RTP Clock Source Signalling
draft-williams-avtcore-clksrc-00

Abstract

   NTP timestamps are used by several RTP protocols for synchronisation
   and statistical measurement. This memo specificies SDP signalling
   identifying NTP timestamp clock sources and SDP signalling
   identifying the media clock sources in a multimedia session.

Requirements Language

   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 RFC 2119 [1].

Status of this Memo

   This Internet-Draft is submitted in full conformance with the
   provisions of BCP 78 and BCP 79.

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   material or to cite them other than as "work in progress."

   This Internet-Draft will expire on August 31, 2012.

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1. **Introduction**

   RTP protocols use NTP format timestamps to facilitate media stream
   synchronisation and for providing estimates of round trip time (RTT)
   and other statistical parameters.

   Information about media clock timing exchanged in NTP format
   timestamps may come from a clock which is synchronised to a global
   time reference, but this cannot be assumed nor is there a
   standardised mechanism available to indicate that timestamps are
   derived from a common reference clock. Therefore, RTP
   implementations typically assume that NTP timestamps are taken using
   unsynchronised clocks and must compensate for absolute time
   differences and rate differences. Without a shared reference clock,
   RTP can time align flows from the same source at a given receiver
   using relative timing, however tight synchronisation between two or
   more different receivers (possibly with different network paths) or
   between two or more senders is not possible.

   High performance AV systems often use a reference media clock
   distributed to all devices in the system. The reference media clock
   is often distinct from the the reference clock used to provide
   timestamps. A reference media clock may be provided along with a
   audio or video signal interface, or via a dedicated clock signal
   (e.g. genlock [9] or audio word clock [10]. If sending and receiving
   media clocks are known to be synchronised to a common reference
   clock, performance can improved by minimising buffering and avoiding
   rate conversion.

   This specification defines SDP signalling of timestamp clock sources
   and media reference clock sources.

2. **Applications**

   Timestamp clock source and reference media clock signalling benefit
   applications requiring synchronised media capture or playout and low
   latency operation.

   Exmaples include, but are not limited to:

   Social TV RTCP for inter-destination media synchronization [4]
      defines social TV as the combination of media content consumption
      by two or more users at different devices and locations and real-
      time communication between those users. An example of Social TV,
      is when two or more users are watching the same television
      broadcast at different devices and locations, while communicating
      with each other using text, audio and/or video. A skew in the

media play-out of the two or more users can have adverse effects
on their experience. A well-known use case here is one friend
experiencing a goal in a football match well before or after other
friend(s).

Video Walls A video wall consists of multiple computer monitors,
video projectors, or television sets tiled together contiguously
or overlapped in order to form one large screen. Each of the
screens reproduces a portion of the larger picture. In some
implementations, each screen may be individually connected to the
network and receive its portion of the overall image from a
network-connected video server or video scaler. Screens are
refreshed at 60 hertz (every 16-2/3 milliseconds) or potentially
faster. If the refresh is not synchronized, the effect of
multiple screens acting as one is broken.

Netwoked Audio Networked loudspeakers, amplifiers and analogue I/O
devices transmitting or receiving audio signals via RTP can be
connected to various parts of a building or campus network. Such
situations can for example be found in large conference rooms,
legislative chambers, classrooms (especially those supporting
distance learning) and other large-scale environments such as
stadiums. Since humans are more susceptible to differences in
audio delay, this use case needs even more accuracy than the video
wall use case. Depending on the exact application, the need for
accuracy can then be in the range of microseconds [11].

Sensor Arrays Sensor arrays contain many synchronised measurement
elements producing signals which are then combined to form an
overall measurement. Accurate capture of the phase relationships
between the various signals arriving at each element of the array
is critically important for proper operation. Examples include
towed or fixed sonar arrays, seismic arrays and phased arrays.

