



NTP dissemination services and automated monitoring

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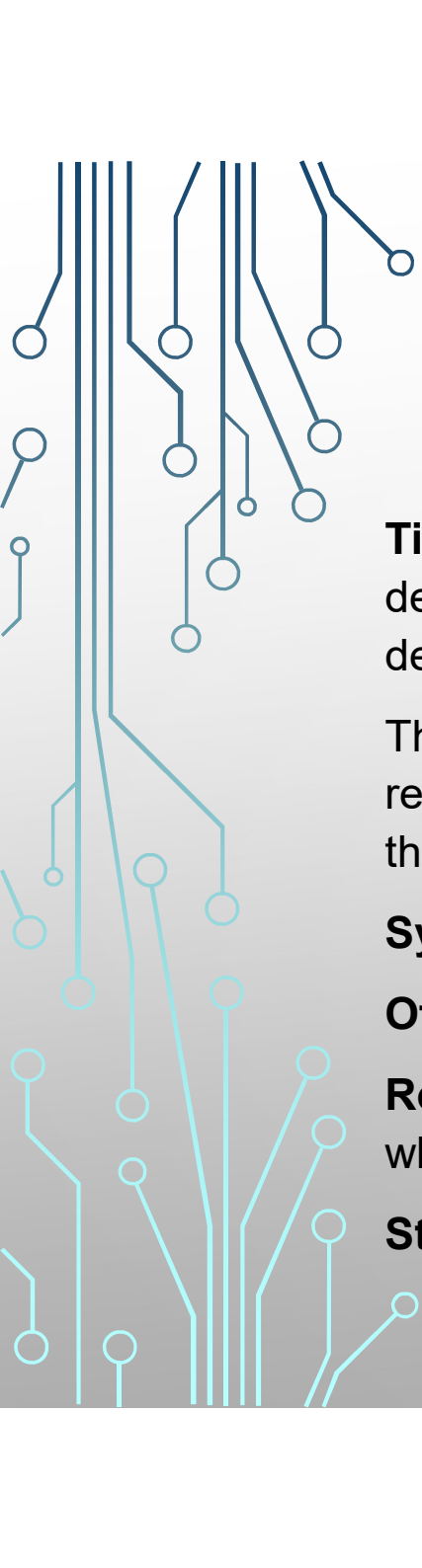
2025-05-07

BIPM - SIM UTC SUMMER SCHOOL 7-9 MAY, QUERÉTARO

A decorative graphic on the left side of the slide, consisting of a network of light blue lines and small circles, resembling a circuit board or a neural network, set against a dark blue background.

GENERAL CONCEPTS

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CONCEPTS

Timestamp: A timestamp included in NTP messages to synchronize the time of devices on a network. This timestamp determines the time difference between a device's local clock and the clock on a time server.

These timestamps are used in NTP packet headers to record events like request/response arrival and departure times, which are crucial for determining the offset and delay between clocks.

Synchronization: The process of setting two or more clocks to the same time.

Offset: Time difference between a client and a server.

Round Trip Delay: The time it takes for the Timestamp to travel from the point where the request is made to the time server and back.

Stratum: Server hierarchy

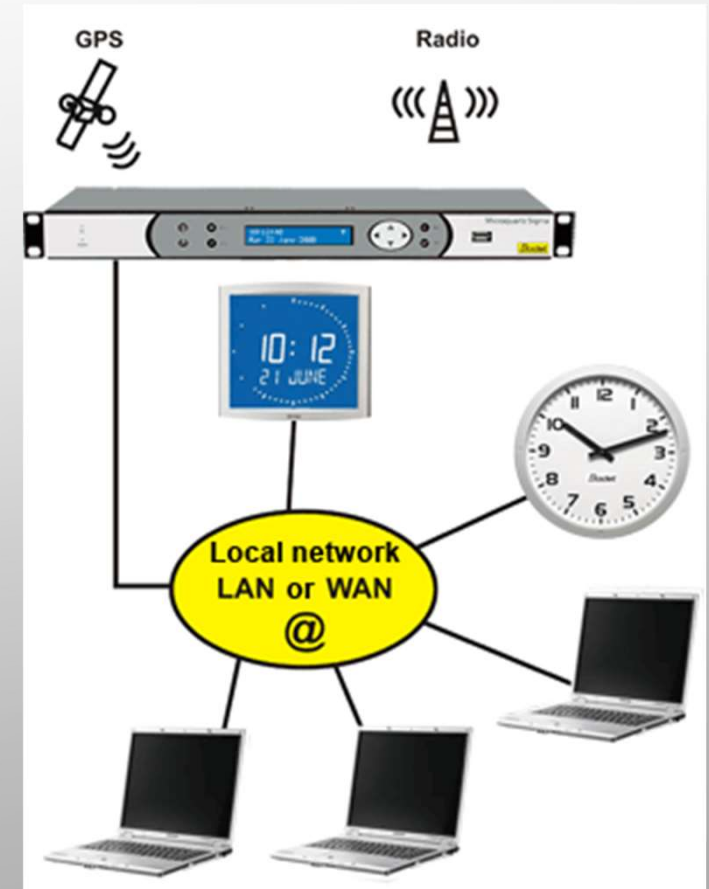


NTP PROTOCOL

- Networking protocol for clock synchronization between computer systems.
- Transmit the time stamp information from the primary servers to secondary time servers and clients.
- The servers listen for a NTP request on port 123 and respond by sending a UDP/IP data packet in the NTP format.
- NTPv4 is defined in RFC 5905.
- Works on Internet and private networks

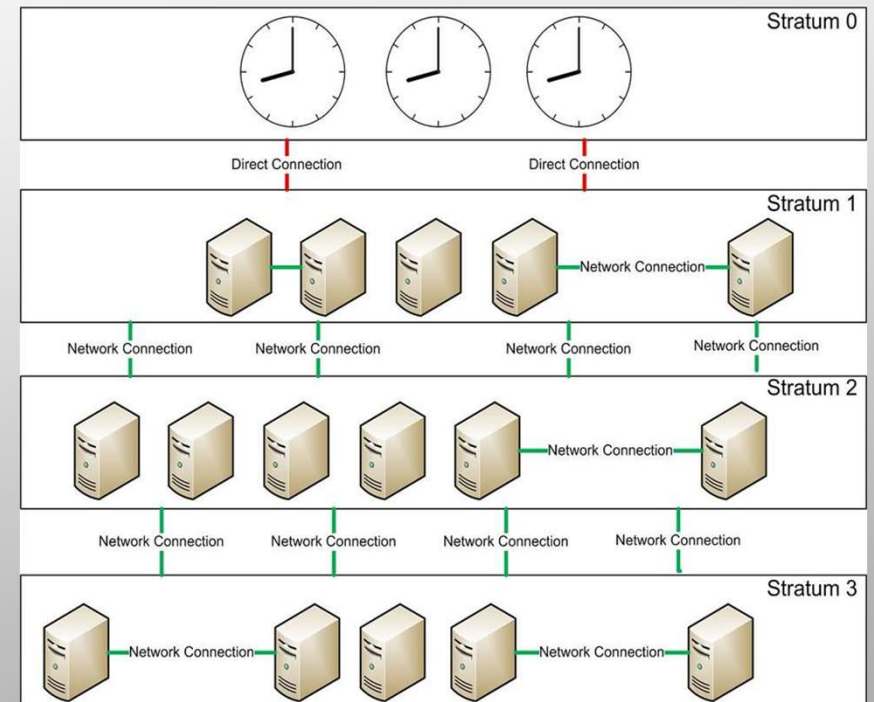
NTP PROTOCOL

- Is required:
 - ✓ A reference clock.
 - ✓ NTP servers.
 - ✓ Software (sync)
- Time error in milliseconds
- Every computer in the system adjusts its clock according to the time information it retrieves from an NTP time server.

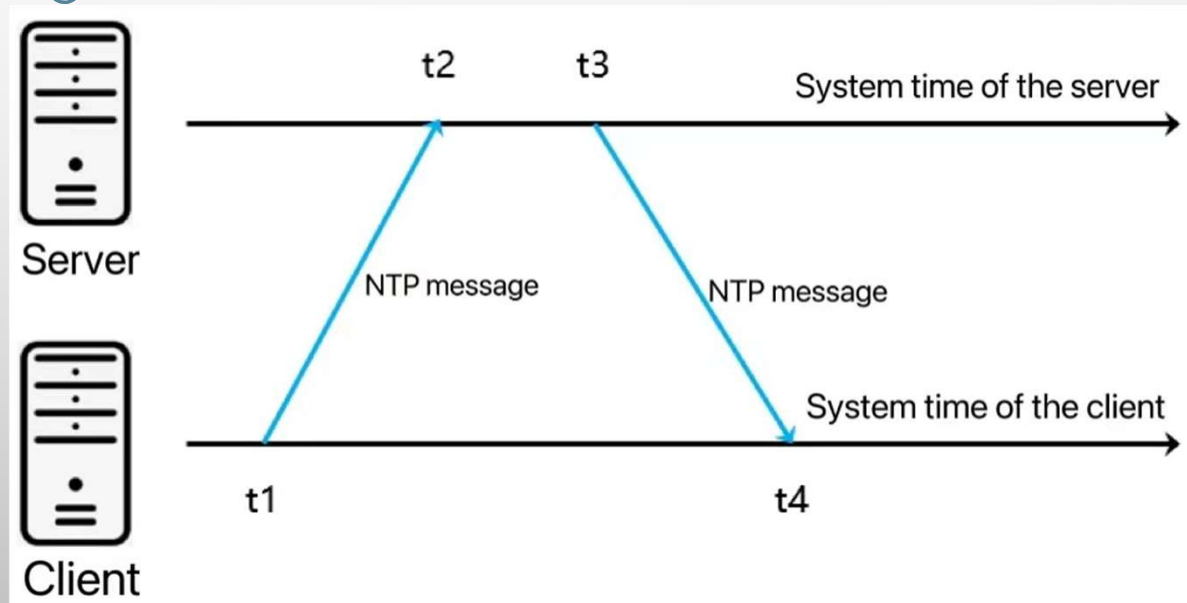


NTP PROTOCOL

- Hierarchical client–server model.
- The client sends a packet request to the server, which responds so that the client can synchronize.
- Once a client is synchronized, it can itself become a server to its own NTP clients.
- Each level of this hierarchy is termed a stratum.
- The stratum zero is the reference clock at the top.



CLOCK SYNCHRONIZATION



$$Offset = \frac{(T_2 - T_1) + (T_3 - T_4)}{2}$$

$$delay = (T_4 - T_1) - (T_3 - T_2)$$

where:

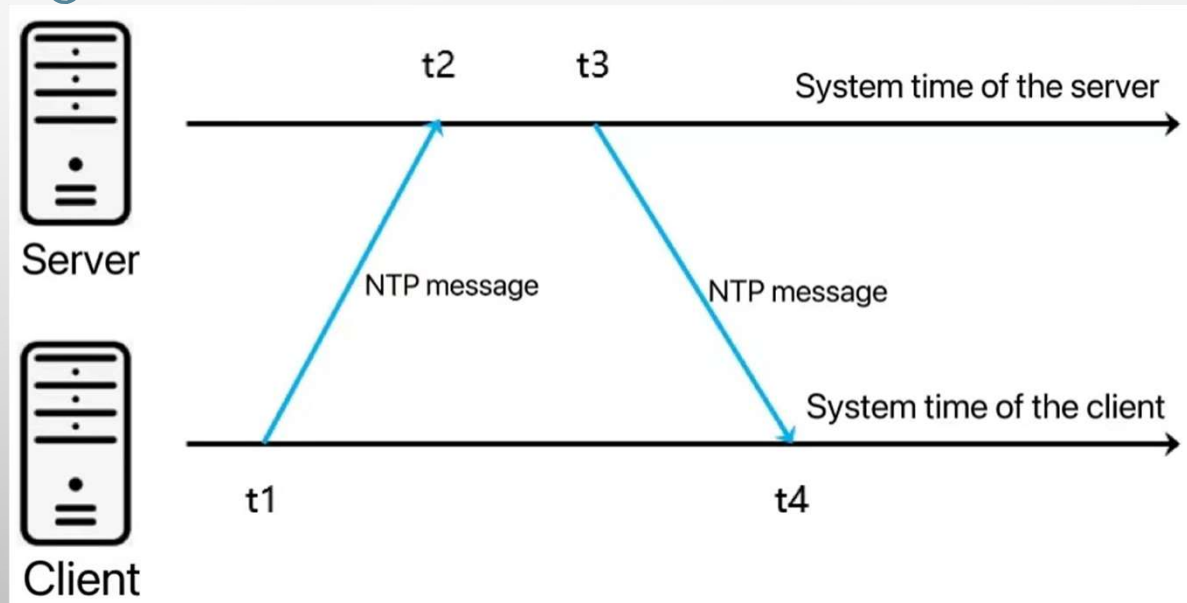
T1: Originate Timestamp

T2: Receive Timestamp

T3: Transmit Timestamp

T4: Reference Timestamp

CLOCK SYNCHRONIZATION



$$Offset = \frac{(T2 - T1) + (T3 - T4)}{2}$$

$$delay = (T4 - T1) - (T3 - T2)$$

where:

