Time Stamping and its Standardization for NMI (+ Topic about the future of UTC)

National Institute of Information and Communications Technology (NICT), Japan

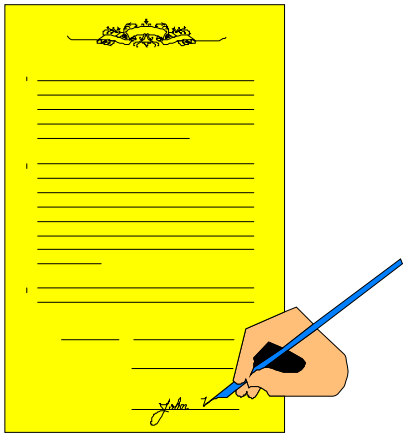
Tsukasa Iwama

1. Time Stamping Service and UTC

What is Time Stamp

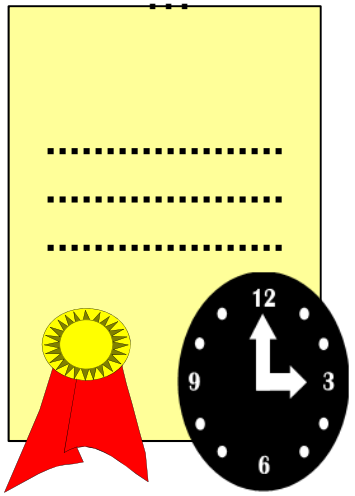
- Keep an Authenticity and Protect against Manipulation of the Documents

Official Paper



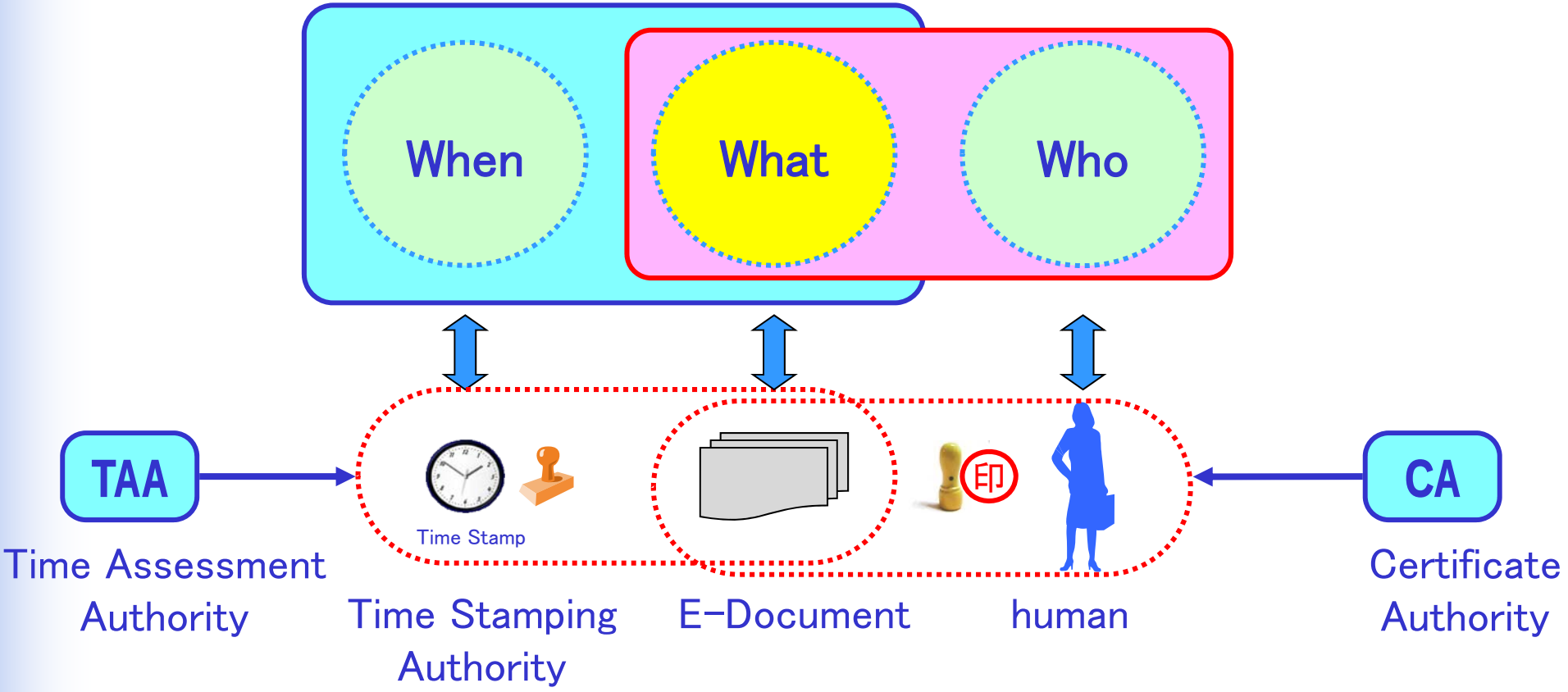
Date & Signature

E-Document



E-Signature & Time Stamp

Time Stamp & Electronic Signature



Time Stamping Service and NMI

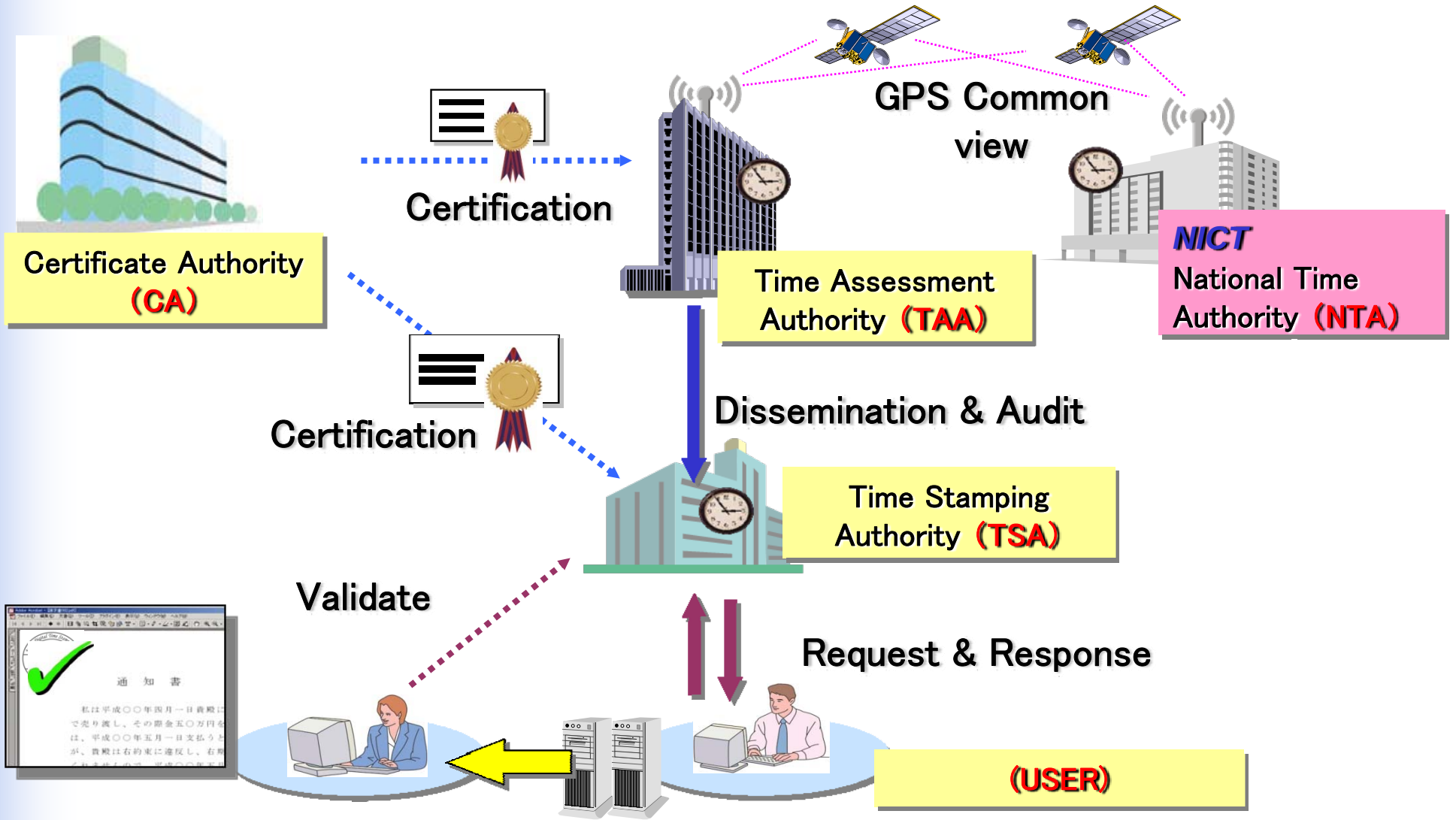
- Time Stamping Service
  - Usually commercial service
  - NMI is not concerned of this service
  - Except for time accuracy

ISO/IEC 18014-1 7.2 Time-stamp response

Accuracy (at TSTinfo)

The accuracy of the genTime field as compared with UTC. TSA guarantees the time difference between UTC and its internal clock is limited within the accuracy.

How to stamping (Japanese Model)



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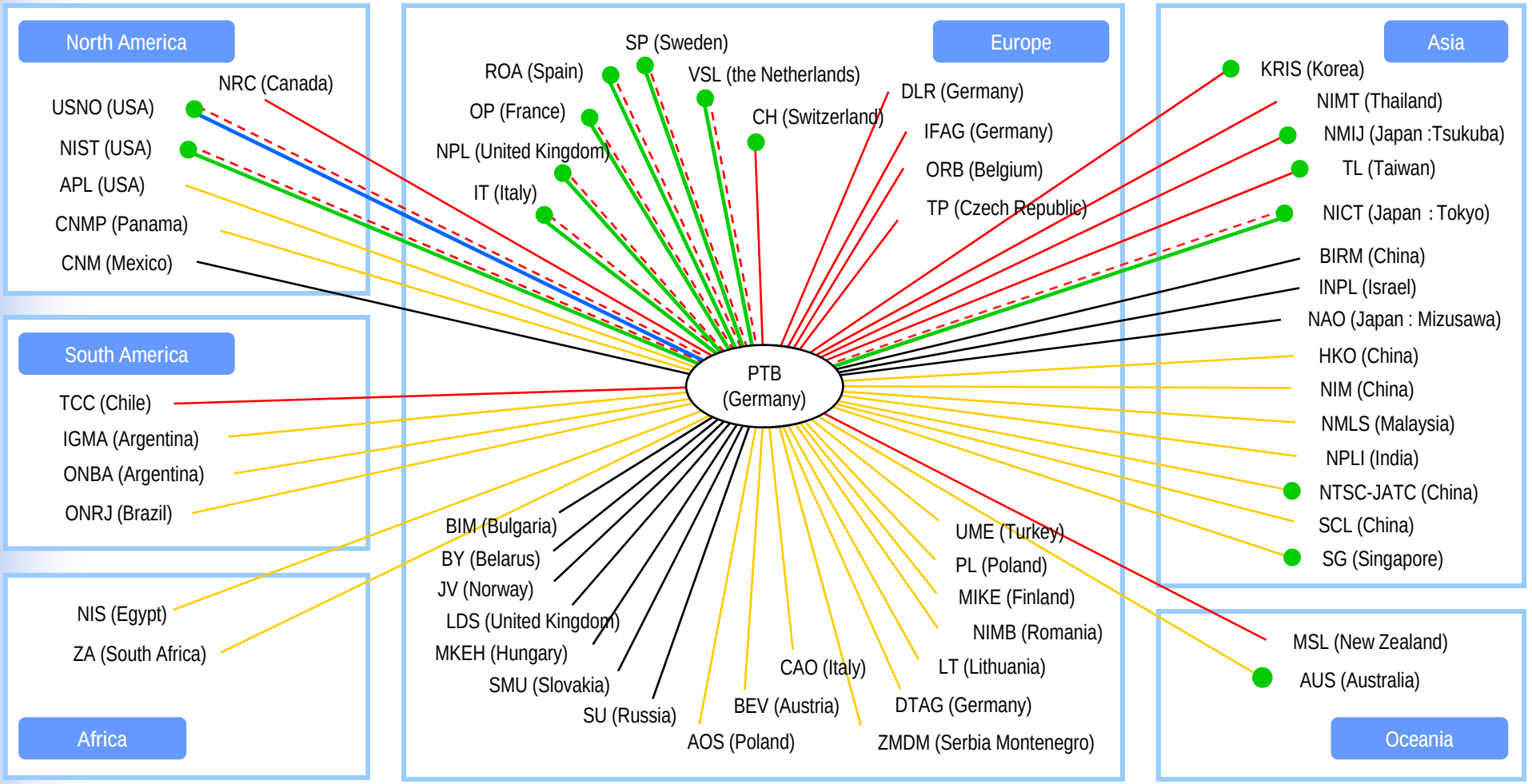
International Time Comparison



