PTP* Hands-On

- Part of workshop** on “HSR/PRP and PTP: Network Redundancy and Time Clock Synchronization” -

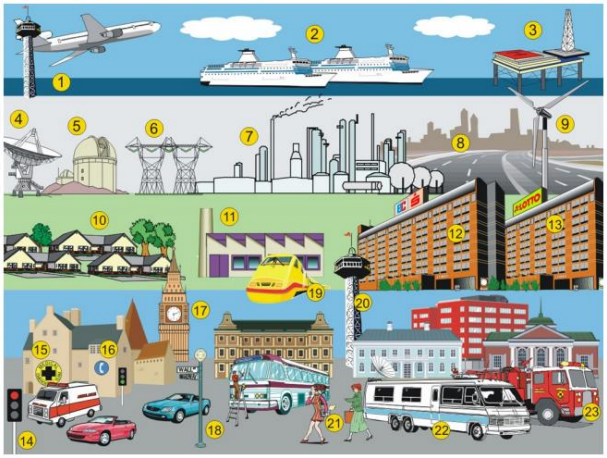
기안도
adki@future-ds.com

주최/주관: 한국통신학회 군통신연구회 / 명지대학교
장소: 숭실대학교 조만식기념관 427호
일자: 2019년6월7일

* PTP: Precision Time Protocol
** 이중화네트워크와 시각동기화 워크샵

Table of Contents

Who needs time synchronization



1. Air Traffic Control
2. Research Vessels
3. Oil Production
4. Satellite Communication
5. Observatories
6. Power Substations
7. Power Plants
8. Toll Charging Systems
9. Wind Energy Plants
10. Public Infrastructure
11. Production Flow
12. Banks, Cash Terminals, Stock Exchange, Data Centers
13. Lottery
14. Traffic Management
15. Operation Coordination
16. Event Management
17. Wall Clocks
18. Lighting Control
19. Railway Time Table
20. Radio Broadcasting
21. Mobile Communication, Call Data Records
22. Outside Broadcast Van
23. Emergency

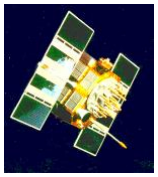
Ref: Martin Burnicki, Computer Time Synchronization Concepts, Meinberg Funkuhren Bad Pyrmont Germany, 2014-04-29

Time accuracy

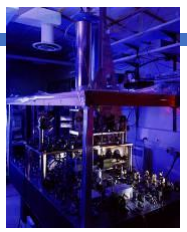
10,000 sec/day
~2 hours/day

1-10 sec/day

0.5 sec/day



10 nanosec/day
GPS



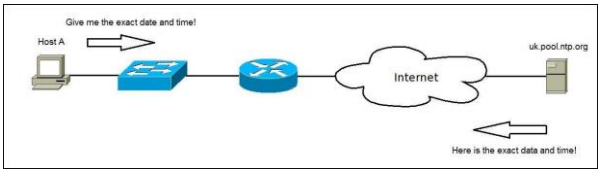
0.1 nanosec/day
Atomic clock

Control application	Typical cycle time
Low speed sensors (temperature, pressure, …)	Tens of milliseconds
Drive control systems	Milliseconds
Motion control (robotics)	Hundreds of microseconds
Precision motion control	Tens of microseconds
High speed devices	Microseconds
Electronic ranging (fault detection)	Hundreds of nanoseconds

Typical time synchronization over network

	NTP	PTP
Accuracy	1ms	1us
Network	LAN, WAN	LAN
Self calibrating	Yes	Yes
Special HW	No	Yes
Communication	Client/Server	Master/Slave