T1: Originate Timestamp

T2: Receive Timestamp

T3: Transmit Timestamp

T4: Reference Timestamp

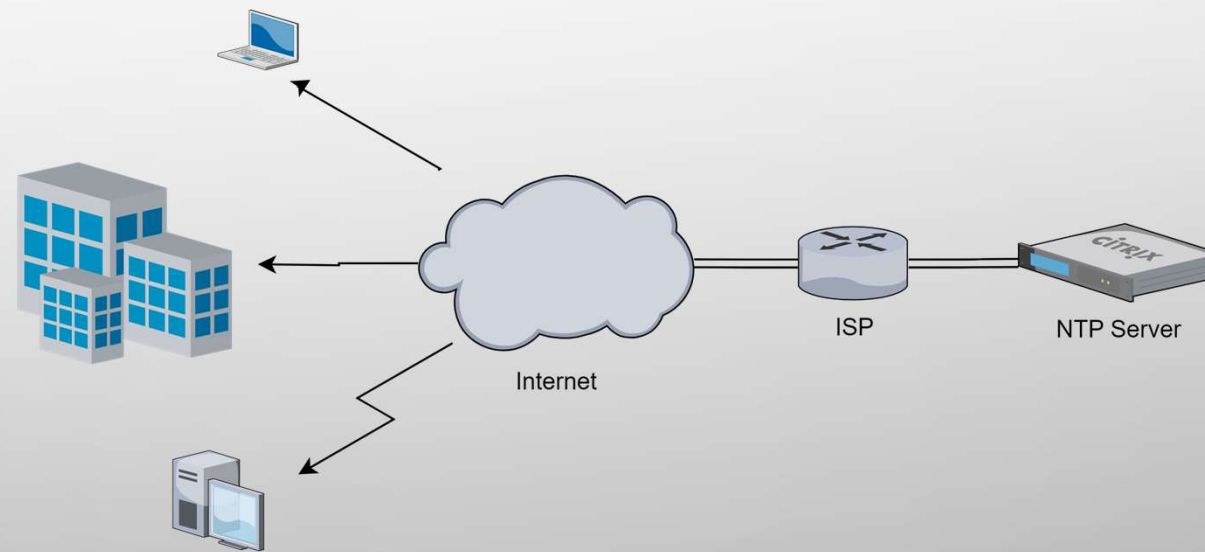
**IF THE NETWORK DELAYS
ARE SYMMETRIC**

A decorative graphic on the left side of the slide, consisting of a network of light blue lines and circles, resembling a circuit board or a neural network, set against a dark blue background.

TOPOLOGIES

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BASIC TOPOLOGY



BASIC TOPOLOGY

Equipment control options

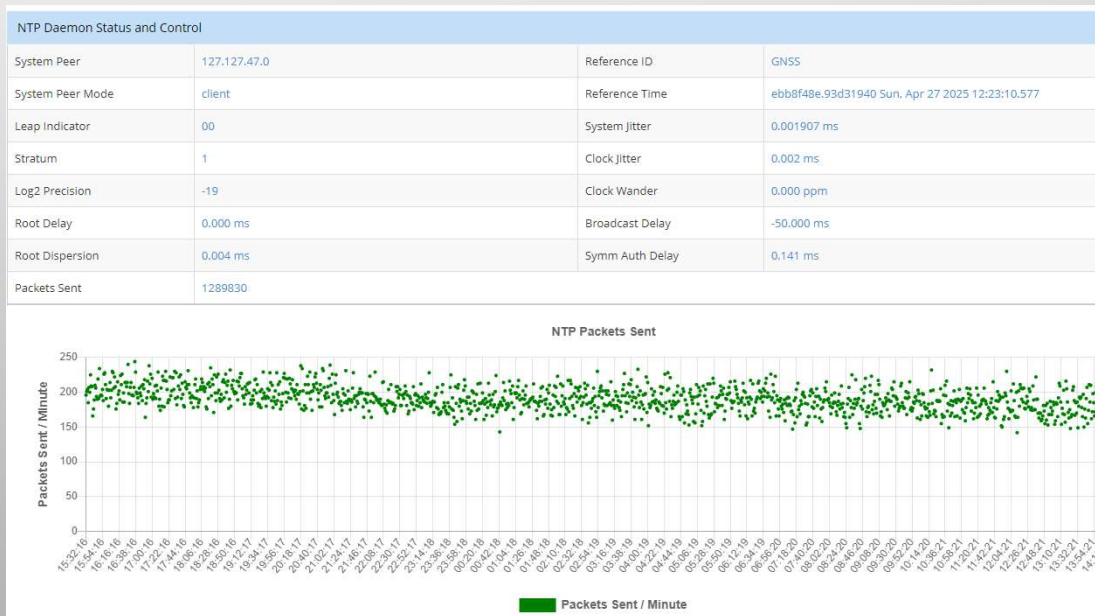
- Packets sent / IP request
- Figure of Merit Status (Stratum, Jitter, Wander, Delays, Dispersion)

Receive Statistics

Authentication Failures:	0	Requests Discarded:	2046
Avg TPS:	0	Requests Processed:	590703
Max TPS:	2		

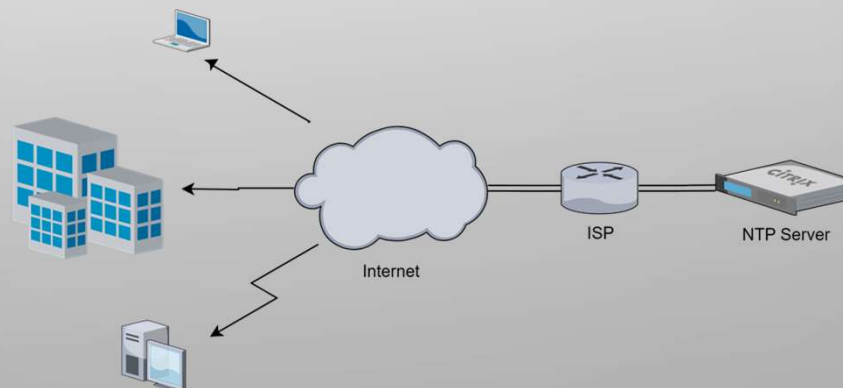
Transmit Statistics

Response Errors:	0
------------------	---

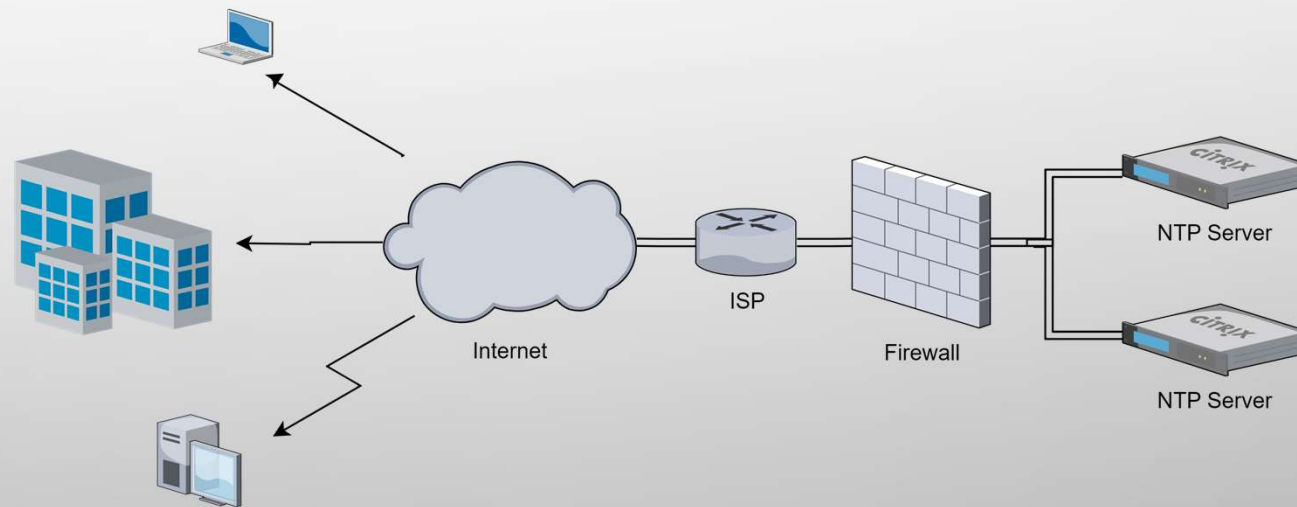


BASIC TOPOLOGY

Advantages	Disadvantages
Easy and fast implementation and maintenance	Security risks
Low cost	Limited capacity
-	Poor scalability



MEDIUM TOPOLOGY

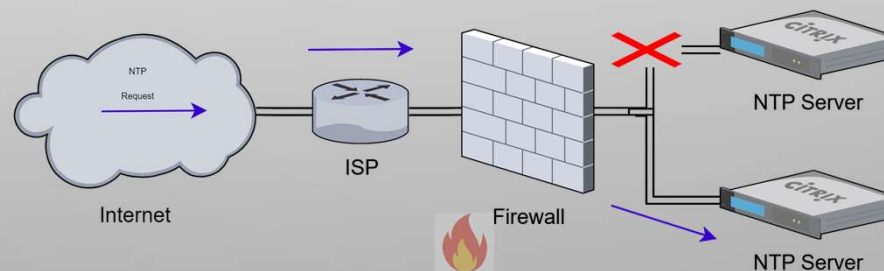


Basic + Back up + Firewall

MEDIUM TOPOLOGY

Characteristics:

- Packets sent
- IP request
- Figure of Merit Status (Stratum, Jitter, Wander, Delays, Dispersion)
- **Quality Control (NTP internal comparison)**
- **Service Redundancy**
- **Security, privacy and network control**



Audit Details for 10.159.2.64

Max Delta Test: Passed. Delta from ref within 5 seconds
Recently Set Test: Passed. Time set within 1 day, 0 hours, 0 minutes
Contact Test: Passed. Responded within last 10 audits.
Audit Group: Audited

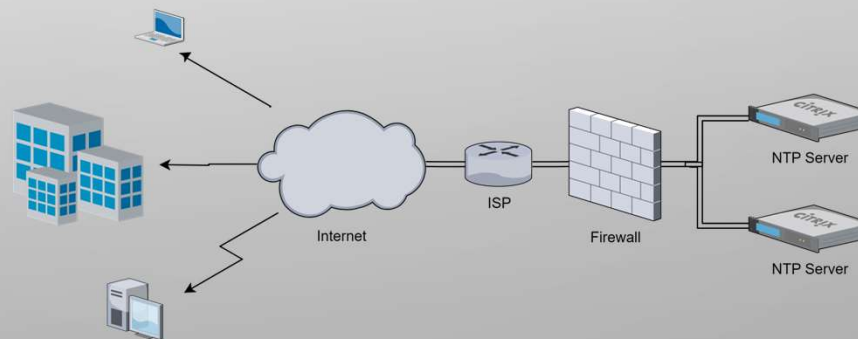
Machine Information	
DNS Name: 10.159.2.64	Domain Time Role: NTP Node
IP Address: 10.159.2.64	Install Date: n/a
Machine Platform: NTP Node	Serial Number: n/a
Time Zone: UTC	Registered: n/a
Last Boot: n/a	Version: 3

Audit Details		
Last Contact: Sun Apr 27 2025 19:55:44 UTC	Last Time Source: GNSS, stratum 1	
Delta from Reference: +0.0071734 seconds	Protocol Used: selected protocol	
Time since last set: 50 seconds	Last Correction: n/a	
Local Time: N/A	Time Checks: n/a	Errors: n/a
UTC Time: Sun Apr 27 2025 19:55:44 UTC	Time Corrections: n/a	

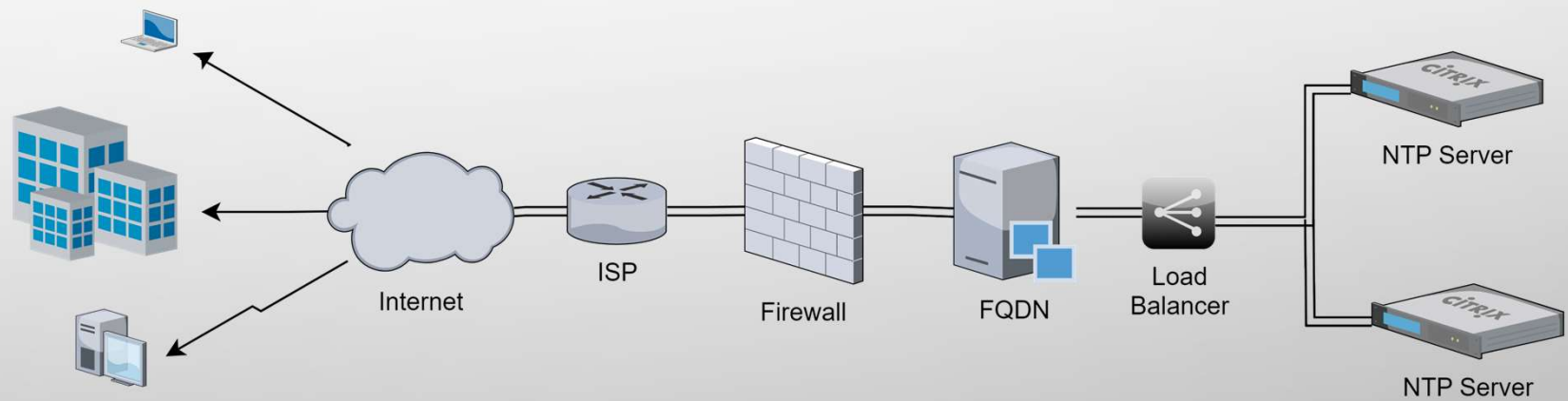
Print Details Close

MEDIUM TOPOLOGY

Advantages	Disadvantages
Better Security	More equipment required
Service Continuity	Limited capacity