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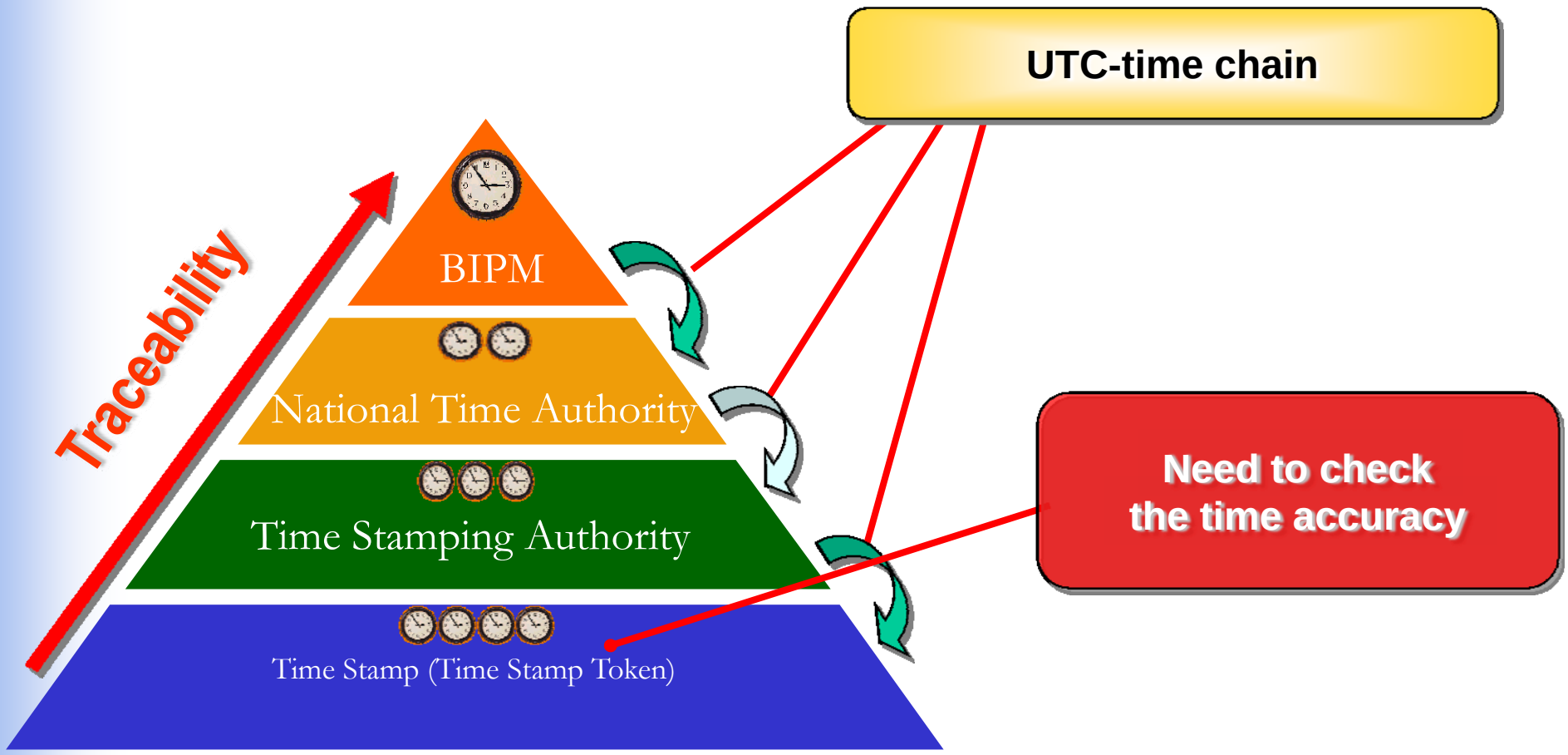
Traceability of Stamping time



2. UTC & ITU

Definition of UTC

- ITU-R TF. 460-6 Annex 1 C

  Coordinated universal time (UTC)

  – UTC is the time-scale maintained by the BIPM, with assistance from the IERS, which forms the basis of a coordinated dissemination of standard frequencies and time signals. It corresponds exactly in rate with TAI but differs from it by an integral number of seconds.

  – The UTC scale is adjusted by the insertion or deletion of seconds (positive or negative leap-seconds) to ensure approximate agreement with UT1.

ITU-R

- ITU-R (Radiocommunication Sector)
  - SG7 (Science service)
    - WP7A

      (Time signals and frequency standard emissions)

Scope

Dissemination, reception and coordination of standard-frequency and time-signal services, including the application of satellite techniques, on a worldwide basis.

ITU-R documents related Time

- ITU-R Recommendation TF. 460-6
  - Standard-frequency and time-signal emissions
    (UTC, UT1, DUT1, leap second)
- Opinion ITU-R 94
  - Time and Frequency transfer using Digital Telecommunication Networks

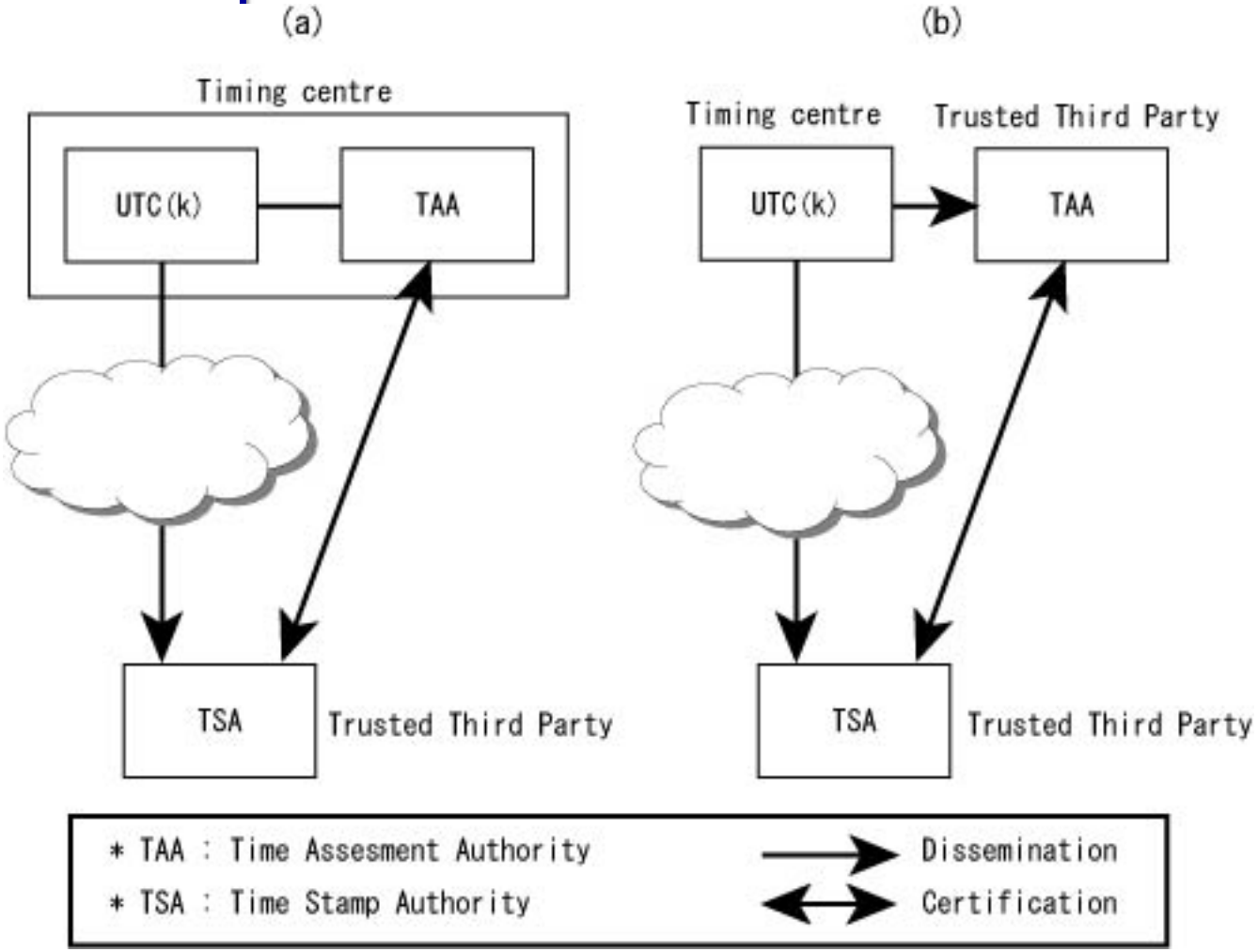
ITU-R documents related Time Stamp

- ITU-R Question TF. 238/7 (2001)
  - Trusted Time Source for Time Stamp Authority

- ITU-R Recommendation TF. [trusted time source]
  - Trusted Time Source for Time Stamp Authority
    (Function of Time Assessment Authority)

