	1:59:59	1:59:59	0:59:59	20:59:59	19:59:59	19:59:59	18:59:59	Time
Timezone	AEST	JST	KST	SGT	HKT	IST	GST	CEST	CEST	BST	BRT	EDT	EDT	CDT	Timezone
Offset	UTC + 10:00	UTC + 9:00	UTC + 9:00	UTC + 8:00	UTC + 8:00	UTC + 5:30	UTC + 4:00	UTC + 2:00	UTC + 2:00	UTC + 1:00	UTC - 3:00	UTC - 3:00	UTC - 4:00	UTC - 5:00	Offset
Exchange	**ASX**	**JPX**	**KRX**	**SGX**	**HKEX**	**NSE**	**DGCX**	**Eurex**	**Euronext**	**LME**	**BM&F**	**TMX**	**ICE (US + EU)**	**CME Group**	**Exchange**
Usual State	About to open	About to open	About to open	Open	Closed	Closed	Closed	Closed	Closed	Open	Closed	Closed	About to open	Open	Usual State
Adjusted State	About to open	About to open	About to open	Open	Closed	Closed	Closed	Closed	Closed	Delayed open @ 01:15 BST	Closed	Closed	Delayed open @ 20:05 EDT	Delayed open @ 19:45 CDT	Adjusted State
Clock Synchronization	PTP	NTP	*tbc*	*tbc*						*tbc*	*tbc*		NTP	NTP	Clock Synchronization
Clock Adjustment	Dilution between 09:59:59 and 10:12:00 AEST	Dilution between 07:00:00 and 09:00:00 JST	Dilution between 09:00:00 and 09:20:00 KST	Dilution between 03:00:00 and 05:00:00 SGT on July 2nd						*tbc*	Adjustment on Sunday June 28th		Step back @ 20:00:00 EDT	Step back @ 19:00:00 CDT	Clock Adjustment
API	FIX	OM	KOSCOM	OM						FIX	FIX		FIX	FIX	API
API Timestamp	*tbc*	Will continue linearly	*tbc*	*tbc*						*tbc*	Timestamp will be 1 second ahead forall of June 30th.		23:59:59 UTC will be repeated twice	23:59:59 UTC will be repeated twice	API Timestamp
Link	here	Member Notice	Email to FIA	Member Notice						Member Notice	Member Notice		here	here	Link

Exchange	ASX24	TFX
Usual State	Open	Open
Adjusted State	Open	Open
Clock Synchronization	PTP	*tbc*
Clock Adjustment	Dilution between 10:00:00 and 10:00:02 AEST	Dilution between 09:00:00 and 09:50:00 JST
API	FIX	FIX
API Timestamp	*tbc*	*tbc*
Link	here	Email to FIA

Exchange	CHI-X	TOCOM
Usual State	About to open	About to open
Adjusted State	About to open	About to open
Clock Synchronization	*tbc*	*tbc*
Clock Adjustment	Dilution between 22:00:00 and 10:00:00 AEST	*tbc*
API		OM
API Timestamp	Will continue linearly	*tbc*
Link	here	*tbc*

ICE (ex. LIFFE)
Closed
Closed

NYSE	CFE	Exchange
About to close	Open	Usual State
Early close @ 19:55 EDT	Paused between 18:55 and 19:10 CDT	Adjusted State
tbc	*tbc*	Clock Synchronization
tbc	*tbc*	Clock Adjustment
CCG	FIX	API
tbc	*tbc*	API Timestamp
Member Notice	Member Notice	Link

NASDAQ	Eris	Exchange
About to close	Closed	Usual State
Early close @ 19:30 EDT	Closed	Adjusted State
tbc	tbc	Clock Synchronization
tbc	tbc	Clock Adjustment
FIX/OUCH	FIX	API
tbc	tbc	API Timestamp
here	Member Notice	Link

BrokerTec	Nadex	Exchange
Open	Open	Usual State
Delayed open at 20:45 EDT	Delayed open @ 20:00 CDT	Adjusted State
tbc	tbc	Clock Synchronization
tbc	tbc	Clock Adjustment
FIX	FIX	API
tbc	23:59:59 will be repeated twice	API Timestamp
tbc	here	Link