ADVANCE TOPOLOGY

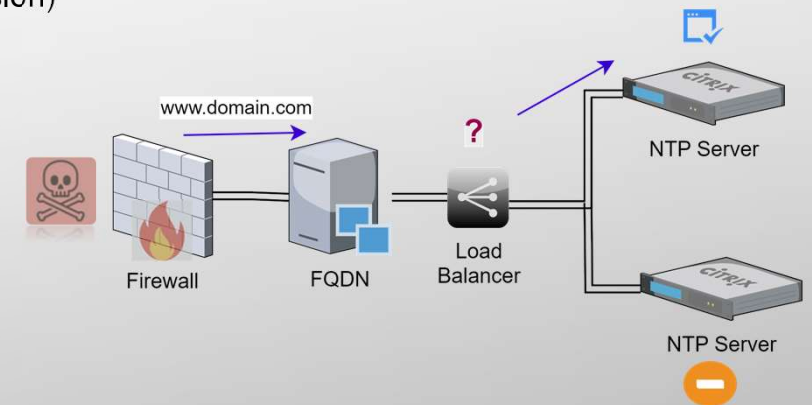


Medium + Load Balance + FQDN

ADVANCE TOPOLOGY

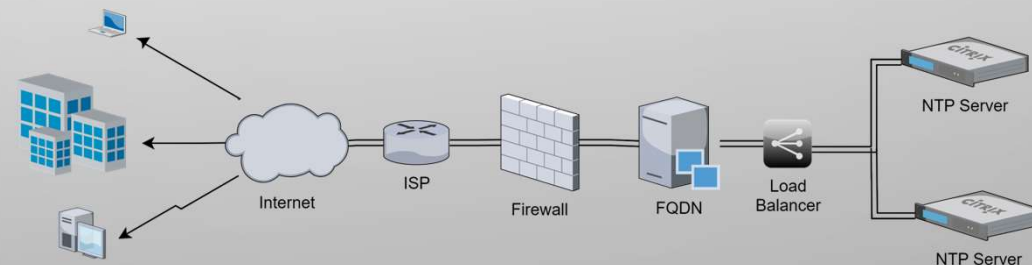
Characteristics:

- Packets sent
- Figure of Merit Status (Stratum, Jitter, Wander, Delays, Dispersion)
- IP request
- Quality Control (NTP internal comparison)
- Service Redundancy
- Security, privacy and network control
- **Fully Qualified Domain Name**
 - **Host localization (avoid IP dependency)**
- **Load Balance:**
 - **Request balance according specific rules (availability, geography, percentage, others)**
- **Traffic continuity and monitoring tools**



ADVANCE TOPOLOGY

Advantages	Disadvantages
Best Security	Most expensive
Robust and Scalable Network	Complex Topology
Network administration	IT Dependency



A decorative graphic on the left side of the slide, consisting of a network of light blue lines and circles of varying sizes, resembling a circuit board or a data network. The lines are vertical and horizontal, with some diagonal connections, and the circles are placed at various points along these lines.

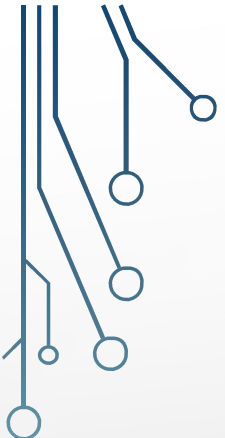
SERVICES AND MONITORING

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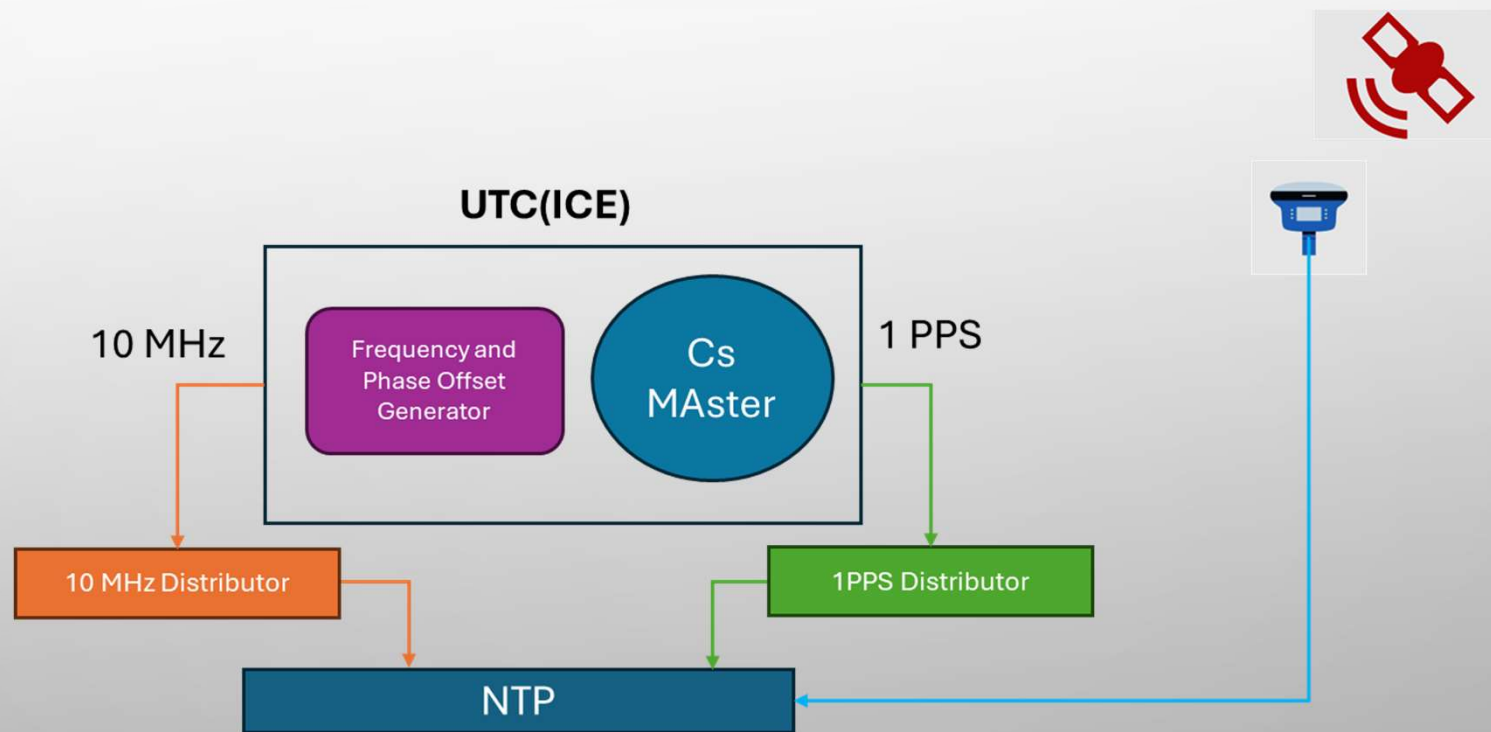
A decorative graphic on the left side of the slide, consisting of a network of light blue lines and circles of varying sizes, resembling a circuit board or a neural network diagram. The lines are vertical and horizontal, with circles at various points along the paths.

Case A (ICE-LAMETRO)

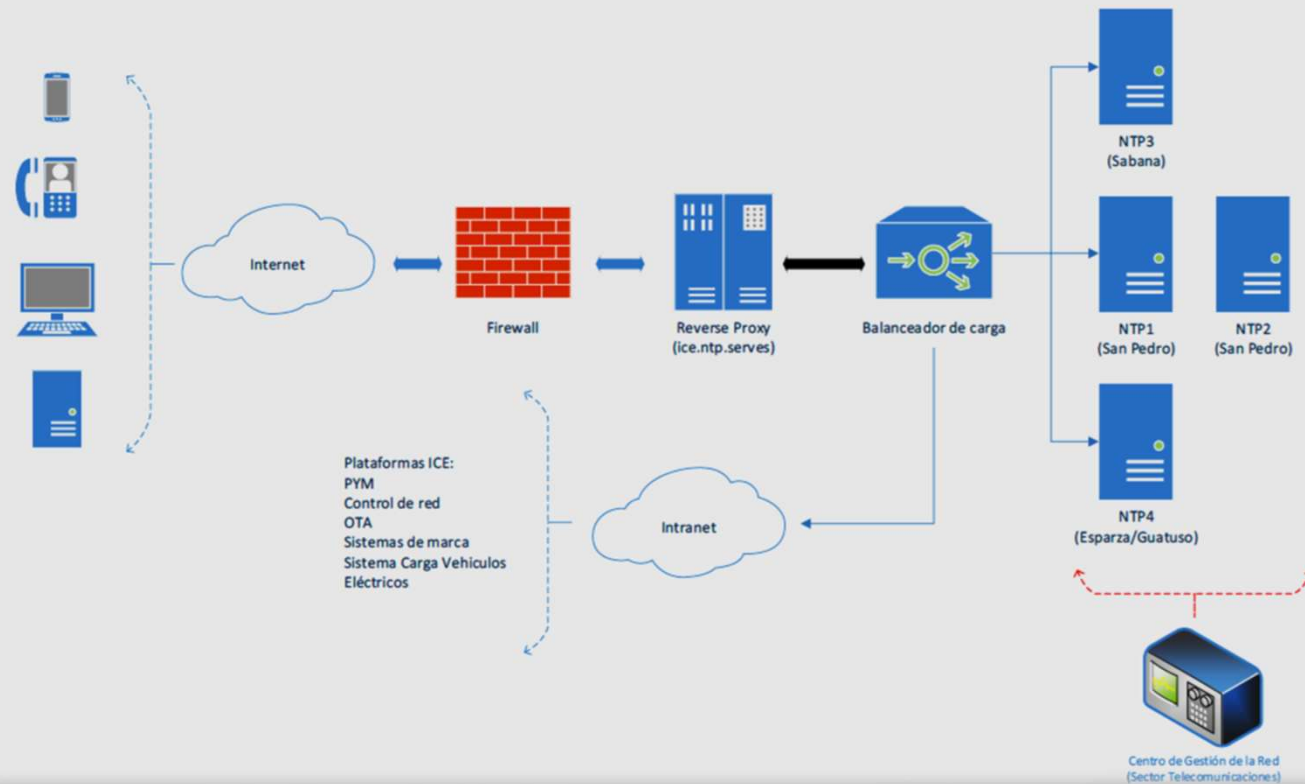
BIPM - SIM UTC SUMMER SCHOOL 7-9 MAY, QUERÉTARO



CASE A (ICE-LAMETRO)



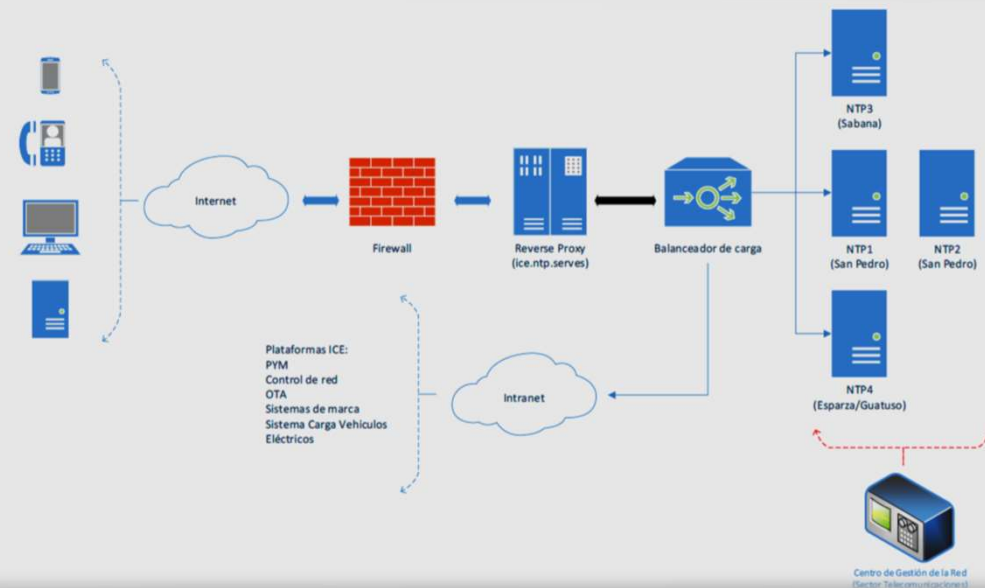
CASE A (ICE-LAMETRO)



CASE A (ICE-LAMETRO)

Description:

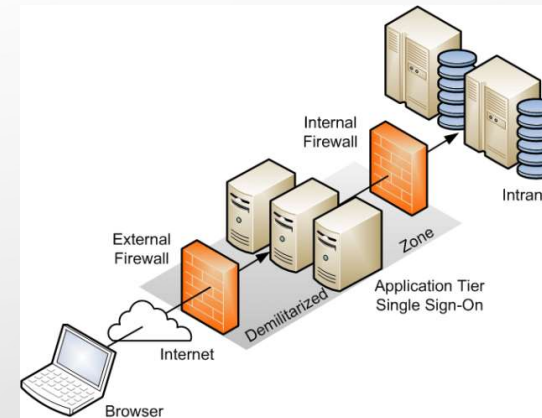
- Double Multi Mode (OM4) Optical Fiber Link for redundancy
- Double Switch Working on Mirror Mode for service continuity
- NOC and SOC (IT Department Support)
 - DMZ Network
 - FQDN
 - Load balancer
- Main Site:
 - Three NTP (24 000 request / second)
- 2nd Site:
 - 1 NTP (10 000 request / second)
- 3rd Site (in progress):
 - 1 NTP (10 000 request / second)



CASE A (ICE-LAMETRO)

Security Operation Center (SOC)