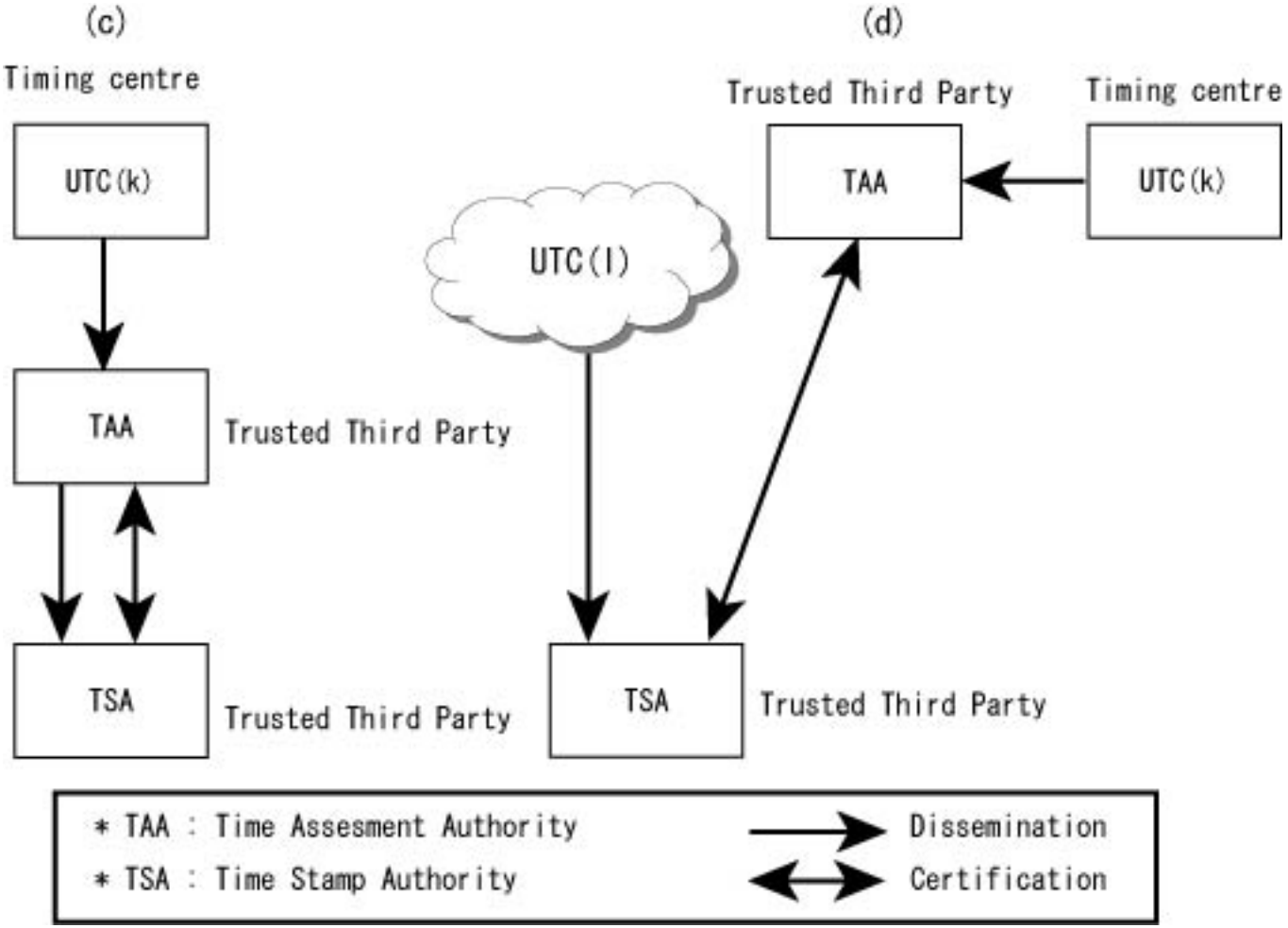
Time Assessment Authority (1)

- Basic Example



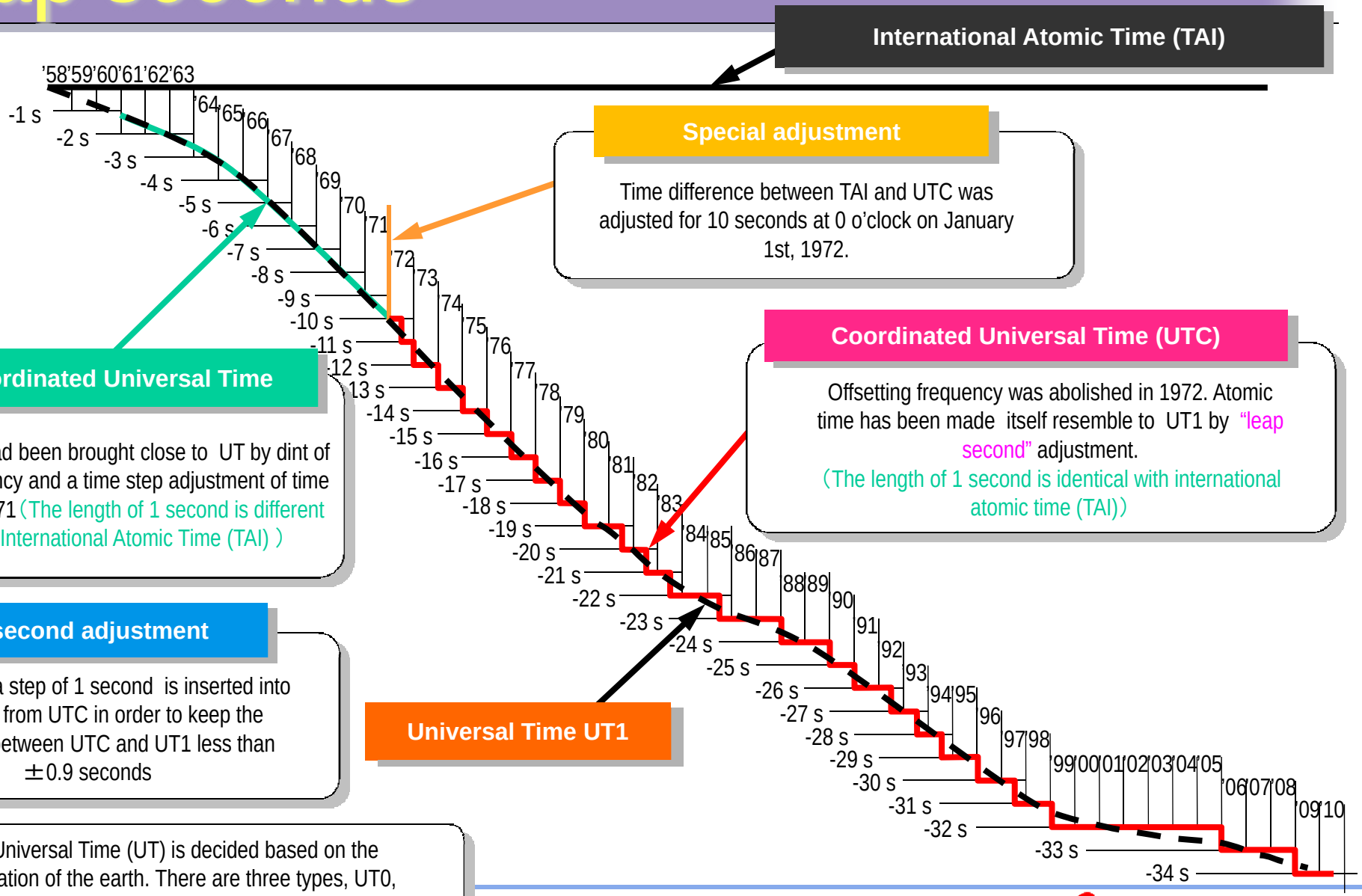
Time Assessment Authority (2)

- Example of Japan　Example of GNSS Using



3. Future of UTC

Leap seconds



Special adjustment

Time difference between TAI and UTC was adjusted for 10 seconds at 0 o'clock on January 1st, 1972.

Former Coordinated Universal Time

Atomic time: it had been brought close to UT by dint of offsetting frequency and a time step adjustment of time from 1961 to 1971（The length of 1 second is different from that of International Atomic Time (TAI)）

Coordinated Universal Time (UTC)

Offsetting frequency was abolished in 1972. Atomic time has been made itself resemble to UT1 by "leap second" adjustment.
（The length of 1 second is identical with international atomic time (TAI)）

Leap second adjustment

Adjustment: a step of 1 second is inserted into or deleted from UTC in order to keep the difference between UTC and UT1 less than ±0.9 seconds

Universal Time (UT) is decided based on the rotation of the earth. There are three types, UT0, UT1 and UT2 in detail.

ITU-R Recommendation TF. 460

- Standard-frequency and time-signal emissions

  (UTC, UT1, DUT1, leap second)

  2000 ~ 2006 Special Rapporteur Group in WP7A

  2000 ~ 2009 Discussion in WP7A

  2009 Revised Recommendation to SG7

  (Future)

  2010 Discussion in SG7

  2011 Discussion in Radiocommunication Assembly & World Radiocommunicaion conference

Thank you for your attention

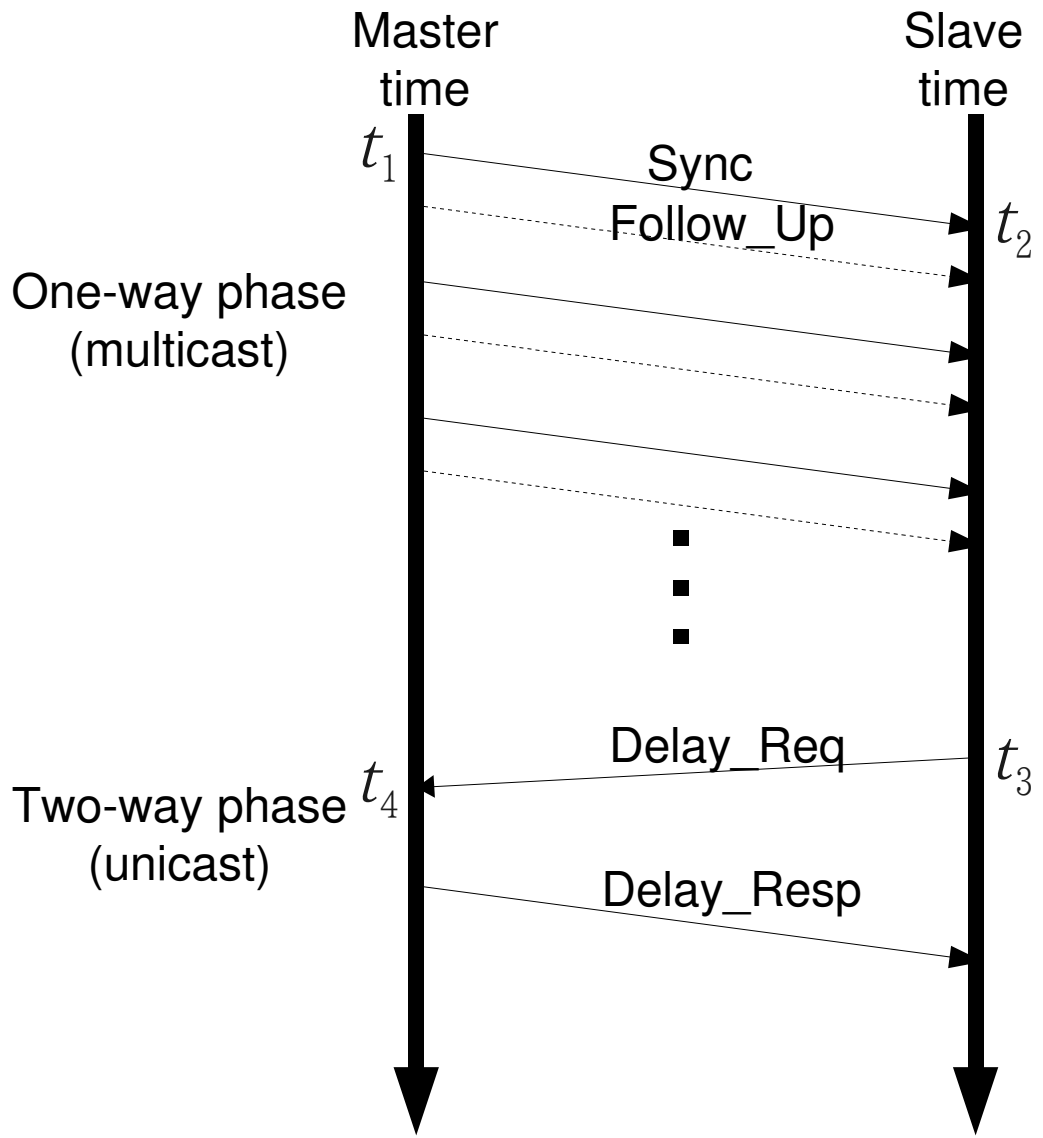
Time and Frequency Dissemination via Packet Network

