RTP and Leap Seconds
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Abstract

This document discusses issues that arise when RTP sessions span Universal Coordinate Time (UTC) leap seconds. It updates RFC 3550 to describe how RTP senders and receivers should behave in the presence of leap seconds.

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1. Introduction

In some media networking applications, RTP streams are referenced to a wall-clock time (absolute date and time). This is accomplished through use of the NTP timestamp field in the RTCP sender report (SR) to create a mapping between RTP timestamps and the wall clock. When a wall-clock reference is used, the play-out time for RTP packets is referenced to the wall clock. Smooth and continuous media play out requires a smooth and continuous time base. The time base used by the wall clock may include leap seconds which are not rendered smoothly.

This document provides recommendations for smoothly rendering streamed media referenced to common wall clocks which do not have smooth or continuous behavior in the presence of leap seconds.

2. Terminology

The key words "MUST", "MUST NOT", "REQUIRED", "SHALL", "SHALL NOT", "SHOULD", "SHOULD NOT", "RECOMMENDED", "MAY", and "OPTIONAL" in this document are to be interpreted as described in [1] and indicate requirement levels for compliant implementations.

3. Leap seconds

The world time standard is International Atomic Time (TAI) which is based on vibrations of cesium atoms in an atomic clock. The more common Universal Coordinated Time (UTC) is based on the rotation of the Earth. In 1971 UTC was redefined in terms of TAI and the concept of leap seconds was introduced to allow UTC to remain synchronized with with the rotation of the Earth. Leap seconds are scheduled by the International Earth Rotation and Reference Systems Service. Leap seconds may be scheduled at the last day of any month but are preferentially scheduled for December and June and secondarily March and September.[2] Because Earth's rotation is unpredictable, leap seconds are typically not scheduled more than six months in advance. Leap seconds can be scheduled to either add or remove a second from the day. All leap second events since their introduction in 1971 have been scheduled in June or December and all have added seconds. This is a situation that is expected to but not guaranteed to continue.

NOTE- The ITU is studying a proposal which could eventually eliminate leap seconds from UTC. As of January 2012, this proposal is expected to be decided no earlier than 2015.[3]

3.1. UTC behavior during leap second

UTC clocks insert a 61st second at the end of the day when a leap second is scheduled. The leap second is designated "23h 59m 60s".

3.2. NTP behavior during leap second

Under NTP [4] a leap second is inserted at the beginning of the last second of the day. This results in the clock freezing or slowing for one second immediately prior to the last second of the affected day. This results in the last second of the day having a real-time duration of two seconds.

3.3. POSIX behavior during leap second

Most POSIX systems insert the leap second at the end of the last second of the day. This results in repetition of the last second. A timestamp within the last second of the day is therefore ambiguous in that it can refer to a moment in time in either of the last two seconds of a day containing a leap second.

3.4. Summary of leap-second behaviors

Table 1 summarizes behavior across a leap second for the wall clocks discussed above.

The table illustrates the leap second that occurred June 30, 2012 when the offset between International Atomic time (TAI) and UTC changed from 34 to 35 seconds. The first column shows RTP timestamps for an 8 kHz audio stream. The second column shows the TAI reference. Following columns show behavior for the leap-second-bearing wall clocks described above. Time values are shown at half-second intervals.

RTP	TAI	UTC	POSIX	NTP
8000	00:00:32.500	23:59:58.500	23:59:58.500	23:59:58.500
12000	00:00:33.000	23:59:59.000	23:59:59.000	23:59:59.000
16000	00:00:33.500	23:59:59.500	23:59:59.500	23:59:59.500
20000	00:00:34.000	23:59:60.000	23:59:59.000	00:00:00.000
24000	00:00:34.500	23:59:60.500	23:59:59.500	00:00:00.000
28000	00:00:35.000	00:00:00.000	00:00:00.000	00:00:00.000
32000	00:00:35.500	00:00:00.500	00:00:00.500	00:00:00.500

Table 1

4. Recommendations

Senders and receivers which are not referenced to a wall clock are not affected by issues associated with leap seconds and no special accommodation is required.

RTP implementation using a wall-clock reference is simplified by using a clock with a timescale which does not include leap seconds. IEEE 1588 [5], GPS [6] and other TAI [7] references do not include leap seconds. NTP time, operating system clocks and other UTC (Coordinated Universal Time) references include leap seconds.

All participants working to a leap-second-bearing reference SHOULD recognize leap seconds and have a working communications channel to receive notification of leap second scheduling. Without prior knowledge of leap second schedule, NTP servers and clients may become offset by exactly one second with respect to their UTC reference. This potential discrepancy begins when a leap second occurs and ends when all participants receive a time update from a server or peer. Depending on the system implementation, the offset can last anywhere from a few seconds to a few days. A long-lived discrepancy can be particularly disruptive to RTP operation.

Because of the ambiguity leap seconds can introduce and the inconsistent manner in which different systems accommodate leap seconds, generating or using NTP timestamps during the entire last second of a day on which a leap second has been scheduled SHOULD be avoided. Note that the period to be avoided has a real-time duration of two seconds. In the Table 1 example, the region to be avoided is indicated by RTP timestamps 12000 through 28000

4.1. RTP Sender Reports and Receiver Reports

RTP Senders working to a leap-second-bearing reference SHOULD NOT generate sender reports containing an originating NTP timestamp in the vicinity of a leap second. Receivers SHOULD ignore timestamps in any such reports inadvertently generated.

4.2. RTP Packet Playout

Receivers working to a leap-second-bearing reference SHOULD take leap seconds in their reference into account in determining play-out time from RTP timestamps for data in RTP packets.

5. Security Considerations

It is believed that the recommendations herein introduce no new

security considerations beyond those already discussed in [8].

6. IANA Considerations

This document has no actions for IANA.

7. Acknowledgements

The authors would like to thank Steve Allen for his valuable comments in helping to improve this document.

8. Normative References

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[4] Mills, D., Delaware, U., Martin, J., Ed., Burbank, J., and W. Kasch, "Network Time Protocol Version 4: Protocol and Algorithms Specification", June 2010.

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[7] BIPM, "Circular T", May 2012.

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