- Demilitarized Zone (DMZ) Network
 - Isolate servers that are exposed to the public in a separate monitored zone
 - External users can access these services while keeping the rest of the internal network protected
- Fully Qualified Domain Name (FQDN):
 - Eliminate ambiguity in identifying a specific host or server on the internet
 - Ensuring accurate and reliable communication
- Load Balance Service
 - Two sites attending request (one site back up)
 - Distributes incoming requests to the server with the fewest active connections (least_conn)



ntp.ice.go.cr.go.cr (int/ext service)

ntp1.ice.go.cr.go.cr (int/ext service redundancy)

ntp2.ice.go.cr.go.cr (internal service)

```
upstream ntp_servers {  
    #Servidores NTP en LAMETRO  
    least_conn;  
    server 10.159.50.28:123;  
    server 10.159.50.29:123;  
    server 10.159.50.53:123;  
    server 10.159.50.54:123;  
    server 10.159.50.55:123;  
    server 10.161.38.21:123;  
    server 10.161.38.22:123;  
    server 10.161.38.23:123;  
    server 10.159.2.63:123 backup;  
    server 10.159.2.64:123 backup;  
}
```

CASE A (ICE-LAMETRO)

Network Operation Control (NOC)

- Traffic continuity:
 - Ethernet signal
 - Service NTP State (UDP/123)
- Traffic monitoring
 - Alarm Event Notification

```
132.163.136.138 -- UDP 200 48 "10.159.50.55:123"  
132.163.136.138 -- UDP 200 48 "10.159.50.28:123"  
201.199.239.38 -- UDP 200 48 "10.159.50.29:123"  
172.16.1.8 -- UDP 200 48 "10.159.50.53:123"  
132.163.136.138 -- UDP 200 48 "10.159.50.54:123"  
36.249.155.2 -- UDP 502 0 "10.161.38.22:123"  
172.16.1.8 -- UDP 502 0 "10.161.38.23:123"  
201.199.239.38 -- UDP 502 0 "10.161.38.21:123"  
201.199.239.38 -- UDP 200 48 "10.159.50.55:123"
```

- Stress Test
 - Evaluate NTP Servers Request Capabilities

Time	Type	Application N...	Source	Origin	Destination	Service	HTTPS Inspec...	URL
Today, 14:16:50	Connection		172.16.1.170	speseg02	10.159.50.29	UDP/123		
Today, 14:16:50	Connection		172.16.1.170	speseg02	10.159.50.28	UDP/123		
Today, 14:16:49	Connection		172.16.1.170	speseg02	10.159.50.53	UDP/123		
Today, 14:16:46	Connection		172.16.1.170	speseg02	10.159.50.56	UDP/123		
Today, 14:16:44	Connection		172.16.1.170	speseg02	10.159.50.54	UDP/123		
Today, 14:16:44	Connection		172.16.1.170	speseg02	10.159.50.55	UDP/123		
Today, 14:16:46	Connection		172.16.1.170	speseg02	10.159.50.56	UDP/123		
Today, 14:16:44	Connection		172.16.1.170	speseg02	10.159.50.54	UDP/123		
Today, 14:16:44	Connection		172.16.1.170	speseg02	10.159.50.55	UDP/123		
Today, 14:16:43	Connection		172.16.1.170	speseg02	10.159.50.30	UDP/123		
Today, 14:16:42	Connection		172.16.1.170	speseg02	10.159.50.29	UDP/123		
Today, 14:16:42	Connection		172.16.1.170	speseg02	10.159.50.30	UDP/123		
Today, 14:16:40	Connection		172.16.1.170	speseg02	10.159.50.56	UDP/123		
Today, 14:16:39	Connection		172.16.1.170	speseg02	10.159.50.27	UDP/123		
Today, 14:16:40	Connection		172.16.1.170	speseg02	10.159.50.56	UDP/123		
Today, 14:16:39	Connection		172.16.1.170	speseg02	10.159.50.27	UDP/123		
Today, 14:16:38	Connection		172.16.1.170	speseg02	10.159.50.55	UDP/123		
Today, 14:16:37	Connection		172.16.1.170	speseg02	10.159.50.28	UDP/123		
Today, 14:16:36	Connection		172.16.1.170	speseg02	10.159.50.28	UDP/123		
Today, 14:16:34	Connection		172.16.1.170	speseg02	10.159.50.53	UDP/123		
Today, 14:16:33	Connection		172.16.1.170	speseg02	10.159.50.54	UDP/123		
Today, 14:16:33	Connection		172.16.1.170	speseg02	10.159.50.55	UDP/123		
Today, 14:16:33	Connection		172.16.1.170	speseg02	10.159.50.54	UDP/123		

UDP_v2.jmx (N:\SGC-LAMETRO\MTS\Equipo del Laboratorio\TP\Servidores NTP\resultados de entres 17-8-24\Proyecto ICE-NTP\ICE-NTP_v2.jmx) - Apache JMeter (3.6.3)

File Edit Search Run Options Tools Help

Test Plan
└─ NTP3 (Microchip S450)
 └─ NTP
 └─ Summary Report

Summary Report

Name: Summary Report

Comments:

Write results to file / Read from file

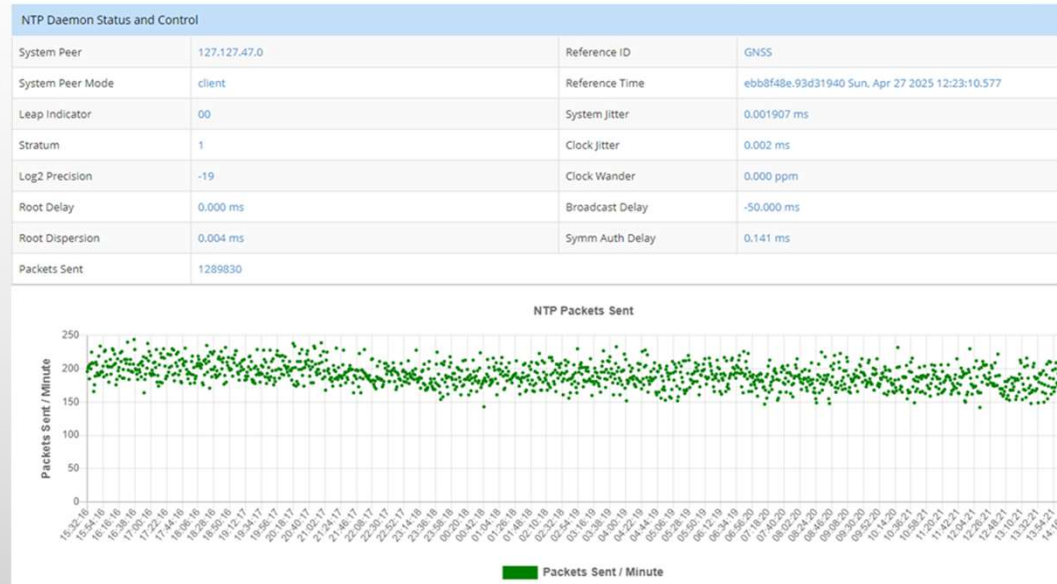
Filename: Browse... Log/Display Only: ☐ Errors ☐ Successes

Label	# Samples	Average	Min	Max	Std. Dev.	Error %	Throughput	Received KB/sec	Sent KB/sec	Avg. Bytes
NTP	2202805	3	0	198	1.50	0.00%	11330.7/sec	1062.25	0.00	96.0
TOTAL	2202805	3	0	198	1.50	0.00%	11330.7/sec	1062.25	0.00	96.0

CASE A (ICE-LAMETRO)

Monitoring Tools:

- Packets sent
- FOM Status:
 - Stratum
 - Jitter
 - Wander
 - Delays
 - Dispersion
- Alarm Event Email
 - Ethernet link
 - Signal Quality (1PPS, 10 MHz, GNSS)
 - Jamming/Spoofing



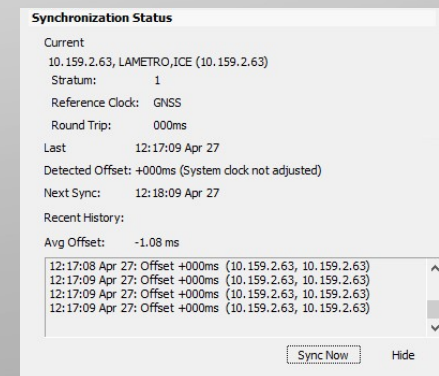
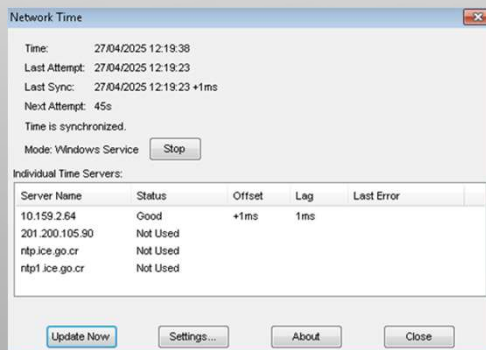
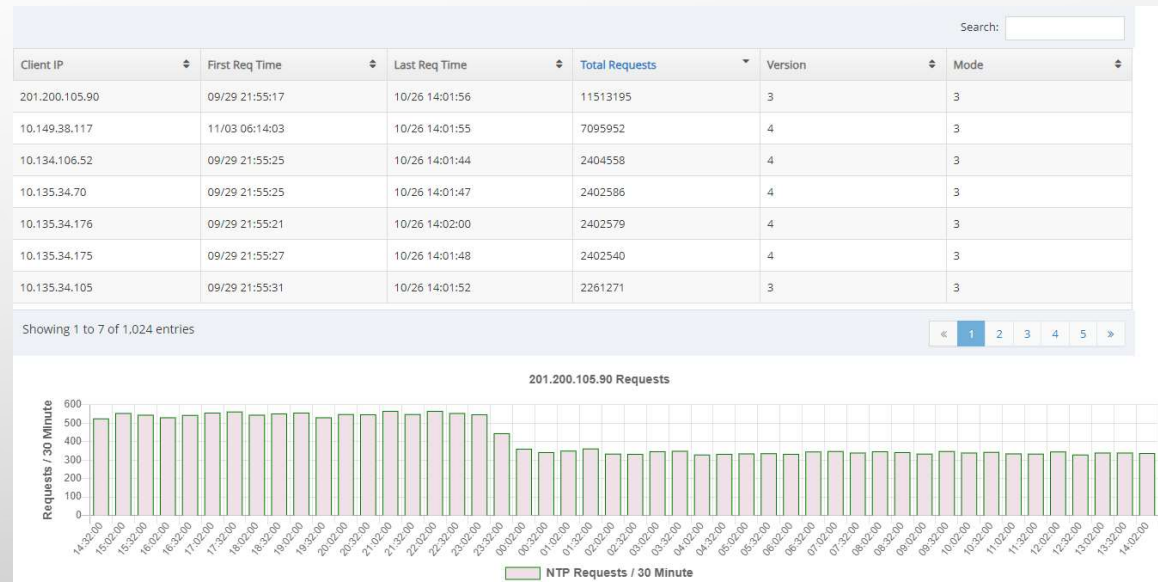
 SyncServer_S6xx_Admin
Para Fallas Cordero Oscar; osgefa@gmail.com; Morales Valverde Junior José
 Este remitente es externo a la organización.

Sent by: Sender email not configured on SyncServer
Time: Wed Nov 20 15:29:56 2024
Model: SyncServer S650
Serial: SCA17300007D
Hostname: ICE-NTP2
Message: Id: 116, Index: 000, Severity: major, Alarm: set, Msg: Ethernet port 2 link down

CASE A (ICE-LAMETRO)

Monitoring:

- NTP request:
 - Total
 - IP Client
- Offset and Round Trip Measured (client site)



CASE A (ICE-LAMETRO)

General Control:

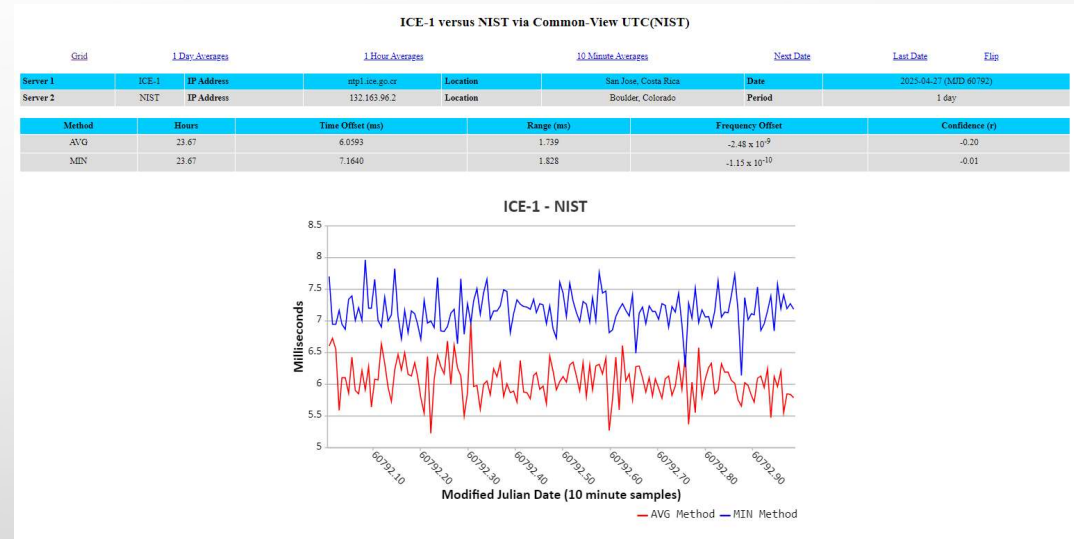
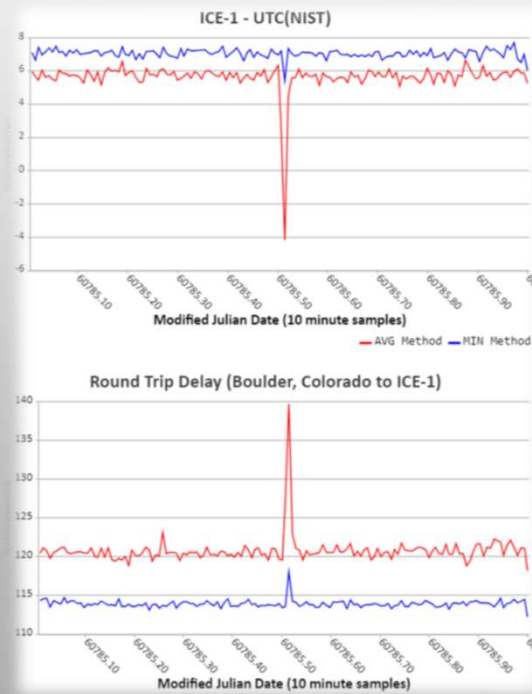
- SIM TN Comparison for several reference
- Visual Alarms
- Fast interface