Akihiko Machizawa
machi@nict.go.jp

Contents

- Principles
- NICT Public NTP service
- Frequency dissemination via the Internet
- Network delay problems
- Precision Time Protocol (IEEE 1588)

Synchronization message exchange



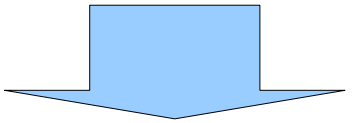
Delay and offset estimation

$$t_2 = t_1 + offset + delay$$

$$t_4 = t_3 - offset + delay$$

$$delay = \{(t_4 - t_1) - (t_3 - t_2)\}/2$$

$$offset = (t_2 + t_3)/2 - (t_1 + t_4)/2$$



Statistical analysis

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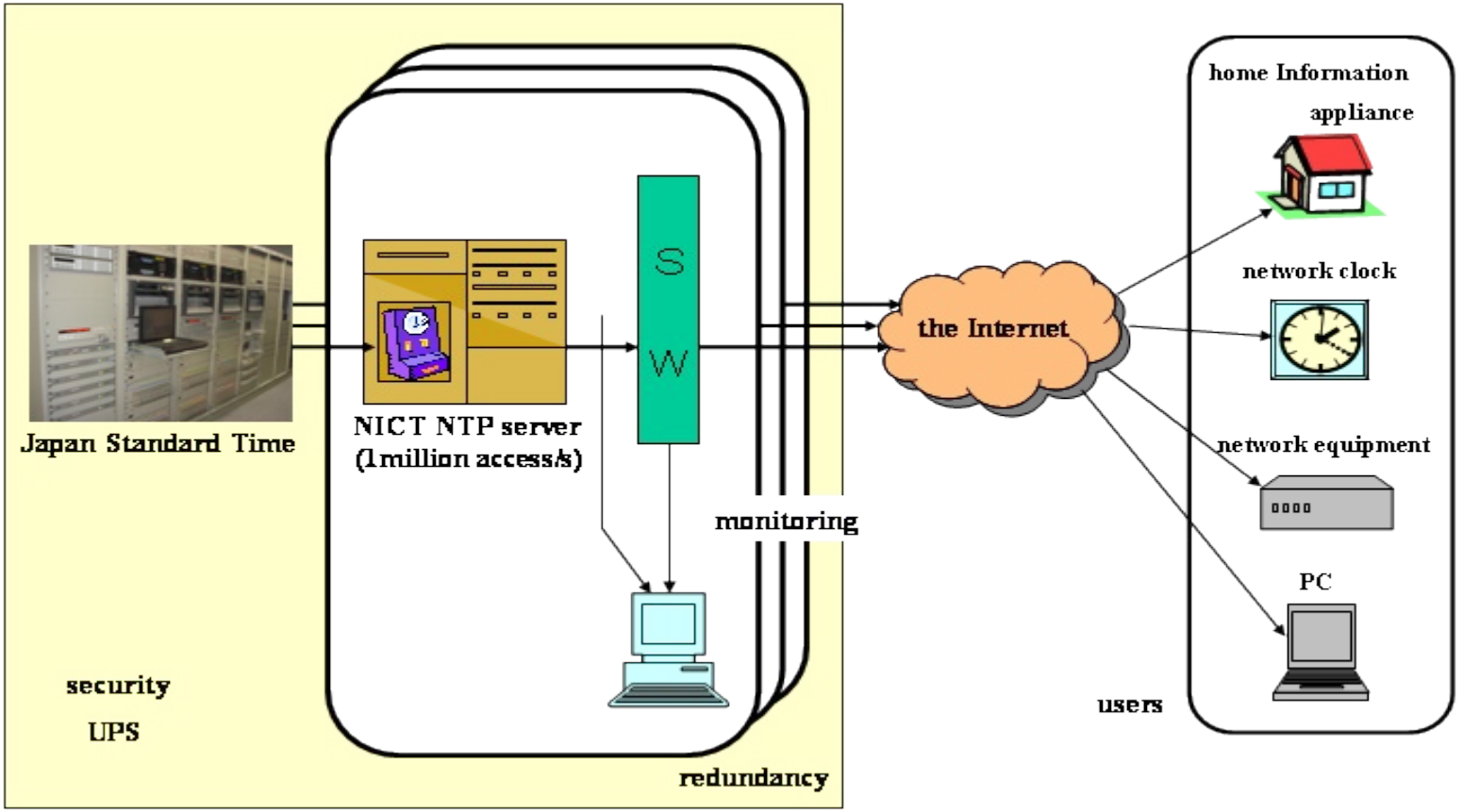
NICT Public NTP Service



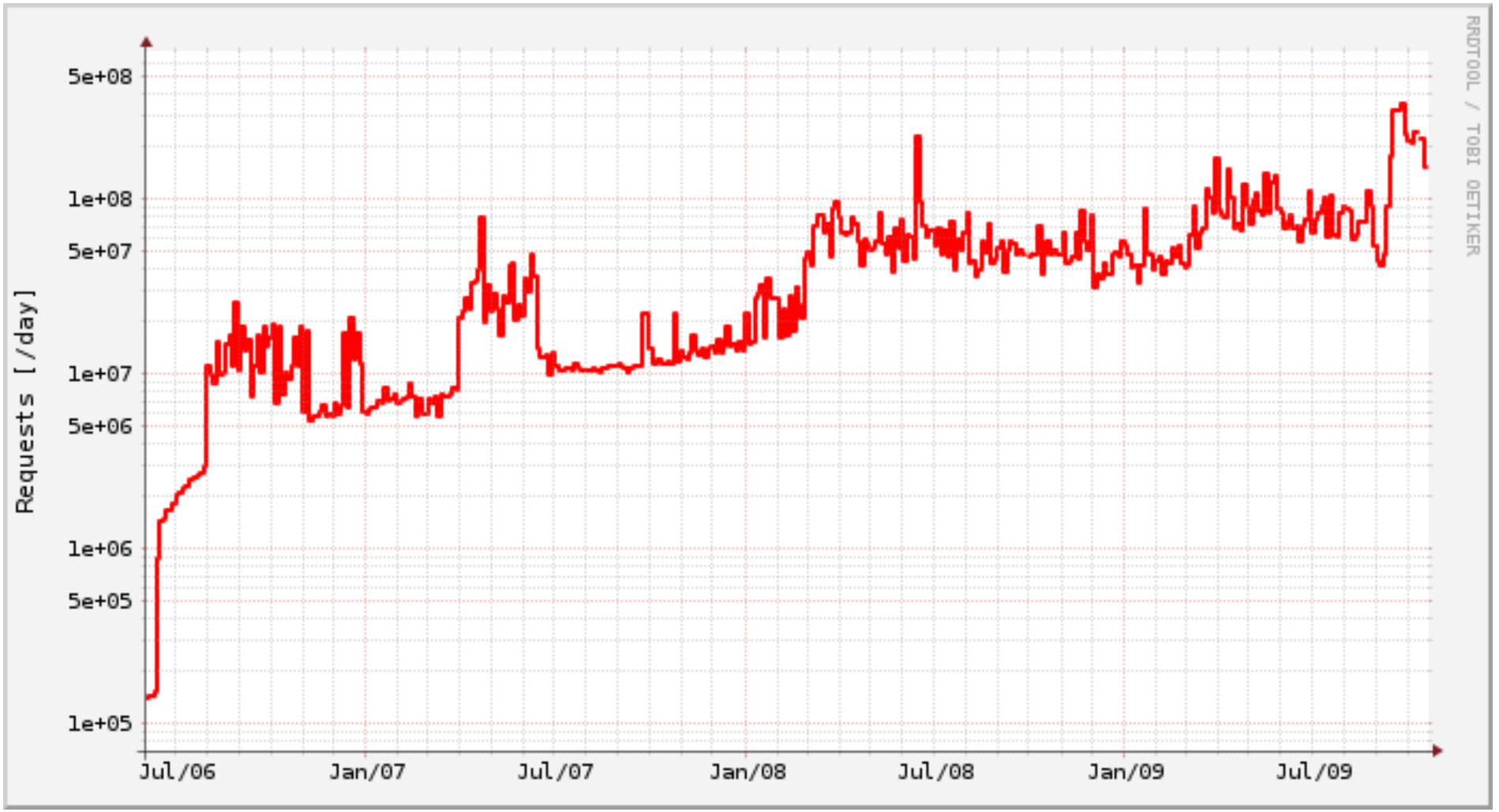
- Redundacy
  - Time source, NTP server, Network, Electric power

Hardware NTP server

Hardware NTP server

	Hardware NTP Server	Normal (Software) NTP Server
Performance	1,000,000 request/s	5,000 request/s
Accuracy	10ns	1,000ns
Security issue	none	Crackable