3. **Definitions**

The definitions of streams, sources and levels of information in SDP
descriptions follow the definitions found in Source-Specific Media
Attributes in the Session Description Protocol (SDP) [2].

multimedia session A set of multimedia senders and receivers as well
as the data streams flowing from senders to receivers. The
Session Description Protocol (SDP) [3] describes multimedia
sessions.

media stream An RTP session potentially containing more than one RTP
   source. SDP media descriptions beginning with an "m"-line define
   the parameters of a media stream.

media source A media source is single stream of RTP packets,
   identified by an RTP SSRC.

session-level Session-level information applies to an entire
   multimedia session. In an SDP description, session-level
   information appears before the first "m"-line.

media-level Media-level information applies to a single media stream
   (RTP session). In an SDP description, media-level information
   appears after each "m"-line.

source-level Source-level information applies to a single stream of
   RTP packets, identified by an RTP SSRC Source-Specific Media
   Attributes in the Session Description Protocol (SDP) [2] defines
   how source-level information is included into an SDP session
   description.

traceable time A clock is considered to provide traceable time if it
   can be proven to be synchronised to a global time reference. GPS
   XXX is commonly used to provide a traceable time reference. Some
   network time synchronisation protocols (e.g. XXX PTP) can
   explicitly indicate that the master clock is providing a traceable
   time reference over the network.

4. Timestamp Reference Clock Source Signalling

The NTP timestamps used by RTP are taking by reading a local clock at
the sender or receiver. This local clock may be synchronised to
another clock (time source) by some means or it may be
unsynchronised. A variety of methods are available to synchronise
local clocks to a reference time source, including network time
protocols (e.g. NTP [5]) and radio clocks like GPS [XXX].

The following sections describe and define SDP signalling indicating
whether and how the local timestamping clock in an RTP sender/
receiver is synchronised to a reference clock.

4.1. Equivalent Timestamp Clocks

Two or more local clocks that are sufficiently synchronised will
produce timestamps for a given event which are effectively identical
for the purposes of RTP. A local clock in one RTP sender/receiver
can be considered equivalent to a local clock in another RTP sender/

receiver providing they are sufficiently synchronised such that
timestamps produced by one clock are indistinguishable from
timestamps produced by the other. The timestamps produced by
equivalent local clocks in two or more RTP senders/receivers
receivers can be directly compared.

One or more local clocks are equivalent if they are synchronised to a
single master clock via a network time protocol (e.g. XXX NTP,
802.1AS, IEEE1588v2).

One or more local clocks are equivalent if they are synchronised to
any member of a set of master clocks provided that the set of master
clocks are synchronised.

One or more local clocks are equivalent if they are synchronised to a
clock master providing a global time reference (e.g. XXX GPS,
Gallileo). Some network time protocols (e.g. XXX PTP) may allow
master clocks to explicitly indicate that they are "traceable" back
to a global time reference.

4.2. Identifying NTP Reference Clocks

A single NTP server is identified by identified by hostname (or IP
address) and an optional port number. If the port number is not
indicated, it is assumed to be the standard NTP port (123) XXX.

Two or more NTP servers may be listed to indicate that they are
interchangeable. RTP senders/receivers can use any of the listed NTP
servers to govern a local clock that is equivalent to a local clock
slaved to a difference server.

XXX Question: Does NTP carry traceability information? Or is this
implicit somehow in the stratum? Apparently there are some bits in
the leap seconds functionality which talk about "tracking"..

4.3. Identifying PTP Reference Clocks

The IEEE1588 Precision Time Protocol (PTP) family of clock
synchronisation protocols provide a shared reference clock in an
network - typically a LAN. IEEE1588 provides sub-microsecond
synchronisation between devices on a LAN and typically locks within
seconds at startup. With support from Ethernet switches, IEEE1588
protocols can achieve nanosecond timing accuracy in LANs. Network
interface chips and cards supporting hardware time-stamping of timing
critical protocol messages are also available.

When using IEEE1588 clock synchronisation, networked AV systems can
achieve sub 1 microsecond time alignment accuracy when rendering AV

signals and can support latencies less than 1ms through a gigabit
LAN.

Three flavours of IEEE1588 are in use today:

o IEEE 1588-2002 [6]: the original "Standard for a Precision Clock
   Synchronization Protocol for Networked Measurement and Control
   Systems". This is often called IEEE1588v1 or PTPv1.

o IEEE 1588-2008 [7]: the second version of the "Standard for a
   Precision Clock Synchronization Protocol for Networked Measurement
   and Control Systems". This is a revised version of the original
   IEEE1588-2002 standard and is often called IEEE1588v2 or PTPv2.

o IEEE 802.1AS [8]: "Timing and Synchronization for Time Sensitive
   Applications in Bridged Local Area Networks". This is a Layer-2
   only profile of IEEE 1588-2008 for use in Audio/Video Bridged
   LANs.

Each IEEE1588 clock is identified by a globally unique EUI-64 called
a "ClockIdentity". A slave clock using one of the IEEE1588 family of
network time protocols acquires the ClockIdentity/EUI-64 of the
grandmaster clock that is the ultimate source of timing information.
A master clock which is itself slaved to another master clock passes
the grand master clock identity through to its slaves.