Nasdaq eSpeed	Exchange
Open	Usual State
Delayed open at 20:45 EDT	Adjusted State
tbc	Clock Synchronization
tbc	Clock Adjustment
FIX	API
tbc	API Timestamp
here	Link

To view the full publication go to: https://fia.org/articles/fia-coordinates-industry-preparations-leap-second-event

FIA acknowledges that it cannot ensure that every market participant, vendor or trading venue has taken steps to reduce the risk of an issue occurring before, during or after the leap second event. All market participants should be aware that any issues that occur due to the leap second event are likely to be viewed by local regulatory authorities under existing regulations which may - or may not - take into account the impact of the leap second event. We strongly encourage all market participants to understand how different jurisdictions are approaching the leap second event, and take action appropriately.

Appendix B: NTP and PTP Overview

Network Time Protocol (NTP) is a networking protocol for clock synchronization between computer systems over variable-latency data networks. NTP has been in operation since the 1980s and is one of the oldest Internet protocols in current use. It is intended to synchronize all participating computers to within milliseconds of Coordinated Universal Time (UTC).

NTP uses a hierarchical, semi-layered system of time sources. Each level of this hierarchy is termed a "stratum." Each stratum is less precise than its source.

Where a system's time is inaccurate, NTP will update its time to match the time source. Multiple options are available based on the selected NTP solution, operating system and configuration. Typical options include a Snap method and Drift method.

Precision Time Protocol (PTP) is a relatively new protocol that was developed to improve the time synchronization accuracy to the nanosecond level.

The current implementation is PTPv2. The next version is likely to include an improved mechanism for handling leap seconds and other time synchronization events.

Representatives from IMC, Deutsche Börse and ICE published a paper[1] in 2014 regarding the robustness of the PTPv2 time synchronization protocol within financial networks. The paper cites two historical examples of PTPv2 failures at Eurex and IMC. Though not leap second related, the failures were caused by bad updates from a time synchronization protocol.

[1] Increasing robustness of PTPv2 financial networks by Pedro Estrela, Sebastian Neusüß and Wojciech Owczarek, http://tagus.inesc-id.pt/~pestrela/ptp/pedro_estrela_-_ispcs_2014_best_paper_-_Increasing_PTPv2_robustness_-_presentation_v5.pdf

Appendix C: Leap Second Dilution

Time synchronization protocols such as PTPv2 avoid the timestamp 23:59:60 and ***dilute*** the additional second created by the leap second event before or afterwards, leading to a slightly non-linear approach to timestamps.

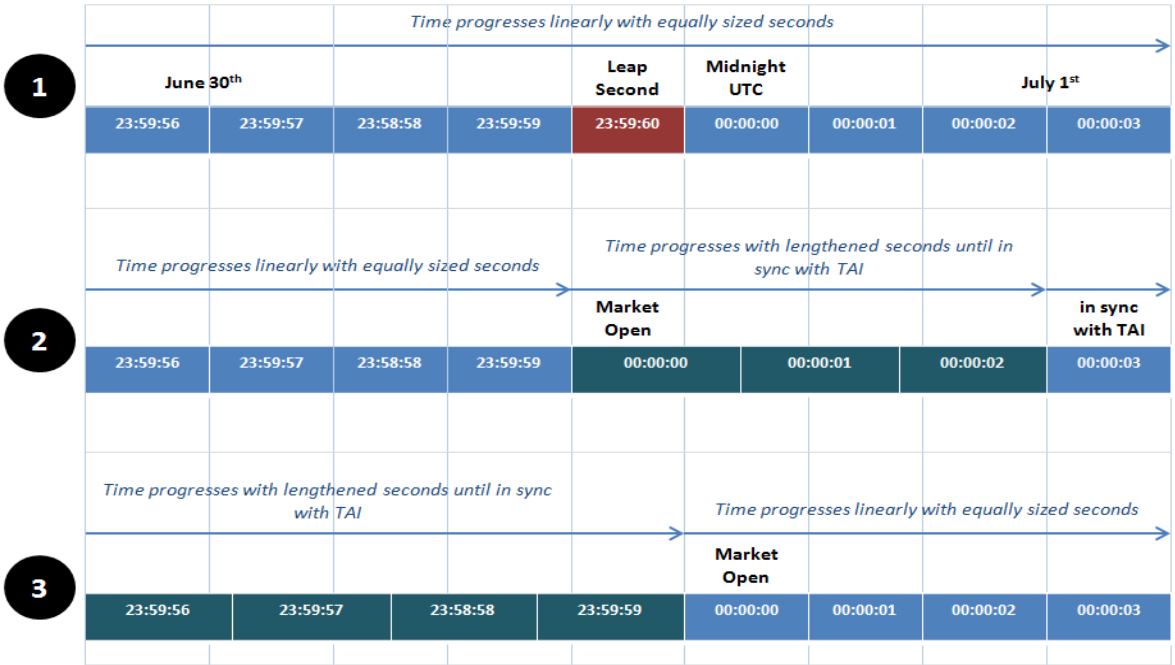
Scenario 1 – Dilution After the Event:

- Asia-Pacific exchanges such as ASX, ASX24, SGX, TFX and KRX will rely on their time synchronization protocols to dilute the leap second ***after*** the event.
- These markets will either open or remain open for continuous trading during the leap second event. Their system clocks will transition from 23:59:59 UTC to 00:00:00 UTC o***ne second earlier*** than midnight TAI.
- The clocks will then add milliseconds over different periods of time after the leap second event on July 1 local time to synchronize with TAI.
- SGX intend to dilute the leap second between 03:00 and 05:00 SGT on July 2.

Scenario 2 – Dilution Before the Event:

- JPX uses a time synchronization protocol that dilutes the leap second ***before*** the leap second event. Their system clocks will add milliseconds over a period of 2 hours prior to midnight UTC and their 00:00:00 UTC time stamp will coincide precisely with midnight TAI.

These different approaches to leap second dilution can be approximately represented in the diagram below.



Key:

1. Linear progression of UTC with insertion of leap second (23:59:60)
2. Leap Second Adjustment ***AFTER*** the event (ASX24, KRX, TFX)
3. Leap Second Adjustment ***BEFORE*** the event (JPX)

Note that lengthened seconds are exaggerated for the purpose of illustration

Appendix D: Hardware and Software Links for Leap Second Information

Note: This is not a comprehensive list of knowledge base articles or notices. Contact your technology providers to validate system vulnerabilities and required actions.

University of Delaware: NTP Timescale and Leap Seconds
Meinberg: Technical Aspects of Leap Second Propagation and Evaluation
Microsoft: Leap Seconds and Windows
Microsoft: Leap Seconds and Windows, Part 2
Red Hat: Resolve Leap Second Issues in Red Hat Enterprise Linux
Red Hat: Leap Second Vulnerability Detector (Requires Red Hat account)
EMC: VPLEX systems may experience unresponsive or reset conditions after June 30, 2015 23:59:59 UTC Leap Second addition. (Requires EMC account)

Additional Notes:

Java requires TZUPDATER to be executed to update the time zone/leap second references.

Oracle 12c for Exadata requires a patch to avoid a system restart during the leap event.

CISCO N3K switches require an upgrade for some versions to avoid a "livelock" condition (CSCut43397).

CISCO N7K switches require an upgrade to SUP1's to avoid a reload or switchover (CSCua77416)

SQL Server, MySQL and Oracle databases are unable to support a time format with a 61st second.

Proper handling at the OS level is a requirement for all DBMS

MySQL – versions 5.1 and later are not susceptible

IBM JVM – No known issues

IBM MQ – No known issues

Tibco – No known issues

To view the full publication go to: https://fia.org/articles/fia-coordinates-industry-preparations-leap-second-event

2001 Pennsylvania Avenue N.W., Suite 600
Washington D.C. 20006-1823
Phone: 202.466.5460 | Fax: 202.296.3184
FIA.org