Requests for NICT Public NTP Server



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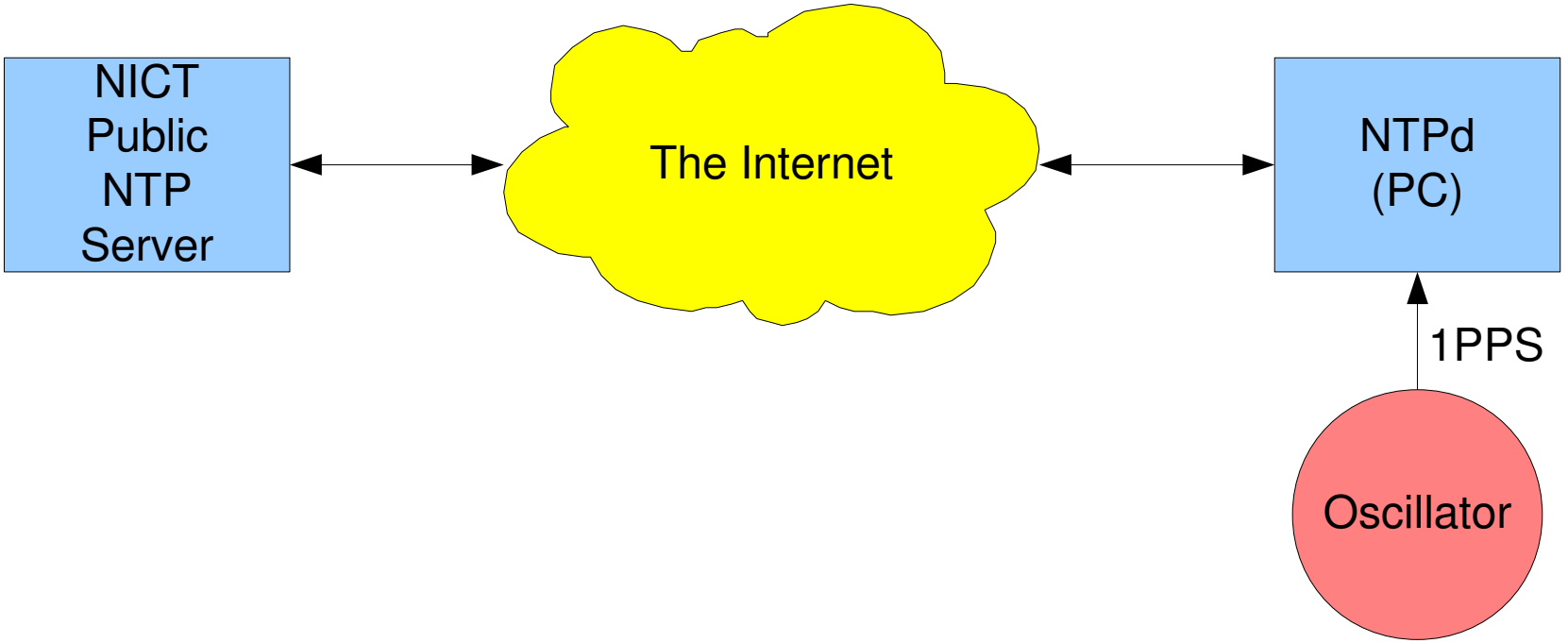
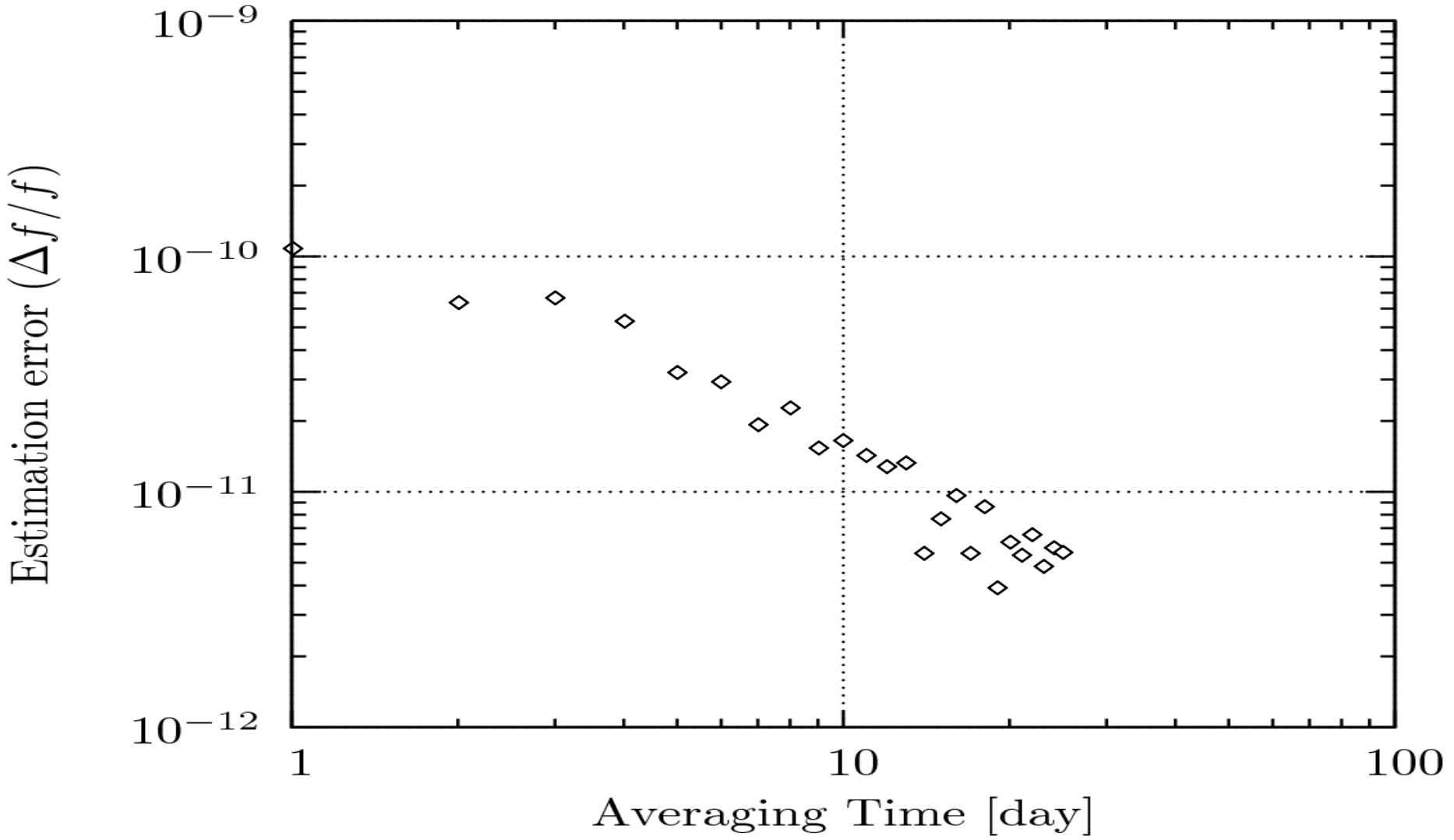
Frequency dissemination via the Internet