Several instances of the IEEE1588v1/v2 protocol may operate
independently on a single network, forming distinct PTP network
protocol domains each of which may have a different master clock. As
the IEEE1588 standards have developed, the definition of PTP domains
has changed. IEEE1588v1 identifies protocol subdomains by a textual
name and IEEE1588v2 identifies protocol domains using a numeric
domain number. 802.1AS is a Layer2 profile of IEEE1588v2 supporting a
single numeric clock domain (0). This specification assumes that an
IEEE1588 clock master for multiple domains will provide the same
timing information to all domains or that each clock domain has a
different master. In other words, this specification assumes that a
timing domain can be uniquely identified using the ClockIdentity of
the grandmaster clock alone.

The PTP family of protocols employ a distributed election protocol
called the "Best Master Clock Algorithm (BMCA) to determine the
active clock master. The clock master choices available to BMCA can
be restricted or favourably biased by setting stratum values,
preffered master clock bits, or other parameters to influence the
election process. In some systems it may be desirable to limit the
number of possible PTP clock masters to avoid re-signalling timestamp
clock sources when the clock master changes.

4.4. Identifying Global Reference Clocks

   Global reference clocks provide a source of tracable time, typically
   via a hardware radio receiver interface. Examples include GPS and
   Gallileo. Apart from the name of the reference clock system, no
   further identification is required.

4.5. Other Reference Clocks

   At the time of writing, it is common for RTP senders/receivers not to
   synchronise their local timestamp clock to a master. An
   unsynchronised clock such as a quartz oscillator is identified as a
   "local" reference clock.

   In some systems, all RTP senders/receivers may use a timetsamp clock
   synchronised to a reference clock that is not provided by one of the
   methods listed above. Examples may include the reference time
   information provided by digital television or cellular services.
   These sources are identified as "private" reference clocks. All RTP
   senders/receivers in a session using a private reference clock are
   assumed to have a mechanism outside this specification confirming
   that their local timestamp clocks are equivalent.

4.6. Traceable Reference Clocks

   A timestamp clock source may be labelled "traceable" if it is known
   to be sourced from a global time reference such as TAI or UTC XXX.
   Providing adjustments are made for differing time bases, timestamps
   taken using a clocks synchronised to a traceable time source can be
   directly compared even if the clocks are synchronised to different
   servers or via different mechanisms. Any traceable timestamp clock
   source can be considered equivalent to another traceable timestamp
   clock source and the timestamps may be directly compared.

   Since any NTP or PTP server providing traceable time can be
   considered equivalent, it is not necessary to identify traceable time
   servers by protocol address.

4.7. Synchronisation Confidence

   Network time protocols periodically exchange timestamped messages
   between servers and clients. Assuming RTP sender/receiver clocks are
   based on commonly available quartz crystal hardware, tight
   synchronisation requires frequent exchange of synchronisation
   messages.

   Unfortunately, in some implementations, it is not possible to control
   the frequency of synchronisation messages nor is it possible to

discover when the last sychronisation message occured. In order to
provide a measure of confidence that the timestamp clock is
sufficiently synchronised, an optional timestamp may be included in
the SDP clock source signalling. In addition, the frequency of
synchronisation message may also optionally be provided.

The optional timestamp and synchronisation frequency parameters
provide an indication of synchronisation quality to the receiver of
those parameters. If the synchronisation confidence timestamp is far
from the timestamp clock at the receiver of the parameters, it can be
assumed that synchronisation has not occured recently or the
timestamp reference clock source is wrongly configured or cannot be
contacted. In this case, the receiver can take action to prevent
unsynchronised playout or may fall back to assuming that the
timestamp clocks are not synchronised.

Synchronisation frequency is expressed as an 8-bit excess-127 field
which is the base 2 logarithm of the frequency in HZ. The
synchronisation frequencies represented by this field range from
2^-127 Hz to 2^+128 Hz. The field value of 127 corresponds to an
update frequency of 1 Hz.

4.8. SDP Signalling of Timestamp Clock Source

Specification of the timestamp reference clock source may at all
levels of an SDP description (see level definitions (Section 3)
earlier in this document for more information).

Timestamp clock source signalling included at session-level provides
default parameters for all RTP sessions and sources in the session
description. More specific signalling included at the media-level
overrides default session-level signalling. Further, source-level
signalling overrides timestamp clock source signalling at the
enclosing media-level and session-level.