SIM NTP Server Comparisons
(time differences for the 10-minute period ending on 04-27-2025 at 23:40:00 UTC)

																	
		NIST	NRC	ICE	INM	ONRJ-1	CENAM	IBMET	CNMEP	INACAL	INDOCAL	CMEE	CIM	INTI	CNME	UTE	BSJ
	United States		0.3	2.8	-1.0	4.1	0.2	0.5	-1.4	5.0				3.7			-4.6
	Canada	-0.3		2.5	-1.3	3.8	-0.1	0.2	-1.8	4.7				3.4			-4.9
	Costa Rica	-2.8	-2.5		-3.8	1.2	-2.6	-2.3	-4.3	2.2				0.9			-7.4
	Colombia	1.0	1.3	3.8		5.0	1.2	1.5	-0.5	6.0				4.7			-3.6
	Brazil	-4.1	-3.8	-1.2	-5.0		-3.9	-3.6	-5.5	0.9				-0.3			-8.6
	Mexico	-0.2	0.1	2.6	-1.2	3.9		0.3	-1.7	4.8				3.5			-4.8
	Bolivia	-0.5	-0.2	2.3	-1.5	3.6	-0.3		-2.0	4.5				3.2			-5.1
	Panama	1.4	1.8	4.3	0.5	5.5	1.7	2.0		6.5				5.2			-3.1
	Peru	-5.0	-4.7	-2.2	-6.0	-0.9	-4.8	-4.5	-6.5					-1.3			-9.6
	Dominican Rep.																
	Ecuador																
	El Salvador																
	Argentina	-3.7	-3.4	-0.9	-4.7	0.3	-3.5	-3.2	-5.2	1.3							-8.3
	Guatemala																

CASE A (ICE-LAMETRO)

- Evaluate short term service behavior
- Identification of atypical situation and conditions
- Statistic information for performance evaluation



Allan Deviation (ADEV)			
Averaging Time (τ) (hours, minutes)	Samples	ADEV (AVG Method)	ADEV (MIN Method)
0 h, 10 min	285	1.68×10^{-6}	7.53×10^{-7}
0 h, 20 min	283	1.06×10^{-6}	3.99×10^{-7}
0 h, 40 min	279	5.39×10^{-7}	2.09×10^{-7}
1 h, 20 min	271	2.77×10^{-7}	1.10×10^{-7}
2 h, 40 min	255	1.40×10^{-7}	5.26×10^{-8}
5 h, 20 min	223	6.68×10^{-8}	2.63×10^{-8}
10 h, 40 min	159	3.10×10^{-8}	1.17×10^{-8}

Time Deviation (TDEV)			
Averaging Time (τ) (hours, minutes)	Samples	TDEV (AVG Method), ms	TDEV (MIN Method), ms
0 h, 10 min	285	0.5832	0.2609
0 h, 20 min	282	0.5470	0.2002
0 h, 40 min	276	0.4448	0.1626
1 h, 20 min	264	0.3593	0.1253
2 h, 40 min	240	0.3135	0.1262
5 h, 20 min	192	0.1923	0.1085
10 h, 40 min	96	0.1664	0.1375

CASE A (ICE-LAMETRO)

- Daily data presentation
- Up to 200 back days for presentation and evaluation
- Analyze medium term for data anomalies detection

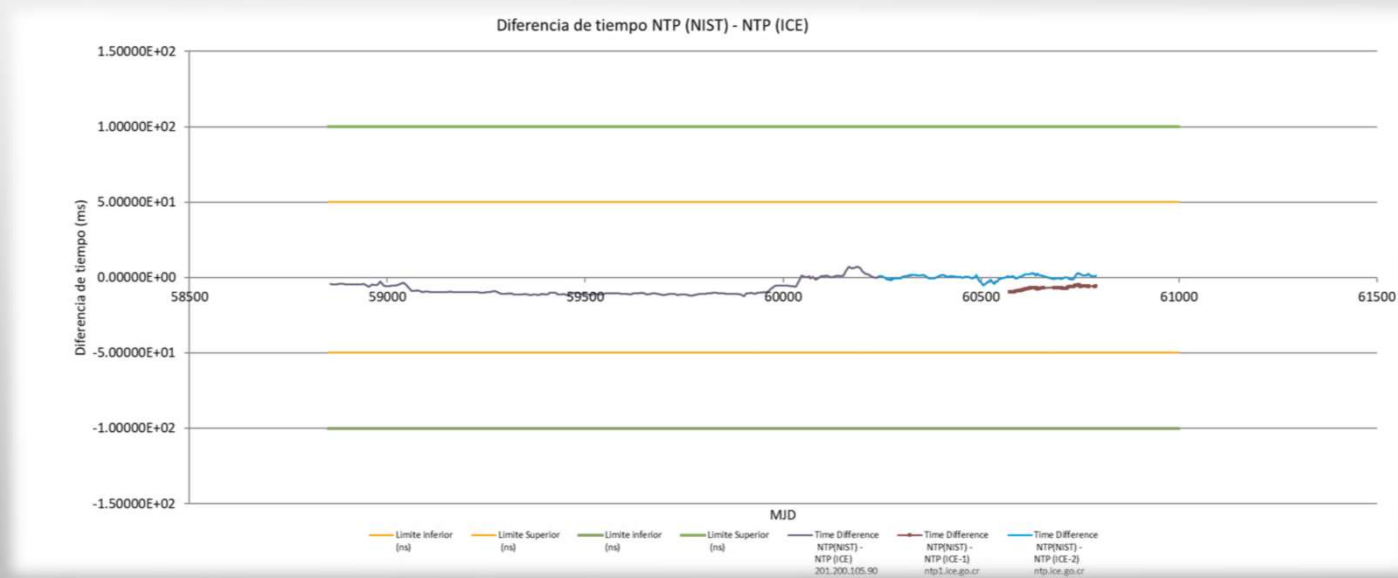


One Day Averages (ICE-1 - NIST)

Point	Date	MJD	Time Diff, AVG Method (ms)	Time Diff, MIN Method (ms)
1	2023-04-13	60778	5.767	7.109
2	2023-04-14	60779	5.862	7.098
3	2023-04-15	60780	5.939	7.146
4	2023-04-16	60781	5.843	7.102
5	2023-04-17	60782	5.378	6.711
6	2023-04-18	60783	5.603	6.890
7	2023-04-19	60784	5.755	6.980
8	2023-04-20	60785	5.690	6.991
9	2023-04-21	60786	5.518	6.771
10	2023-04-22	60787	5.814	7.009
11	2023-04-23	60788	6.148	7.192
12	2023-04-24	60789	4.885	6.526
13	2023-04-25	60790	5.998	6.920
14	2023-04-26	60791	6.004	7.043
15	2023-04-27	60792	6.055	7.165

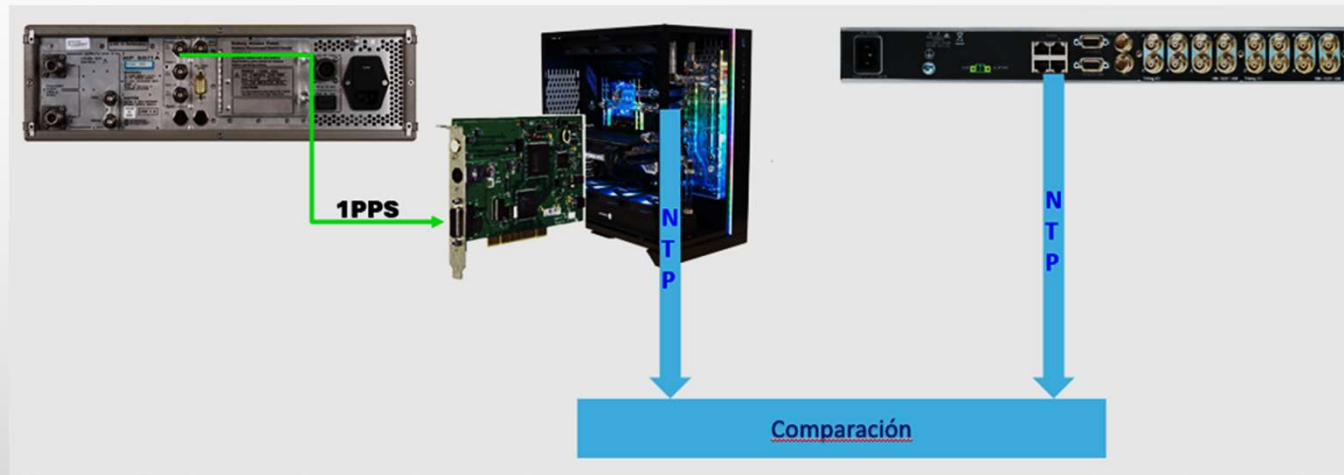
CASE A (ICE-LAMETRO)

- Summary information:
 - Local NTP comparison
 - Service Quality
 - Continuity
 - Jumps
 - Limits



CASE A (ICE-LAMETRO)

What is Next?



Server Information			Measurement Results and Uncertainty, U, contributed by Network Asymmetry (values are in milliseconds)						
Location	Name	Server Time - UTC(NIST)	Round Trip Delay	U, Worst Case	U, 3:3	U, 1:1	U, 1:1	U, 1:1	U, 1:1
United States	132.163.4.2	-0.155	1.949	+0.975	+0.487	+0.195	+0.046	+0.024	
Cloud	amazon.atp.org	-2.156	36.541	+18.271	+9.136	+3.654	+0.870	+0.446	
Cloud	time4.google.com	0.024	13.217	+6.628	+3.314	+1.326	+0.316	+0.163	
Cloud	time.windows.com	0.040	21.024	+11.512	+5.756	+2.302	+0.548	+0.281	
Sweden	193.11.166.2	-2.371	148.312	+74.156	+37.078	+14.831	+3.531	+1.809	
Brazil	200.20.186.74	-4.081	127.815	+63.907	+31.954	+15.781	+3.757	+1.925	
United States	132.163.96.2	-0.029	1.785	+0.892	+0.446	+0.178	+0.043	+0.023	
India	14.139.60.106	0.667	278.099	+139.049	+69.525	+27.810	+6.021	+3.591	
India	14.139.60.107	1.066	279.793	+139.897	+69.948	+27.979	+6.662	+3.412	
Costa Rica-1	atp.lac.gcr	6.499	119.500	+59.790	+29.875	+11.950	+2.845	+1.457	
Costa Rica-2	atp.lac.gcr	-2.185	103.629	+51.815	+25.907	+10.363	+2.467	+1.264	

This table was created at 04-27-2023 (GMT 00:00) 23:54:02 UTC and will refresh every five minutes. Click on a time difference number to graph Server Time - UTC(NIST).
The BLUE column estimates the uncertainty for typical network conditions where asymmetry equals a small percentage of the round trip delay.
If Server Time - UTC(NIST) is:
• GREEN then the server clock appears to be properly synchronized because the time difference is small enough to be reasonably attributed to network conditions.
• 111,111 then the server clock appears to not be properly synchronized because a time difference this large would require > 3:1 network asymmetry.
• RED then the time difference is too large to be attributed to even worst case network conditions and the server clock should be resynchronized.

		NIST	amazon.atp.org	time4.google.com	time.windows.com	193.11.166.2	200.20.186.74	132.163.96.2	14.139.60.106	14.139.60.107	atp.lac.gcr	atp.lac.gcr
United States	132.163.4.2		2.6	-0.3	-0.2	3.3	3.9	-0.1	-0.9	-1.2	-0.7	3.8
Cloud		-0.8		2.3	-2.2	0.2	1.9	2.1	-2.8	-3.2	-0.7	8.9
Cloud		0.2	2.2		-0.9	2.4	4.1	0.1	-0.6	-1.1	-0.5	1.3
Cloud		0.2	2.2	0.6		2.4	4.1	0.1	-0.6	-1.6	-0.5	1.3
Sweden		2.2	-0.2	2.4	-2.4		1.7	-2.3	-3.8	-3.5	-0.9	-0.2
Brazil		-3.9	-1.9	-4.1	-4.1	-1.7		-4.1	-4.7	-5.2	-10.6	-1.9
United States		0.1	2.1	-0.1	-0.1	2.3	4.1		-0.7	-1.1	-0.5	1.3
India		0.8	2.8	0.6	0.6	3.0	4.7	0.7		-0.4	-0.8	2.9
India		1.2	2.2	1.3	1.9	3.0	5.2	1.3	0.4		-0.4	3.3
Costa Rica-1		0.7	0.7	0.6	0.6	0.9	10.6	0.5	5.6			8.7
Costa Rica-2		-2.6	-0.6	-2.2	-2.2	0.2	1.9	2.2	-2.9	-3.3	-0.7	

This table was created at 04-27-2023 (GMT 00:00) 23:54:02 UTC and will refresh every five minutes. Values are in milliseconds, time differences > 10 ms are marked as red.
Click on a time difference or count: count to graph the time difference between the server and UTC(NIST). Click on a number to graph the time difference between two servers.