Frequency dissemination performance via the Internet



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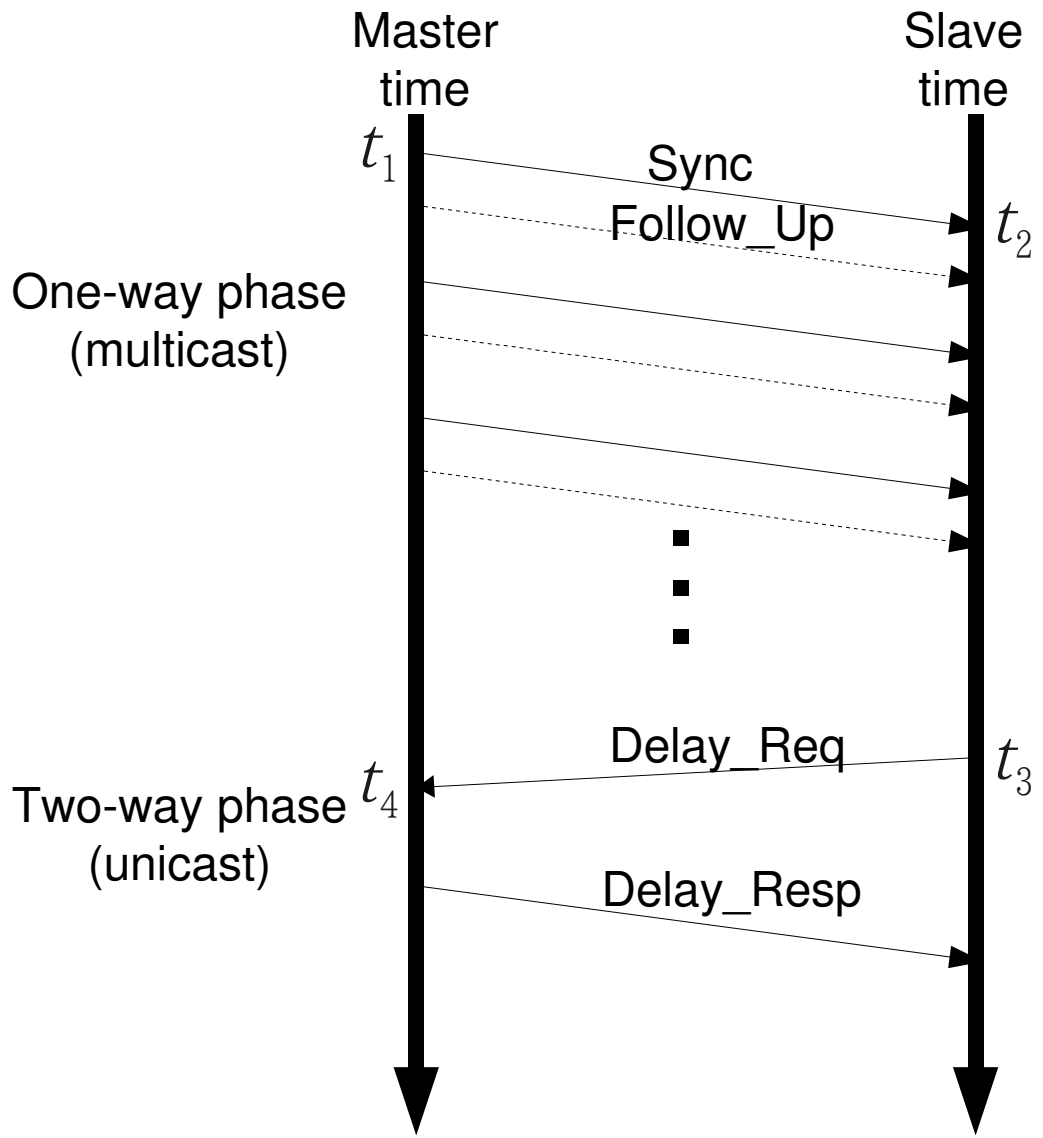
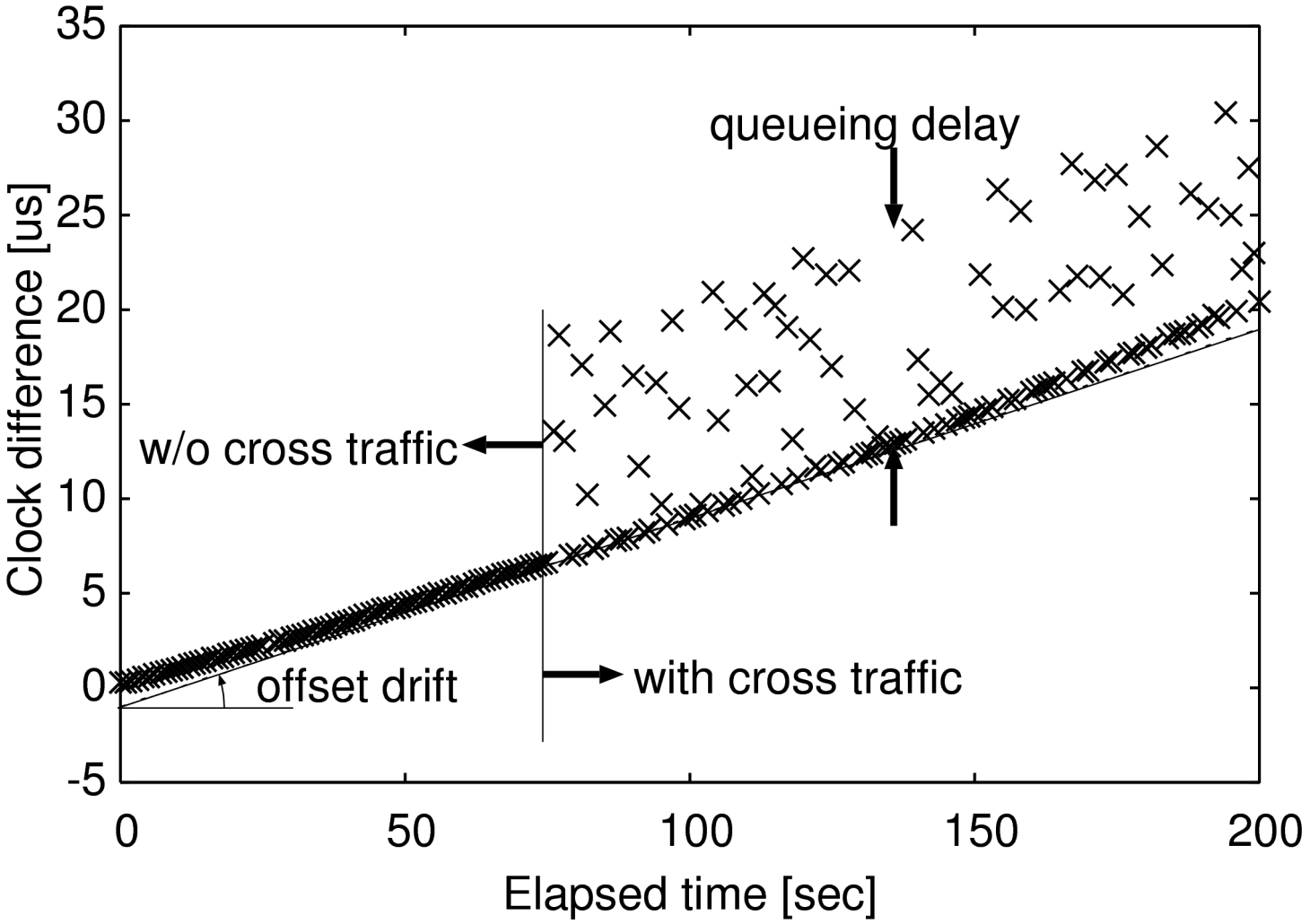
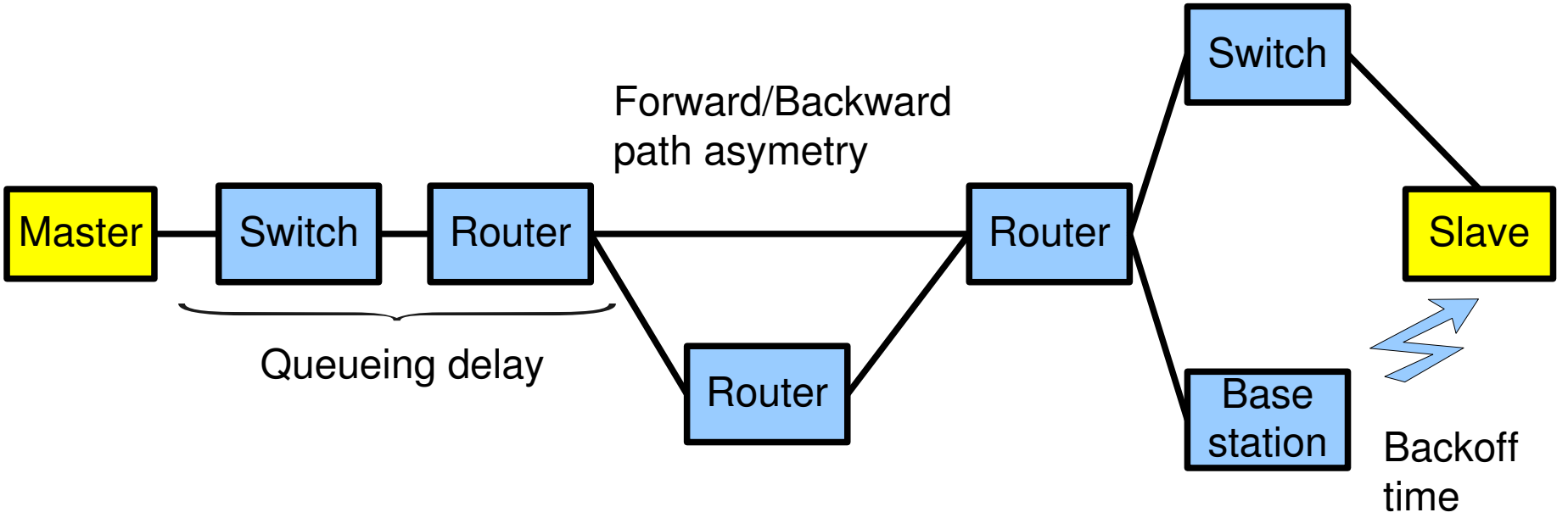