If timestamp clock source signalling is included anywhere in an SDP
description, it must be properly defined for all levels in the
description. This may simply be achieved by providing default
signalling at the session level.

Timestamp reference clock parameters may be repeated at a given level
(i.e. for a session or source) to provide information about
additional servers or clock sources. If the attribute is repeated at
a given level, all clocks described at that level are assumed to be
equivalent. Traceable clock sources MUST NOT be mixed with clock
sources having explicit addresses for a given source or session.
Unless synchronisation confidence information is available for each
of the reference clocks listed at a given level, it SHOULD only be

included with the first reference clock source attribute at that
level.

Note that clock source parameters may change from time to time, for
example, as a result of a PTP clock master election. The SIP XXX
protocol supports re-signalling of updated SDP information, however
other protocols may require additional notification mechanisms.

```
timestamp-refclk = "a=ts-refclk:" clksrc SP [sync-confidence] CRLF

clksrc = ntp / ptp / gps / gal / local / private

ntp             = "ntp=" ntp-server-addr
ntp-server-addr =  host [ ":" port ]
ntp-server-addr =/ "traceable" )

ptp             = "ptp=" ptp-version ":" ptp-gmid
ptp-version     =  "IEEE1588-2002"
ptp-version     =/ "IEEE1588-2008"
ptp-version     =/ "IEEE802.1AS-2011"
ptp-gmid        =  EUI64
ptp-gmid        =/ "traceable"

gps     =  "gps"
gal     =  "gal"
local   =  "local"
private =  "private" [ ":" "traceable" ]


sync-confidence = sync-timestamp [SP sync-frequency]

sync-timestamp  = sync-date SP sync-time SP sync-UTCoffset

sync-date       = 4DIGIT "-" 2DIGIT "-" 2DIGIT
                  ; yyyy-mm-dd (e.g., 1982-12-02)

sync-time       = 2DIGIT ":" 2DIGIT ":" 2DIGIT "." 3DIGIT
                  ; 00:00:00.000 - 23:59:59.999

sync-UTCoffset  = ( "+" / "-" ) 2DIGIT ":" 2DIGIT
                  ; +HH:MM or -HH:MM

sync-frequency  = 2HEXDIG
                  ; If N is the field value, HZ=2^(N-127)


host            = hostname / IPv4address / IPv6reference
```

```
   hostname      =  *( domainlabel "." ) toplabel [ "." ]
   toplabel      =  ALPHA / ALPHA *( alphanum / "-" ) alphanum
   domainlabel   =  alphanum
                 =/ alphanum *( alphanum / "-" ) alphanum

   IPv4address   =  1*3DIGIT "." 1*3DIGIT "." 1*3DIGIT "." 1*3DIGIT
   IPv6reference =  "[" IPv6address "]"
   IPv6address   =  hexpart [ ":" IPv4address ]
   hexpart       =  hexseq / hexseq "::" [ hexseq ] / "::" [ hexseq ]
   hexseq        =  hex4 *( ":" hex4)
   hex4          =  1*4HEXDIG

   port = 1*DIGIT

   EUI-64 = 7(HEXDIG "-") 2HEXDIG
```

Figure 1: Timestamp Reference Clock Source Signalling

4.8.1. Examples

Figure 2 shows an example SDP description with a timestamp reference
clock source defined at the session-level.

```
         v=0
         o=jdoe 2890844526 2890842807 IN IP4 10.47.16.5
         s=SDP Seminar
         i=A Seminar on the session description protocol
         u=http://www.example.com/seminars/sdp.pdf
         e=j.doe@example.com (Jane Doe)
         c=IN IP4 224.2.17.12/127
         t=2873397496 2873404696
         a=recvonly
         a=ts-refclk:ntp=traceable
         m=audio 49170 RTP/AVP 0
         m=video 51372 RTP/AVP 99
         a=rtpmap:99 h263-1998/90000
```