NTP: Network Time Protocol



NTP hierarchy

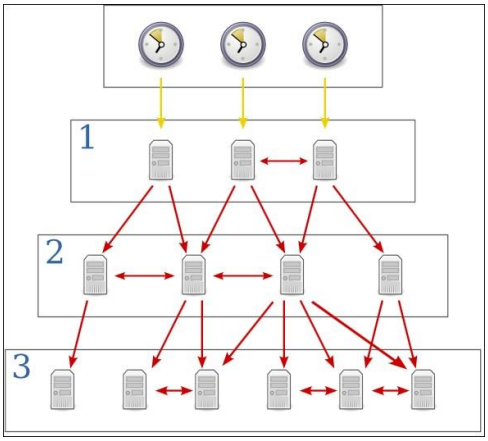
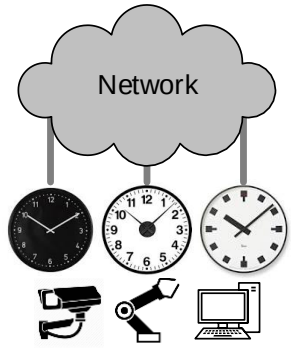


Table of Contents

IEEE 1588 PTP

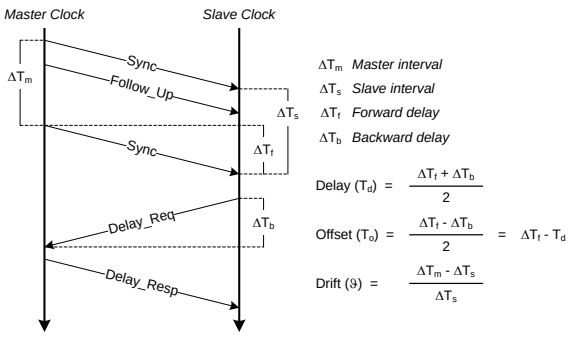
- IEEE 1588
  - (commonly known as Precision Time Protocol, PTP)
  - v1: 2002
  - v2: 2008 (IEC 61588 Ed.2)
- IEEE 1588 specifies "*A protocol to synchronize independent clocks running on separate nodes of a distributed measurement or control system to a high accuracy and precision*".
- IEEE 1588 is a protocol designed to synchronize real-time clocks in the nodes of a distributed system that communicate using a network.
  - IEEE 1588은 네트워을 통해 통신하는 분산 시스템의 각 노드에 있는 시계를 동기시키는 프로토콜



Precision Time Protocol (PTP) is a protocol to synchronize clocks throughout a network and it achieves clock accuracy in the sub-microsecond range on a local area network.

PTP는 네트워을 통한 시간동기화 프로토콜이며, 로컬네트워에서 마이크로초 (10^{-6}sec)이내의 정확도로 시간을 맞춘다.

IEEE Std. 1588-2008 PTPv2



ΔT_m *Master interval*
ΔT_s *Slave interval*
ΔT_f *Forward delay*
ΔT_b *Backward delay*

$$\text{Delay } (T_d) = \frac{\Delta T_f + \Delta T_b}{2}$$

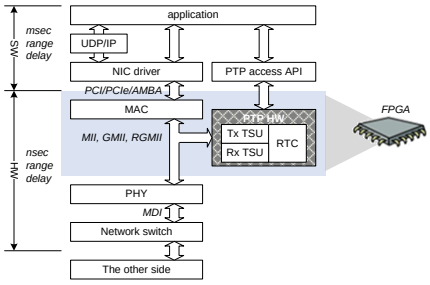
$$\text{Offset } (T_o) = \frac{\Delta T_f - \Delta T_b}{2} = \Delta T_f - T_d$$

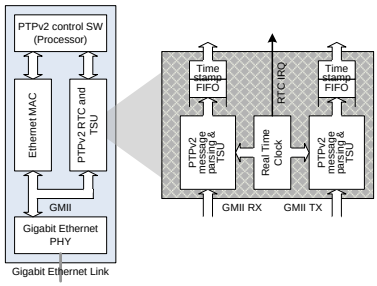
$$\text{Drift } (\vartheta) = \frac{\Delta T_m - \Delta T_s}{\Delta T_s}$$

Message type	Message	Note
Event message	Sync	master to slave (to adjust offset)
	Delay_Req	slave to master (to measure propagation delay)
	Pdelay_Req	port to port (to measure link delay)
	Pdelay_Resp	port to port (to measure link delay)
General message	Announce	
	Follow_Up	master to slave (to adjust offset)
	Delay_Resp	master to slave (to measure propagation delay)
	Pdelay_Resp_Follow_Up	port to port (to measure link delay)
	Management	
	Signaling	