Network delay and clock offset

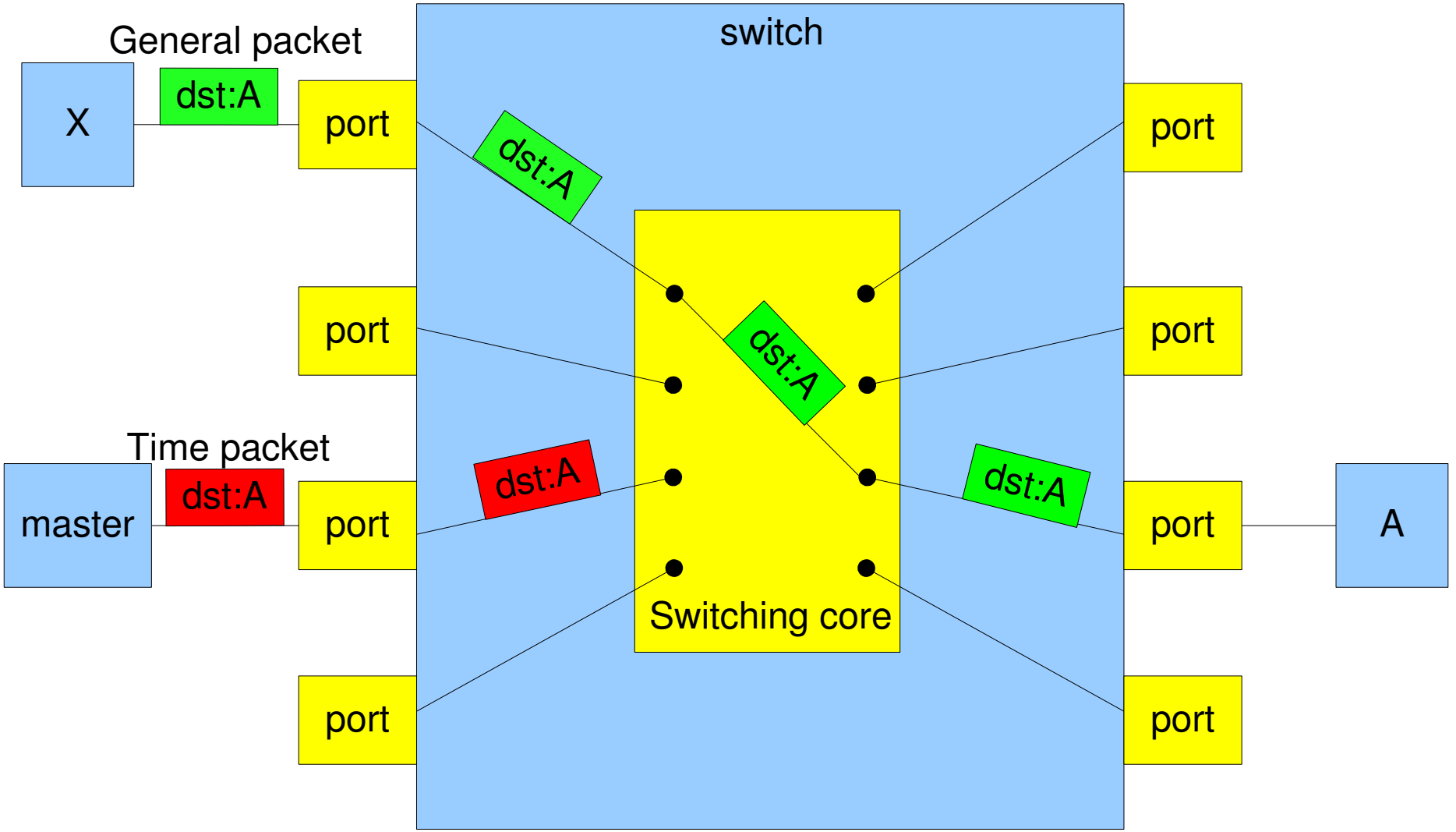
$$t_2 - t_1 = offset + delay$$



Problems of network delay



Queueing delay



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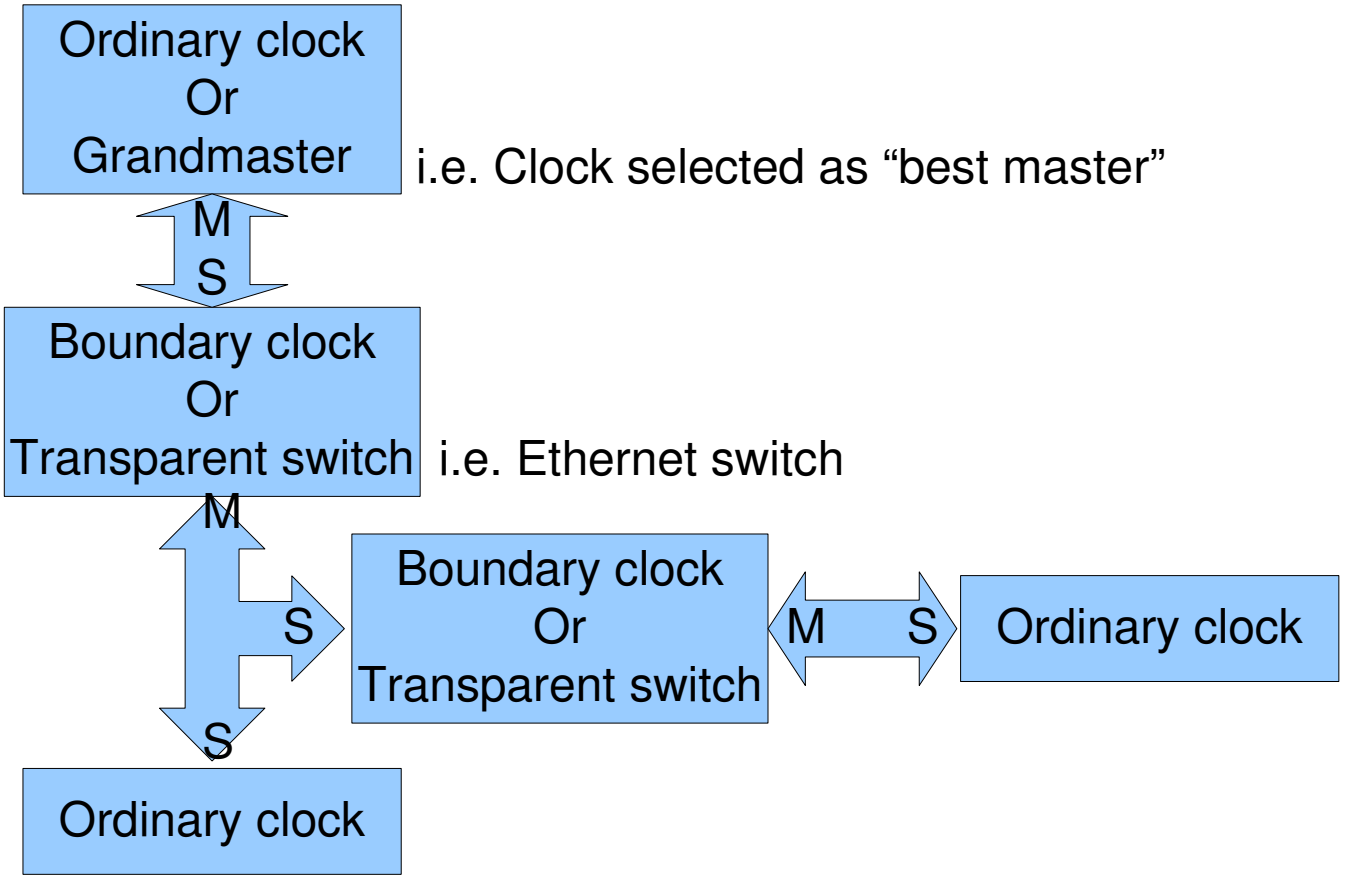
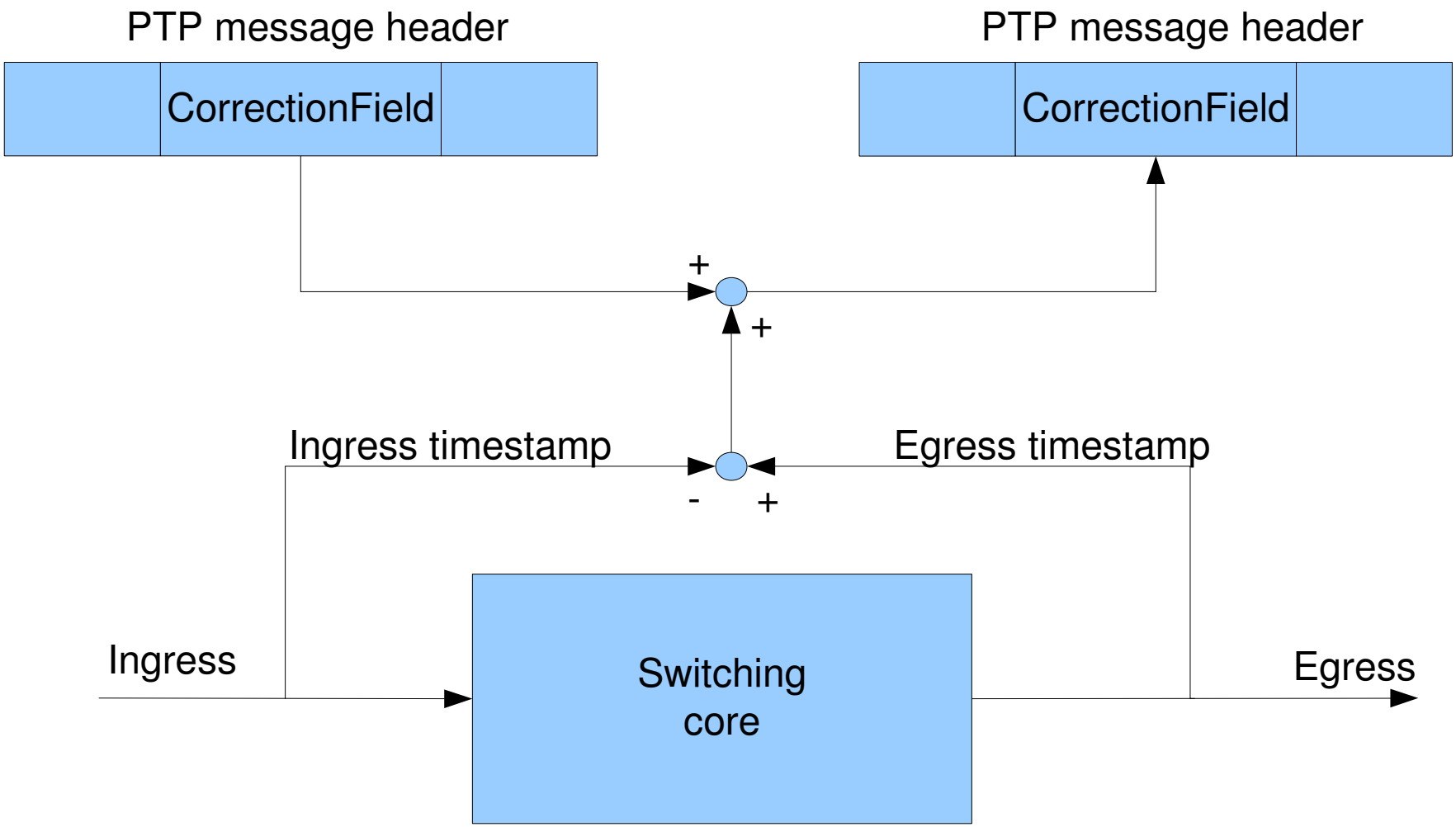
IEEE 1588-2008 (IEEE1588v2):
Precision Clock Synchronization Protocol for Networked Measurement and Control Systems

- Network
- Sub-microsecond
- Spatially localized systems
- Link-by-link synchronization
- Boundary clock and transparent clock
- Administration free operation

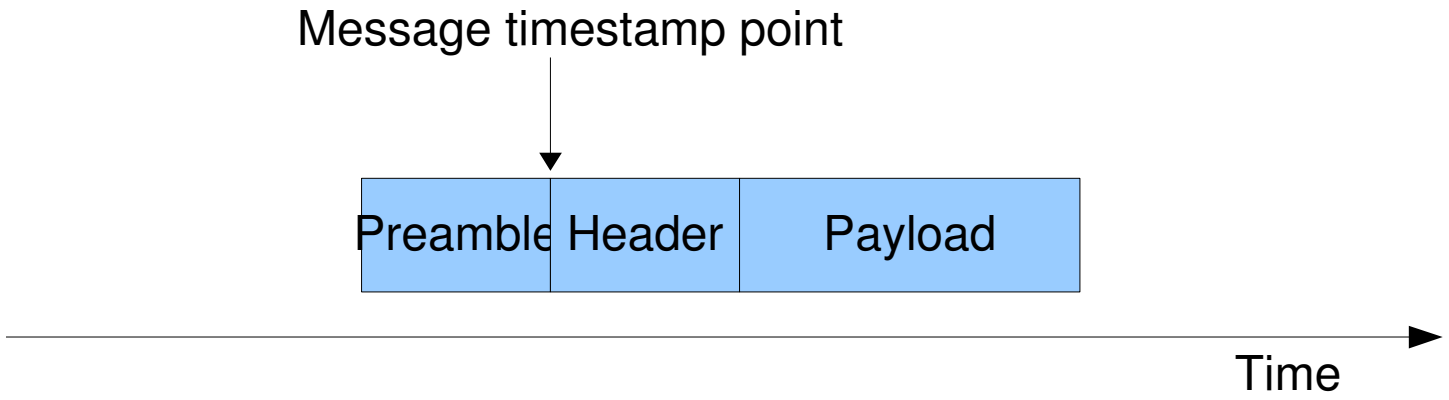
Link-by-link synchronization and Boundary clock