Figure 2: Timestamp reference clock defintion at the session level

Figure 3 shows an example SDP description with timestamp reference
clock definitions at the media-level overriding the session-level
defaults. Note that the synchronisation confidence timestamp appears
on the first attribute at the media-level only.

```
v=0
o=jdoe 2890844526 2890842807 IN IP4 10.47.16.5
s=SDP Seminar
i=A Seminar on the session description protocol
u=http://www.example.com/seminars/sdp.pdf
e=j.doe@example.com (Jane Doe)
c=IN IP4 224.2.17.12/127
t=2873397496 2873404696
a=recvonly
a=ts-refclk:local
m=audio 49170 RTP/AVP 0
a=ts-refclk:ntp=203.0.113.10 2011-02-19 21:03:20.345+01:00
a=ts-refclk:ntp=198.51.100.22
m=video 51372 RTP/AVP 99
a=rtpmap:99 h263-1998/90000
a=ts-refclk:ptp=IEEE802.1AS-2011:39-A7-94-FF-FE-07-CB-D0
```

   Figure 3: Timestamp reference clock definition at the media-level

   Figure 4 shows an example SDP description with a timestamp reference
   clock definition at the source-level overriding the session-level
   default.

```
v=0
o=jdoe 2890844526 2890842807 IN IP4 10.47.16.5
s=SDP Seminar
i=A Seminar on the session description protocol
u=http://www.example.com/seminars/sdp.pdf
e=j.doe@example.com (Jane Doe)
c=IN IP4 224.2.17.12/127
t=2873397496 2873404696
a=recvonly
a=ts-refclk:local
m=audio 49170 RTP/AVP 0
m=video 51372 RTP/AVP 99
a=rtpmap:99 h263-1998/90000
a=ssrc:12345 ts-refclk:ptp=IEEE802.1AS-2011:39-A7-94-FF-FE-07-CB-D0
```

   Figure 4: Timestamp reference clock signalling at the source level

5. Timescales, UTC TAI and leap seconds

   RTP implementation is simplified by using a clock reference with a
   timescale which does not include leap seconds. IEEE 1588, GPS and
   other TAI (Inernational Atomic Time) references do not include leap
   seconds. NTP time, operating system clocks and other UTC
   (Coordinated Universal Time) references include leap seconds (though

the ITU is studying a proposal which could eventually eliminate leap
seconds from UTC).

Leap seconds are potentially scheduled at the end of the last day of
December and June each year. NTP inserts a leap second at the
beginning of the last second of the day. This results in the clock
freezing for one second immediately prior to the last second of the
affected day. Most system clocks insert the leap second at the end
of the last second. This results in repetition of the last second of
the day. Generating or using timestamps during the entire last
second of a day on which a leap second has been scheduled should
therefore be avoided. Note that the period to be avoided has a real-
time duration of two seconds.

It is also important that all participants correctly implement 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 be 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 (which,
depending on the operating system and/or implementation, could be
anywhere from a few minutes to a week). Such a long-lived
discrepancy can be particularly disruptive to RTP operation.

Apart from the long-lived discrepancy due to dependence on both
timing (e.g. NTP) updates and leap seconds scheduling updates, there
is also the potential for a short-lived timing discontinuity having
an effect on RTP playout timing (even though leap seconds are quite
rare).

If a timescale with leap seconds is used for RTP:

o RTP Senders using a leap-second-bearing reference must not
   generate sender reports (SR) containing an originating NTP
   timestamp in the vicinity of a leap second. Receivers should
   ignore timestamps in any such reports inadvertently generated.

o Receivers working to a leap-second-bearing reference must be
   careful to take leap seconds into account if a leap second occurs
   between the time a RTP packet is originated and when it is to be
   presented.

6. Media Clock Source Signalling

   A timestamp clock source (ie media clock is locked to a reference
   clock like NTP, GPS, etc) Reference clock source..

An RTP session.. This should be an SSRC within an RTP session.
Include IP address and port.

An IEEE 1722 stream, identified by a Stream ID.

7. IANA Considerations

The SDP attribute "ts-clksrc" defined by this document is registered
with the IANA registry of SDP Parameters as follows:

SDP Attribute ("att-field"):

   Attribute name: ts-refclk

   Long form: Timestamp reference clock source

   Type of name: att-field

   Type of attribute: session, media and source level

   Subject to charset: no

   Purpose: See sections 1-4 of this document

   Reference: This document

   Values: see this document and registrations below

The attribute has an extensible parameter field and therefore a
registry for these parameters is required. This document creates an
IANA registry called the Timestamp Reference Clock Source Parameters
Registry. It contains the six parameters defined in Figure 1: "ntp",
"ptp", "gps", "gal", "local", "private".

8. Acknowledgements

9. References

9.1. Normative References

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URIs

   [9]   <http://en.wikipedia.org/wiki/Genlock>

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Appendix A.   An Appendix

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