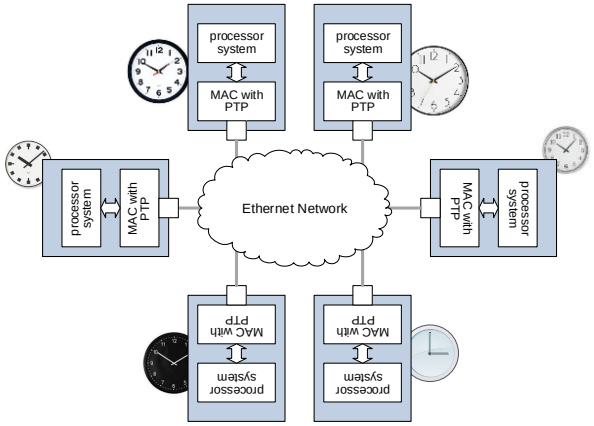
Implementation of PTP

- PTP components
  - RTC: real-time clock
  - TSU: time-stamp unit
  - PTP API

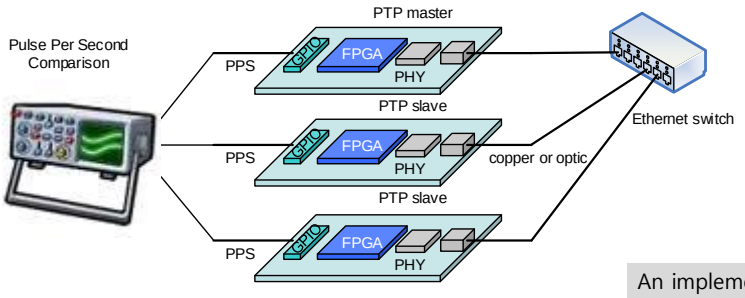




An implementation of PTP



An implementation of PTP in action



An implementation of IEEE 1588 (PTPv2) over Gigabit Ethernet, which synchronizes distributed clocks within x100nsec.

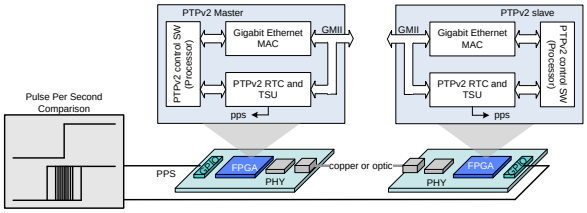
기가비트 이더넷에 IEEE 1588 (PTPv2)를 구현하여 네트워에 분산된 시계들을 수백나노초 (10^{-9}sec) 범위로 동기화시킨다.

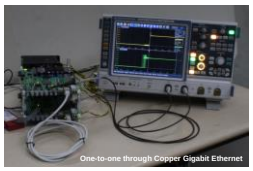
One-to-one testing setup

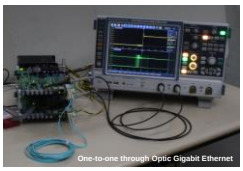
One-to-one 2m copper	
fwd delay (M-to-S)	0x49** (18688) nsec
bwd delay (S-to-M)	0x49** (18688) nsec
PPT variation	|25nsec|

One-to-one 30m copper	
fwd delay (M-to-S)	0x4A** (18944) nsec
bwd delay (S-to-M)	0x4A** (18944) nsec
PPT variation	|50nsec|

Temperature	Room temperature without cooler: ~25 Degree
Sync interval	1 Sync per second
Delay_Req interval	1 Deally_Req per Sync
Oscilosope	Rohde & Schwarz RTO 1044: 4GHz sampling (0.25 nsec), 50 nsec division







㈜퓨쳐디자인시스템
34051 대전광역시 유성구 문지로 193, KAIST 문지캠퍼스, F723호
(042) 864-0211~0212 / contact@future-ds.com / www.future-ds.com

Future Design Systems, Inc.
Faculty Wing F723, KAIST Munji Campus, 193 Munji-ro, Yuseong-gu, Daejeon 34051, Korea
+82-042-864-0211~0212 / contact@future-ds.com / www.future-ds.com

FUTURE
Design Systems