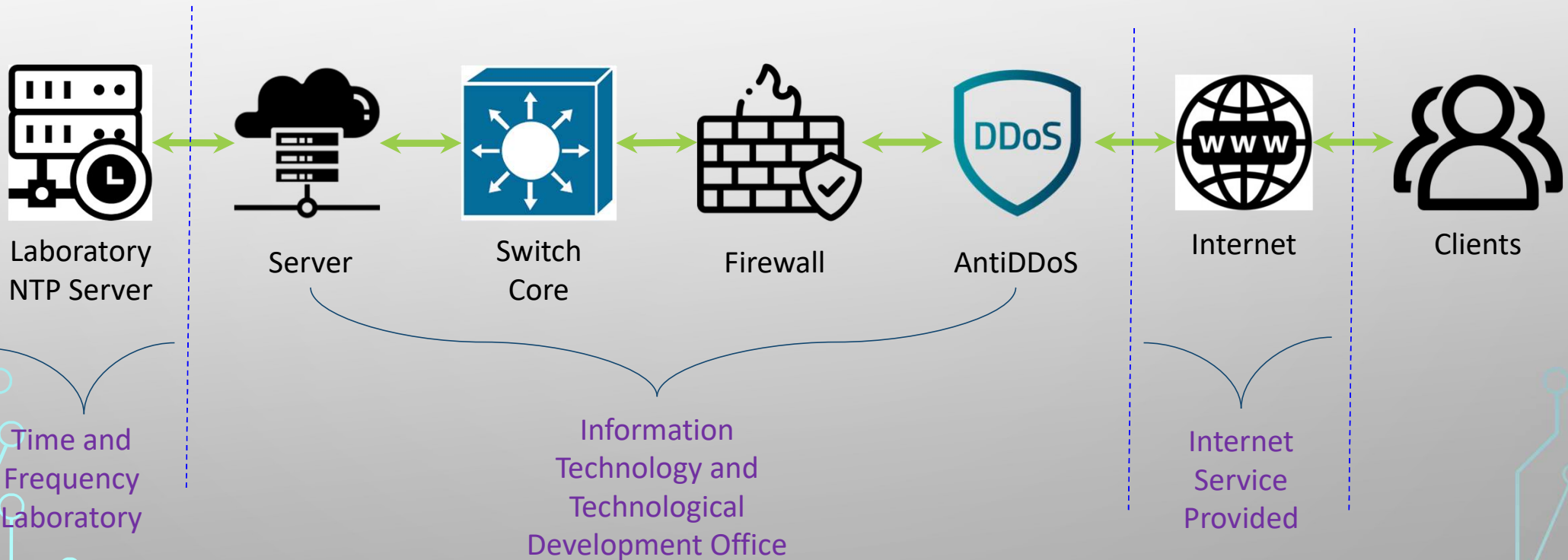
A decorative graphic on the left side of the slide, consisting of a network of light blue lines and circles of varying sizes, resembling a circuit board or a neural network diagram. The lines are vertical and horizontal, with some diagonal connections, and the circles are placed at various points along these lines.

Case B (INM)

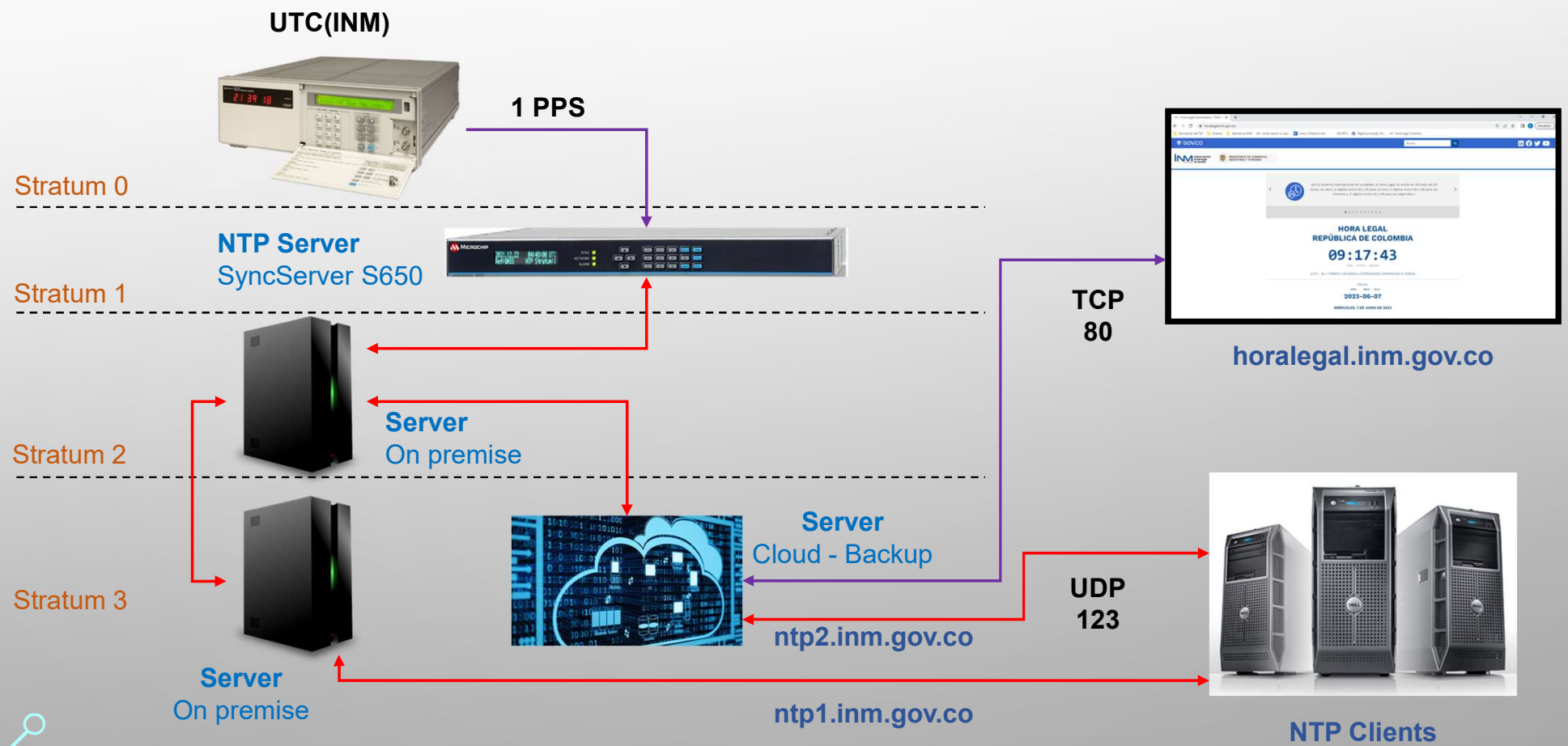
BIPM - SIM UTC SUMMER SCHOOL 7-9 MAY, QUERÉTARO

CASE B (INM)

Network infrastructure for dissemination of time service



NTP SERVICE SCHEMA



PREMIUM SERVICE

- Real time – monitoring offset
- Programming language: JAVA
- Library: NTP JAVA COMMONS-NET
 - Connection: NTPUDPClient port 123
 - Requests: `timeinfo = client.getTime('IP or domain')`
- Local database: CSV file
- CSV file is sent to the INM via e-mail.
- Calculates the offset between INM server and Client server
- Measurement report.
- The application runs on the client's server

NTP PROTOCOL DATA:

- [7] - T1 Originate timestamp
- [8] - T2 Receive timestamp
- [9] - T3 Transmit timestamp
- [10] - T4 Destination timestamp
- [11] - Offset = $[(T2-T1)+(T3-T4)]/2$
- [12] - Delay = $(T4-T1)-(T3-T2)$

getTime

```
public static long getTime(long ntpTimeValue)
```

Convert 64-bit NTP timestamp to Java standard time. Note that java time (milliseconds) by definition has less precision than NTP time (picoseconds) so converting NTP timestamp to java time and back to NTP timestamp loses precision. For example, Tue, Dec 17 2002 09:07:24.810 EST is represented by a single Java-based time value of `f22cd1fc8a`, but its NTP equivalent are all values ranging from `c1a9ae1c.cf9db22c`.

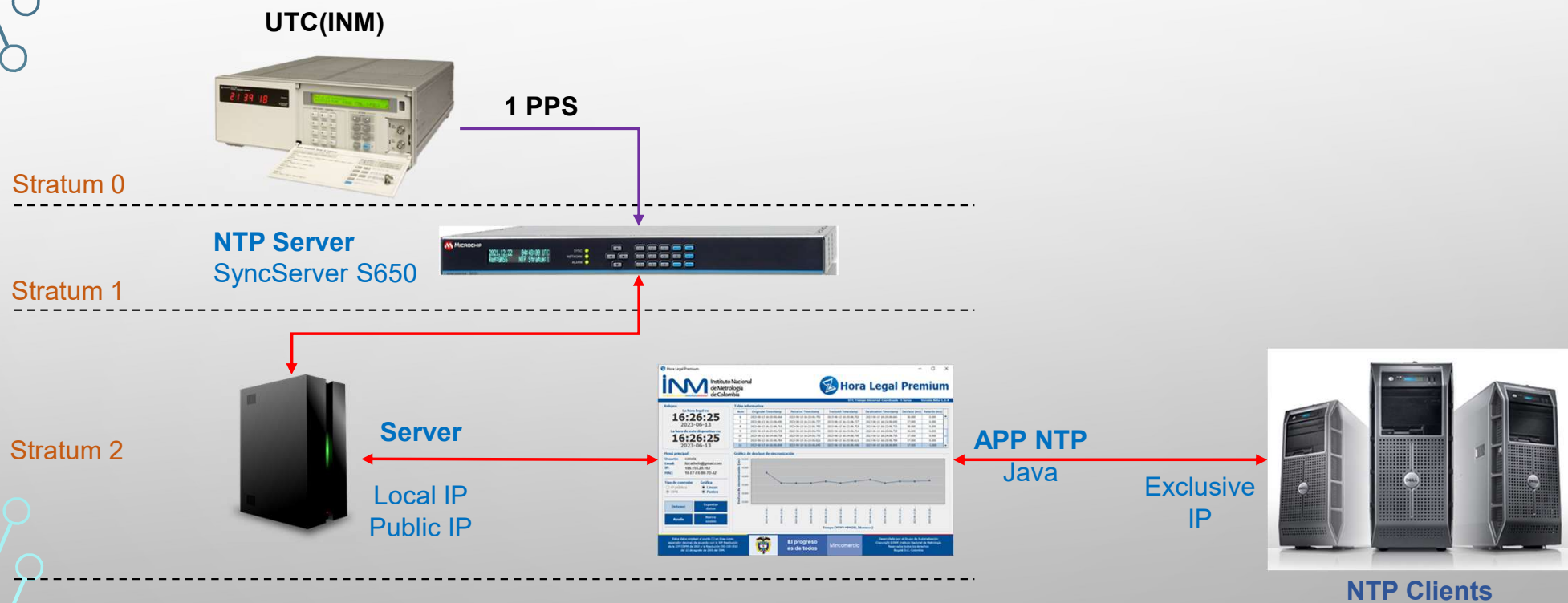
Parameters:

`ntpTimeValue` - the input time

Returns:

the number of milliseconds since January 1, 1970, 00:00:00 GMT represented by this NTP timestamp value.

PREMIUM SERVICE SCHEMA



RFC 5905:2010 A primary server is synchronized to a reference clock directly traceable to UTC.