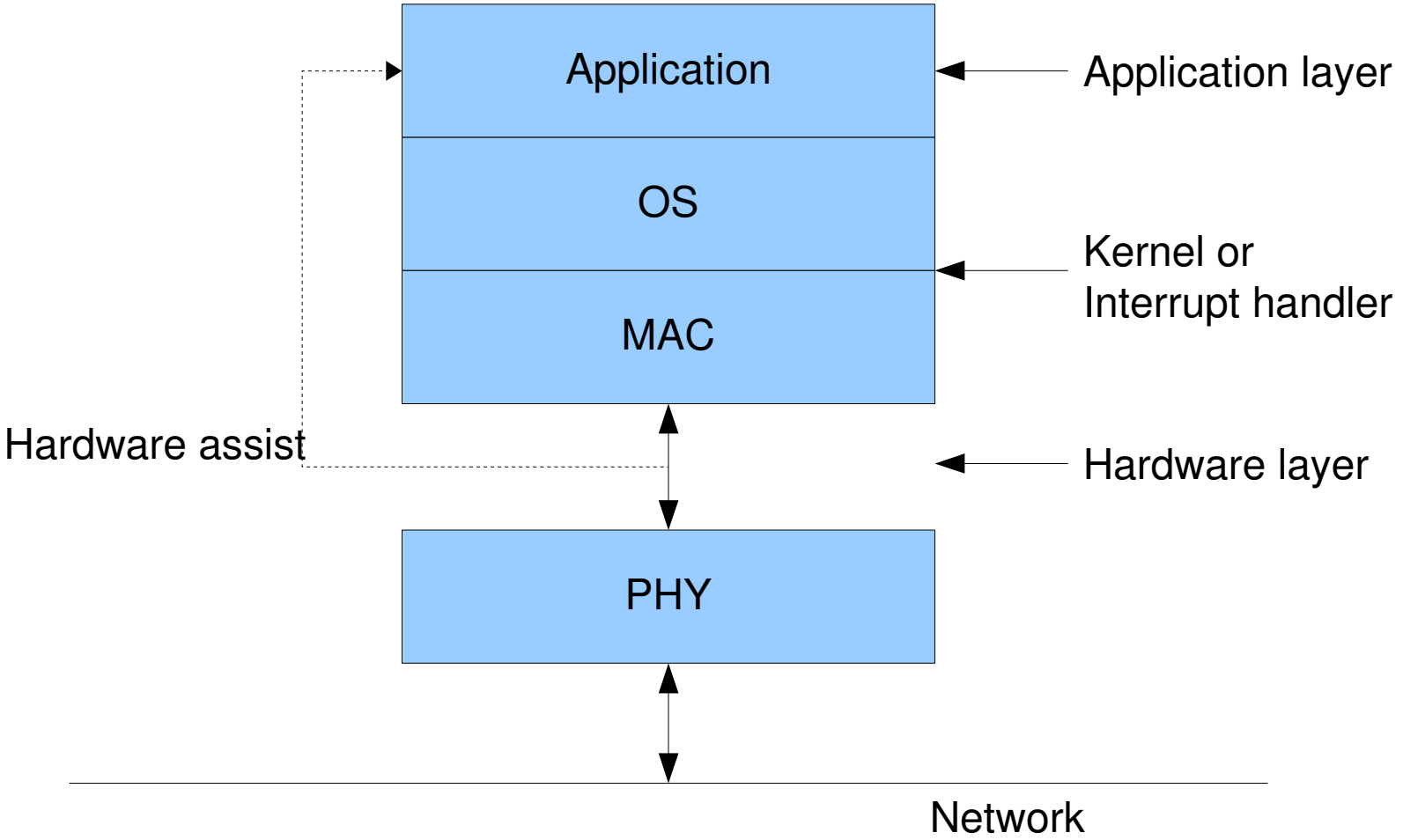
Transparent clock



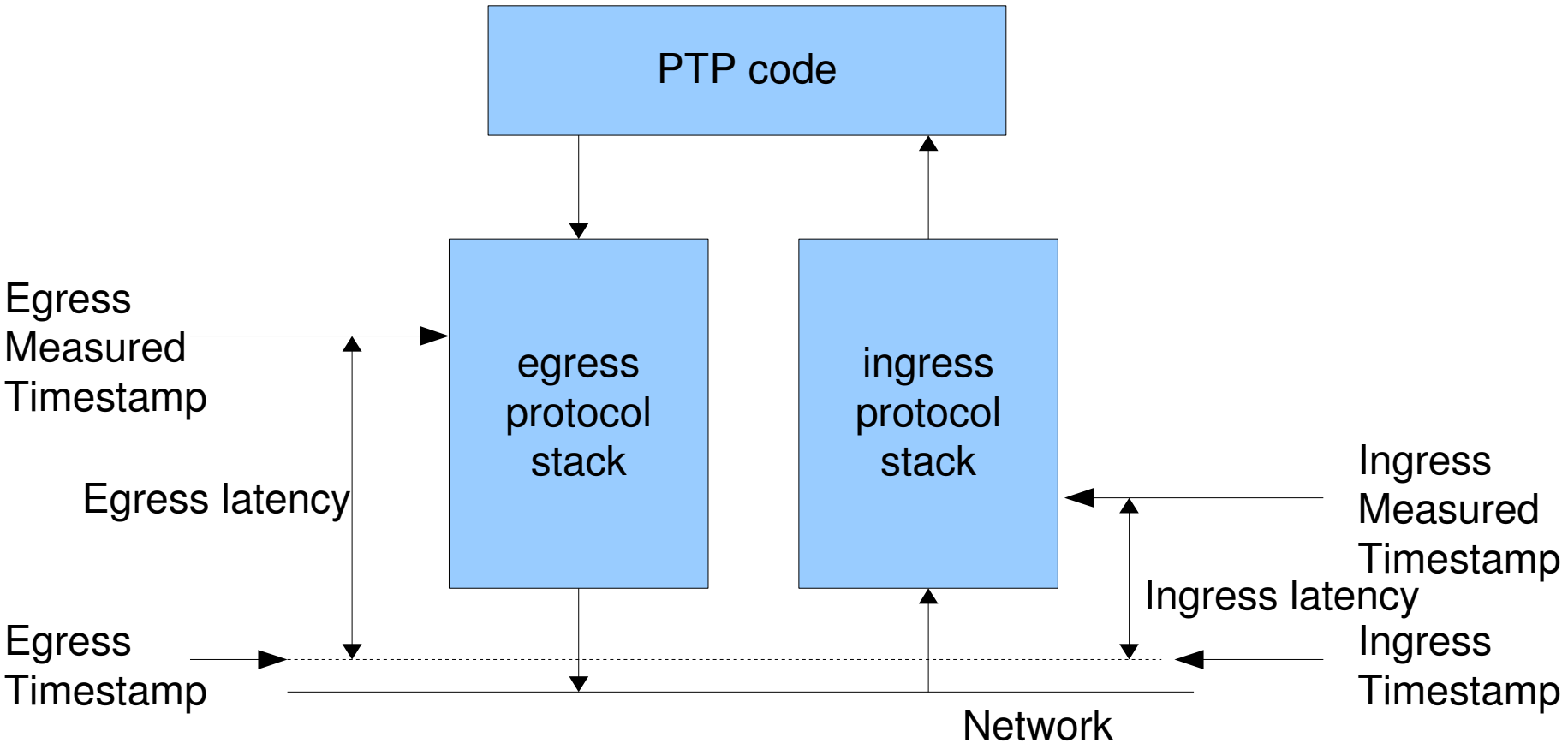
Message timestamp point



Timestamp generation model



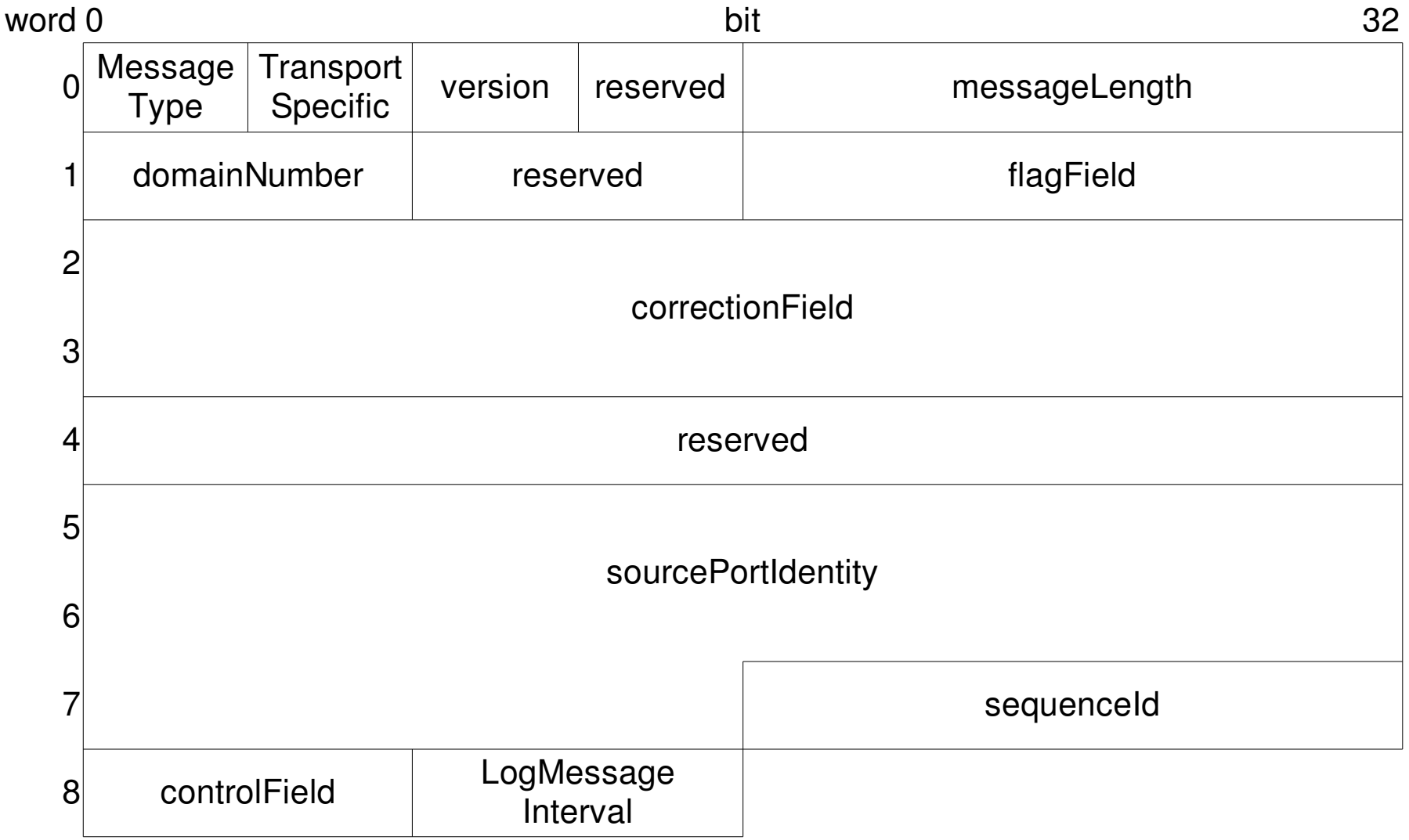
Latency constant



Time scale and format of PTP

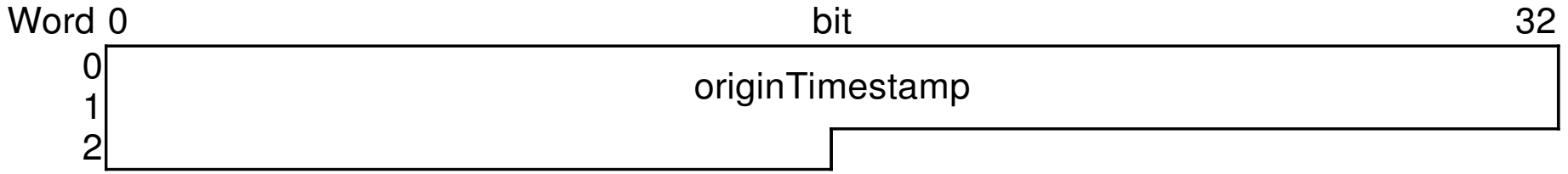
- second:48bit + nanosecond:32bit
- Epoch
  - 1 January 1970 00:00:00 TAI
  - PTP Seconds = GPS Seconds + 315 964 819
- Leap second
  - AnnounceMessage:flagField:leap59/61 indicate that the last minute of the current UTC day contains 59 seconds.
  - CurrentUtcOffset field

Common message header format

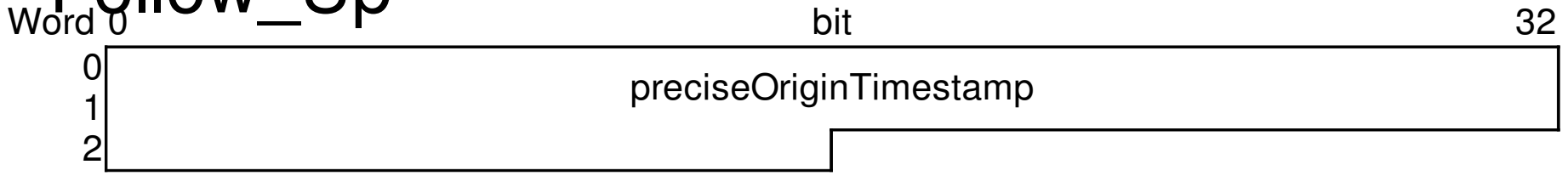


Message payload format

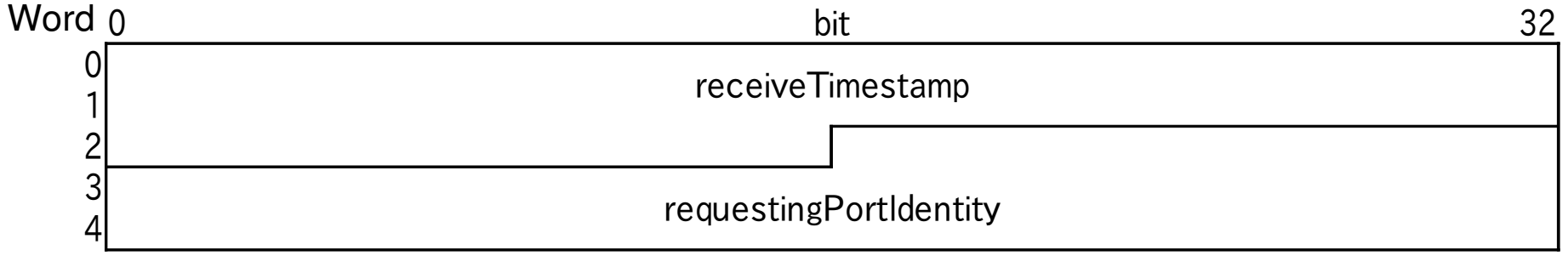
- Sync and Delay_Req



- Follow_Up



- Delay_Resp



Products status of IEEE 1588

- Some Network Controllers
- Some (Grand) master clocks
- A few switches
- Software client: ptpd
- More information
  http://ieee1588.nist.gov/product_catalog.htm

PTP vs NTP

	PTP	NTP
epoch	1970/1/1 0:00	1900/1/1 0:00
timescale	continuous (TAI)	discontinuous (UTC)
time format	second:48bit + nanosecond:32bit	second:32bit + nanosecond:32bit
server selection	automatic	manual
connection	link	path
queueing issue	boundary/transparent clock	-
message length	valid for types	48byte
specification	IEEE1588	RFC1305
delay estimation	two way	two way

Conclusion

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