Relojes:

La hora legal es:

16:58:12
2024-05-17

La hora de este dispositivo es:

16:58:13
2024-05-17

Menú principal

Usuario: canela

Email:

IP: 186.155.28.146

MAC: 20-88-10-6F-F5-D3

Tipo de conexión

- ☐ IP pública
☒ VPN

Gráfica

- ☒ Líneas
☒ Puntos

Detener

Exportar
datos

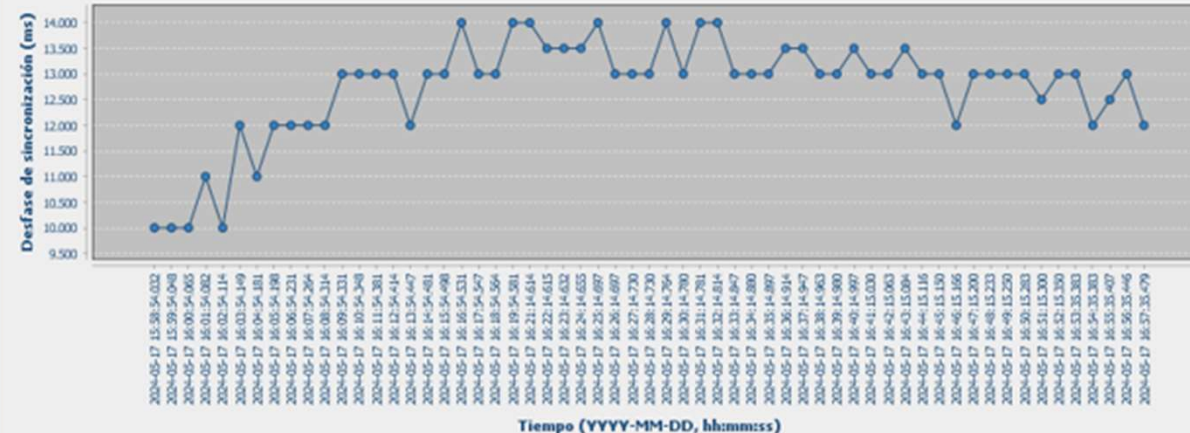
Ayuda

Nueva
sesión

Tabla informativa

Num	Originate Timestamp	Receive Timestamp	Transmit Timestamp	Destination Timestamp	Desfase (ms)	Retardo (ms)
153	2024-05-17 16:51:15.287	2024-05-17 16:51:15.299	2024-05-17 16:51:15.300	2024-05-17 16:51:15.287	12.500	-1.000
154	2024-05-17 16:52:15.337	2024-05-17 16:52:15.350	2024-05-17 16:52:15.350	2024-05-17 16:52:15.337	13.000	0.000
155	2024-05-17 16:53:35.370	2024-05-17 16:53:35.383	2024-05-17 16:53:35.383	2024-05-17 16:53:35.370	13.000	0.000
156	2024-05-17 16:54:35.371	2024-05-17 16:54:35.383	2024-05-17 16:54:35.383	2024-05-17 16:54:35.371	12.000	0.000
157	2024-05-17 16:55:35.394	2024-05-17 16:55:35.407	2024-05-17 16:55:35.407	2024-05-17 16:55:35.395	12.500	1.000
158	2024-05-17 16:56:35.433	2024-05-17 16:56:35.446	2024-05-17 16:56:35.446	2024-05-17 16:56:35.433	13.000	0.000
159	2024-05-17 16:57:35.467	2024-05-17 16:57:35.479	2024-05-17 16:57:35.479	2024-05-17 16:57:35.467	12.000	0.000

Gráfica de desfase de sincronización



Estos datos emplean el punto (.) en línea como
separador decimal, de acuerdo con la 10ª Resolución
de la 22ª CGPM de 2003 y la Resolución DG-210-2015
del 12 de agosto de 2015 del INM.

Instituto Nacional
de Metrología
de Colombia

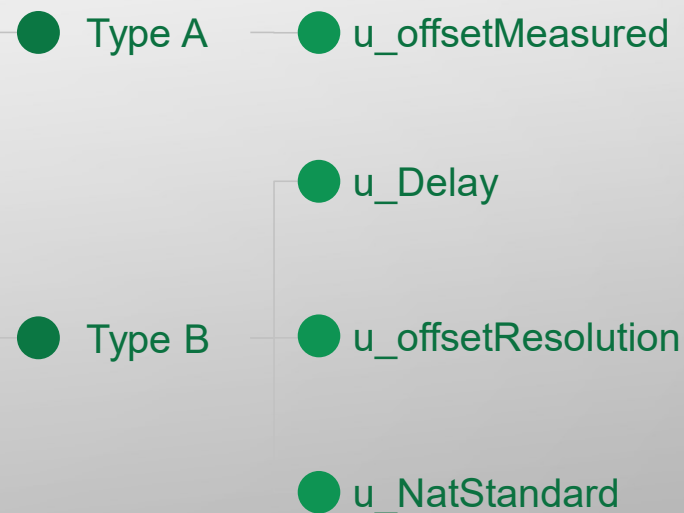
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PREMIUM SERVICE

Mathematical model

$$Offset = \frac{(T2-T1) + (T3-T4)}{2}$$

Uncertainty
budget



Combined uncertainty

$$u_c = \sqrt{u_{NatStandard}^2 + u_{offsetResolution}^2 + u_{Delay}^2 + u_{offsetMeasured}^2}$$

PREMIUM SERVICE

Daily Report

**Instituto Nacional de Metrología de Colombia**

Conexión por VPN

REPORTE NTP
Cliente canela IP 186.155.28.146 MAC 20-88-10-6F-F5-D3

Tiempo de medición:

Fecha Inicial	Fecha Final	Número de mediciones	Intervalo de medición
2024-05-17 14:17:51.426	2024-05-17 17:06:37.274	167	60 s

Desfase de sincronización con la hora legal:

Punto Máximo		Punto Mínimo	
2024-05-17 16:16:54.531	14.000 ms	2024-05-17 14:42:52.069	3.000 ms

Promedio	Factor de cobertura	Incertidumbre Expandida
x=8.940 ms	k=2.005	U=± 0.830 ms

Trazabilidad metrológica:

Patrón Nacional de Tiempo y Frecuencia	Fabricante	Modelo	Serie
Oscilador atómico de Cesio	Microsemi	5071A	US49353454

Estos datos emplean el punto (.) en línea como separador decimal, de acuerdo con la 10ª Resolución de la 22ª CGPM de 2003 y la Resolución DG-210-2015 del 12 de agosto de 2015 del INM.

Este es un correo electrónico de reporte de Hora Legal Premium por cada cliente.

1.4.2

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Monthly Report

**Instituto Nacional de Metrología de Colombia**

INFORME DE MEDICIÓN / MEASUREMENT REPORT
LABORATORIO DE 8-TIEMPO Y FRECUENCIA
8-TIME AND FREQUENCY LABORATORY

Número del informe de medición / Measurement report number: 12

Objeto / Object:	COMPUTADOR PORTATIL	Este informe de medición documenta la trazabilidad a los patrones nacionales, que realizan las unidades de medida de acuerdo con el Sistema Internacional de Unidades (SI). El usuario está obligado a calibrar el instrumento a intervalos apropiados. This measurement report documents the traceability to national standards, which realize the units of measurement according to the International System of Units (SI). The user is obliged to have the object calibrated at appropriate intervals.
Tipo / Type:	VIVBOOK	
Fabricante / Manufacturer:	ASUS	
Número de serie / Serial number:	12M	
Solicitante / Customer:	DIGITALWARE	
Ciudad / City:	BOGOTÁ D.C.	
Fecha de medición / Measurement date:	2020-08-19	
Número de radicación / Radication number:	20002675	

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Los resultados de este informe solo están relacionados con los objetos calibrados / The results of this reports just are related with the calibrated objects.

Fecha de expedición / Issue date:	Calibrado por / Calibrated by:	Autorizado por / Authorized by:
2020-08-19	Ingeniera CLAUDIA FERNANDA RODRIGUEZ RODRIGUEZ Contratista	Ingeniera LIZ CATHERINE HERNANDEZ FORERO Profesional Especializado

Instituto Nacional de Metrología de Colombia - INM
Subdirección de Metrología
Avenida Carrera 50 No.26- 55 Int. 2 CAN Bogotá D.C.-Colombia
Contactador: (57- 1) 2542222 - Website: www.inm.gov.co
E-mail: contacto@inm.gov.co - Twitter: @inmcolombia
Codigo Postal 111321

**El progreso es de todos**
Mineducación

Página 1 de 5

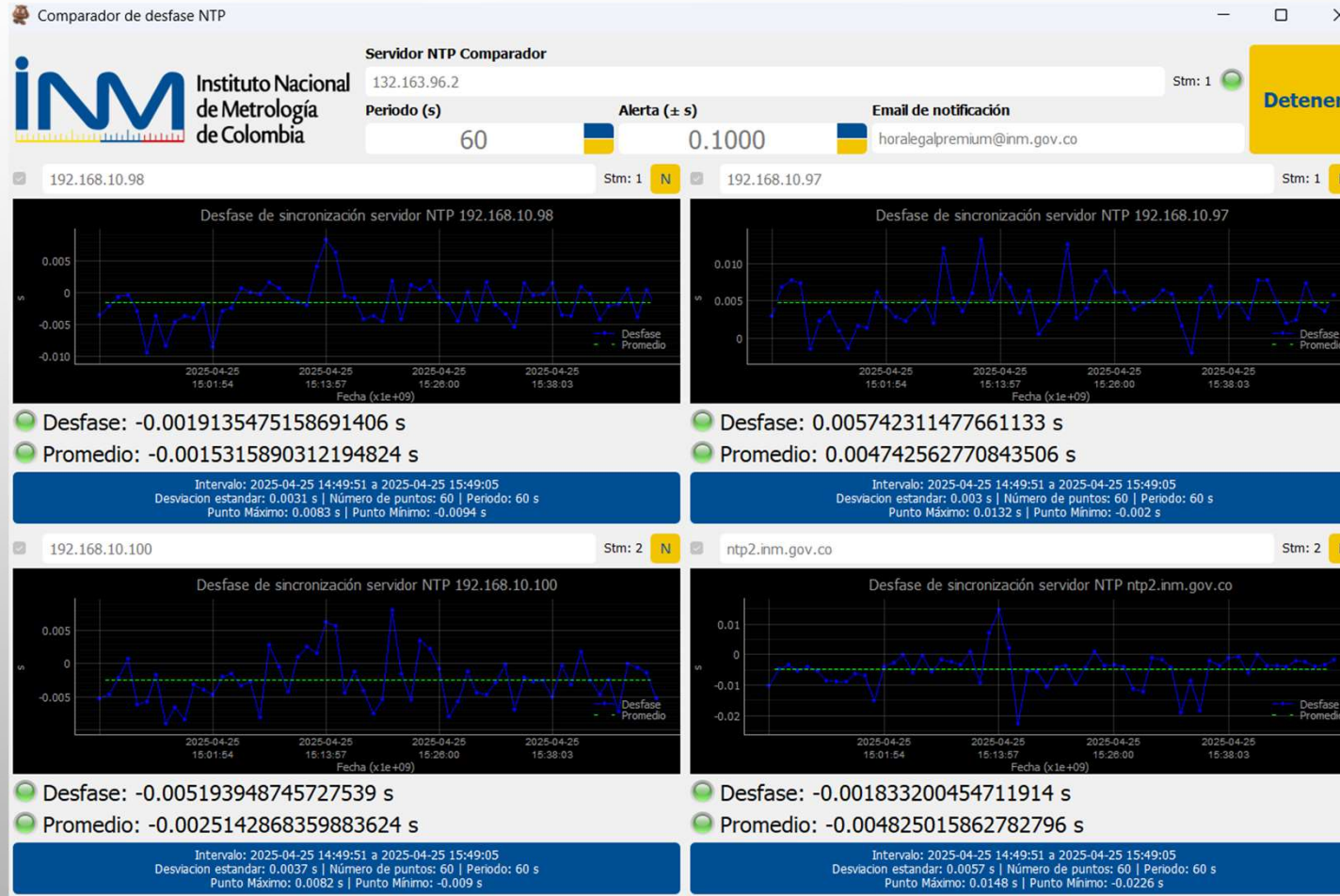
M-01-F-03 (V.1)

BIPM - SIM UTC SUMMER SCHOOL 7-9 MAY, QUERÉTARO

NTP SERVICE MONITORING

- Real time – monitoring
- Programming language: PYTHON
- Library: NTPLIB
 - Connection: `client = ntplib.ntplibclient()`
 - Requests: `client.request('IP or domain')`
- Compares up to 4 IP addresses.
- Local database: CSV files for each month
- Configurable:
 - IP main
 - 4 IP to compare
 - Measurement period
 - Maximum offset for alert
 - Email for notifications
 - Shows the stratum for each IP

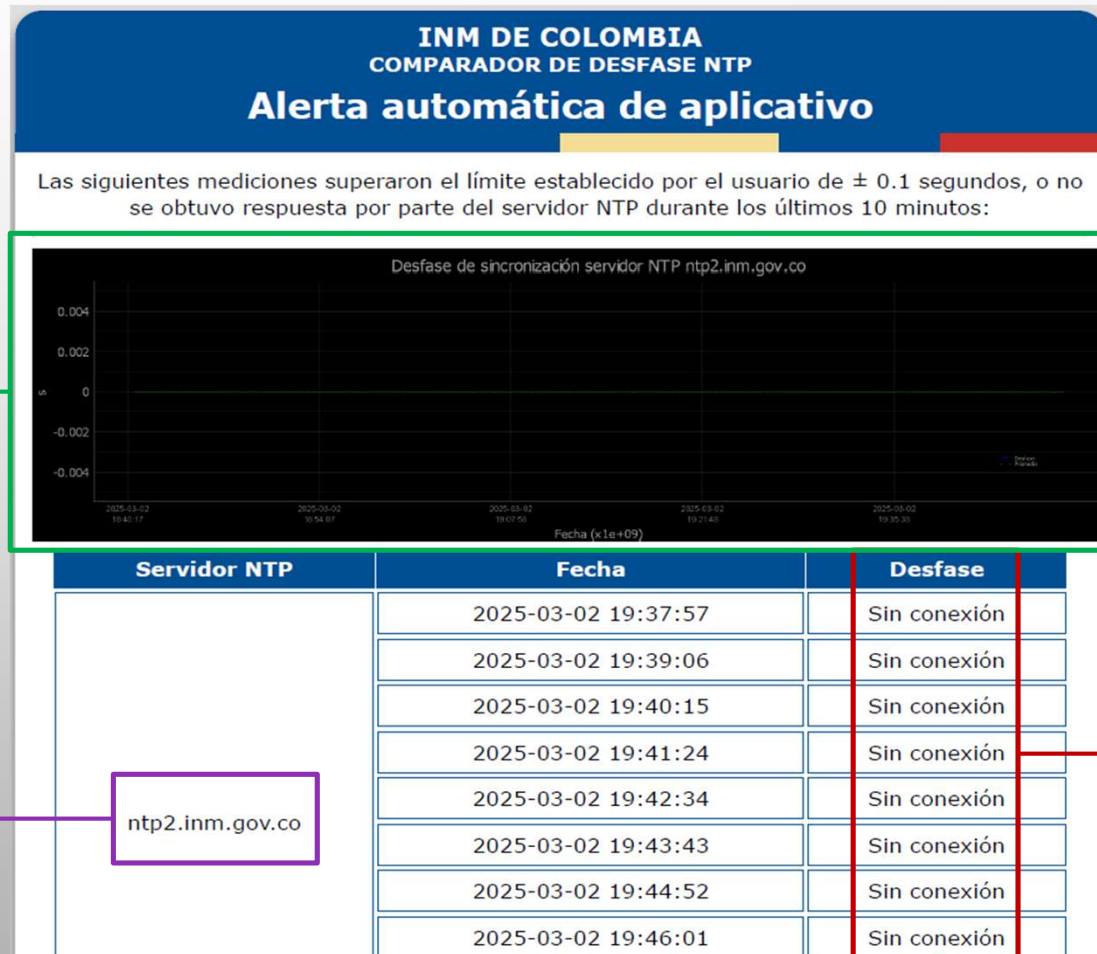
NTP SERVICE MONITORING APP



NTP SERVICE MONITORING - ALERTS

Graph of
the
measured
values

IP
address
or domain



Offset value or
connection
status

APP SYNCHRONIZATION

- Real time – synchronization
 - Programming language: PYTHON
 - Library: NTPLIB
 - Connection: `client = ntplib.ntpclient()`
 - Requests: `client.request('IP or domain')`
 - Calculates the adjustment:
- Configurable:
 - Synchronization period
 - Number of attempts
 - Up to 3 IP or domains to sync.

Local Time + Offset

Configuraciones

Periodo de sincronización (s)	Intentos de sincronización (#)
60	2

Servidor NTP principal #1 (url o ip)
192.168.10.98

Servidor NTP de respaldo #2 (url o ip)
192.168.10.97

Servidor NTP de respaldo #3 (url o ip)
ntp1.inm.gov.co

Guardar **Cancelar**

APP SYNCHRONIZATION



A decorative graphic on the left side of the slide, consisting of a network of light blue lines and circles of varying sizes, resembling a circuit board or a neural network diagram. The lines are vertical and horizontal, with circles at various points along the paths.

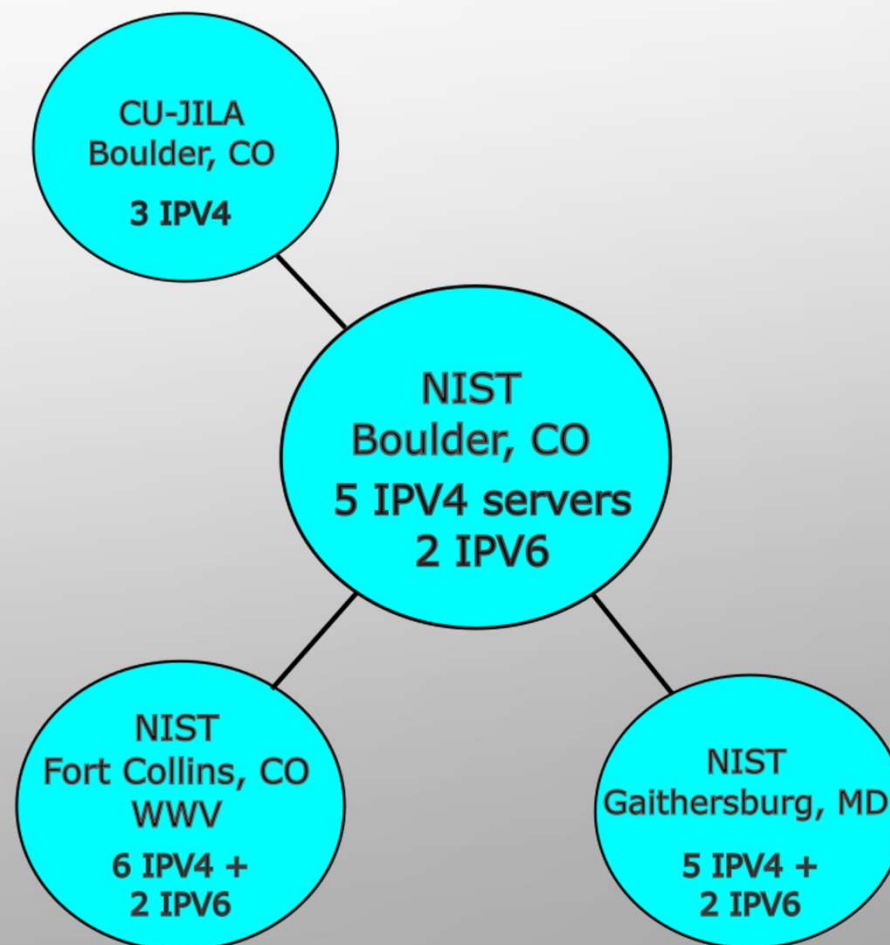
Case C (NIST)

BIPM - SIM UTC SUMMER SCHOOL 7-9 MAY, QUERÉTARO

NIST NTP SERVICES

- NIST supports several servers at multiple sites.
- OS is FreeBSD
- The NTP packet replier is custom C code
- The sync process: 1 PPS from the serial port

Slide from PTTI 2023?



NIST AUTHENTICATED NTP

- Each of the four sites has a server which provides "authenticated NTP".
- Registered users get verified NTP responses (that they came from NIST) where the encryption key is linked to the user's IP address.
- The time messages will be authenticated using symmetric-key encryption in a manner that is fully compatible with the published NTP documentation.
- The time accuracy is not guaranteed, just the source and transaction.

NTP SERVER STATUS PAGE

Web page showing the online status of each server.

This is not dynamic, however – if there's an issue with one of the servers, a file must be changed to show the new status.

There's also an email notification list for folks who want to be notified of availability issues.

Name	IP Address	Location	Status
time-a-g.nist.gov	129.6.15.28	NIST, Gaithersburg, Maryland	All services available
time-b-g.nist.gov	129.6.15.29	NIST, Gaithersburg, Maryland	All services available
time-c-g.nist.gov	129.6.15.30	NIST, Gaithersburg, Maryland	All services available
time-d-g.nist.gov	129.6.15.27	NIST, Gaithersburg, Maryland	All services available
time-d-g.nist.gov	2610:20:6f15:15::27	NIST, Gaithersburg, Maryland	All services available
time-e-g.nist.gov	129.6.15.26	NIST, Gaithersburg, Maryland	All services available
time-e-g.nist.gov	2610:20:6f15:15::26	NIST, Gaithersburg, Maryland	All services available
time-a-www.nist.gov	132.163.97.1	WWV, Fort Collins, Colorado	All services available
time-b-www.nist.gov	132.163.97.2	WWV, Fort Collins, Colorado	All services available
time-c-www.nist.gov	132.163.97.3	WWV, Fort Collins, Colorado	All services available
time-d-www.nist.gov	132.163.97.4	WWV, Fort Collins, Colorado	All services available
time-d-www.nist.gov	2610:20:6f97:97::4	WWV, Fort Collins, Colorado	All services via IPv6
time-e-www.nist.gov	132.163.97.6	WWV, Fort Collins, Colorado	All services available
time-e-www.nist.gov	2610:20:6f97:97::6	WWV, Fort Collins, Colorado	new server, services via IPV6
time-f-www.nist.gov	132.163.97.8	WWV, Fort Collins, Colorado	Only NTP service
time-a-b.nist.gov	132.163.96.1	NIST, Boulder, Colorado	All services available
time-b-b.nist.gov	132.163.96.2	NIST, Boulder, Colorado	All services available
time-c-b.nist.gov	132.163.96.3	NIST, Boulder, Colorado	All services available
time-d-b.nist.gov	132.163.96.4	NIST, Boulder, Colorado	All services available
time-d-b.nist.gov	2610:20:6f96:96::4	NIST, Boulder, Colorado	All services available
time-e-b.nist.gov	132.163.96.6	NIST, Boulder Colorado	All services available
time-e-b.nist.gov	2610:20:6f96:96::6	NIST, Boulder, Colorado	All services available
time.nist.gov	global address for all servers	Multiple locations	All services available
utcnist.colorado.edu	128.138.140.44	University of Colorado, Boulder	All services available
utcnist2.colorado.edu	128.138.141.172	University of Colorado, Boulder	All services available
utcnist3.colorado.edu	128.138.140.211	University of Colorado, Boulder	All services available

NTP/PTP OPTION FOR TMAS



A TMAS box with an internal steered oscillator has the option of adding an NTP/PTP server. This is for calibration customers who want to distribute the NIST time within their network.

An example is a stock market data center.

Another option is NTP monitoring.

***TMAS will be discussed this afternoon.**

NTP CUSTOMERS - MONITORING AT NIST

Monitoring NTP can be done as "common-view", where a site can check NTP from two locations compared to its internal clock, but that adds two different path asymmetries.

A better solution is having a time reference from the timescale directly connected to the monitor.

NTP MONITORING – MEASUREMENT GRID

NTP Measurement Grid (values are in milliseconds, grid updates every 10 seconds)

	NIST	AMAZON	NRC	CIM	ICE	INTI	INM	GOOG	ONRJ-1	ONRJ-2	CENAM	IBMET
NIST		-7.81	-0.15		-0.92	-3.99	0.01	0.45	-4.05	-4.05		-0.39
AMAZON	7.81		7.67		6.90	3.82	7.83	8.26	3.76	3.76		7.42
NRC	0.15	-7.67			-0.77	-3.85	0.16	0.59	-3.90	-3.90		-0.24
CIM												
ICE	0.92	-6.90	0.77			-3.08	0.93	1.36	-3.13	-3.13		0.53
INTI	3.99	-3.82	3.85		3.08		4.01	4.44	-0.06	-0.06		3.60
INM	-0.01	-7.83	-0.16		-0.93	-4.01		0.43	-4.06	-4.06		-0.40
GOOG	-0.45	-8.26	-0.59		-1.36	-4.44	-0.43		-4.50	-4.50		-0.84
ONRJ-1	4.05	-3.76	3.90		3.13	0.06	4.06	4.50		-0.00		3.66
ONRJ-2	4.05	-3.76	3.90		3.13	0.06	4.06	4.50	0.00			3.66
CENAM												
IBMET	0.39	-7.42	0.24		-0.53	-3.60	0.40	0.84	-3.66	-3.66		
RT DLY	1.49	38.24	63.33		112.66	178.92	116.67	13.03	167.69	167.78		144.25
HEALTH												

Root Delay: 0.00244140625
Root Dispersion: 0.0046828125
Reference Clock: NIST
Reference Time: 3954495616.000000000
Originate Time: 3954495700.2242362
Receive Time: 3954495700.224972485
Transmit Time: 3954495700.224973863
Local Clock Time: 3954495700.2257605
Round Trip Delay: 1.523 ms
Local Clock Offset: 0.000025 s slow

No synchronization necessary on 04-25-2025
No synchronization necessary on 04-26-2025
No synchronization necessary on 04-27-2025
No synchronization necessary on 04-28-2025
No synchronization necessary on 04-29-2025
No synchronization necessary on 04-30-2025
No synchronization necessary on 05-01-2025
No synchronization necessary on 05-02-2025

132.163.96.2

22:03:35.891

Set Time

Stop Grid

Run Grid

Check Selected Server

Enter Server Parameters

Exit

Clicking a blue box shows a "common-view" comparison to two different sites.

Clicking a lab name is a direct NTP measurement to NIST

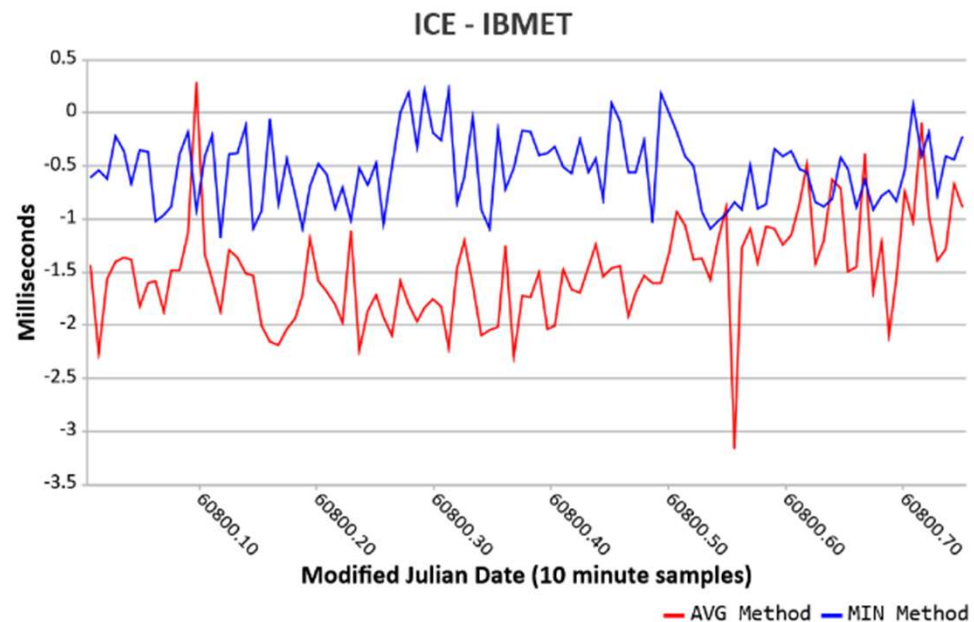
NTP MONITORING – "COMMON-VIEW"

Clicking a blue box shows
"common-view" with NIST as the
pivot (reference in common).

It is NTP from NIST to ICE
minus
NTP from NIST to IBMET

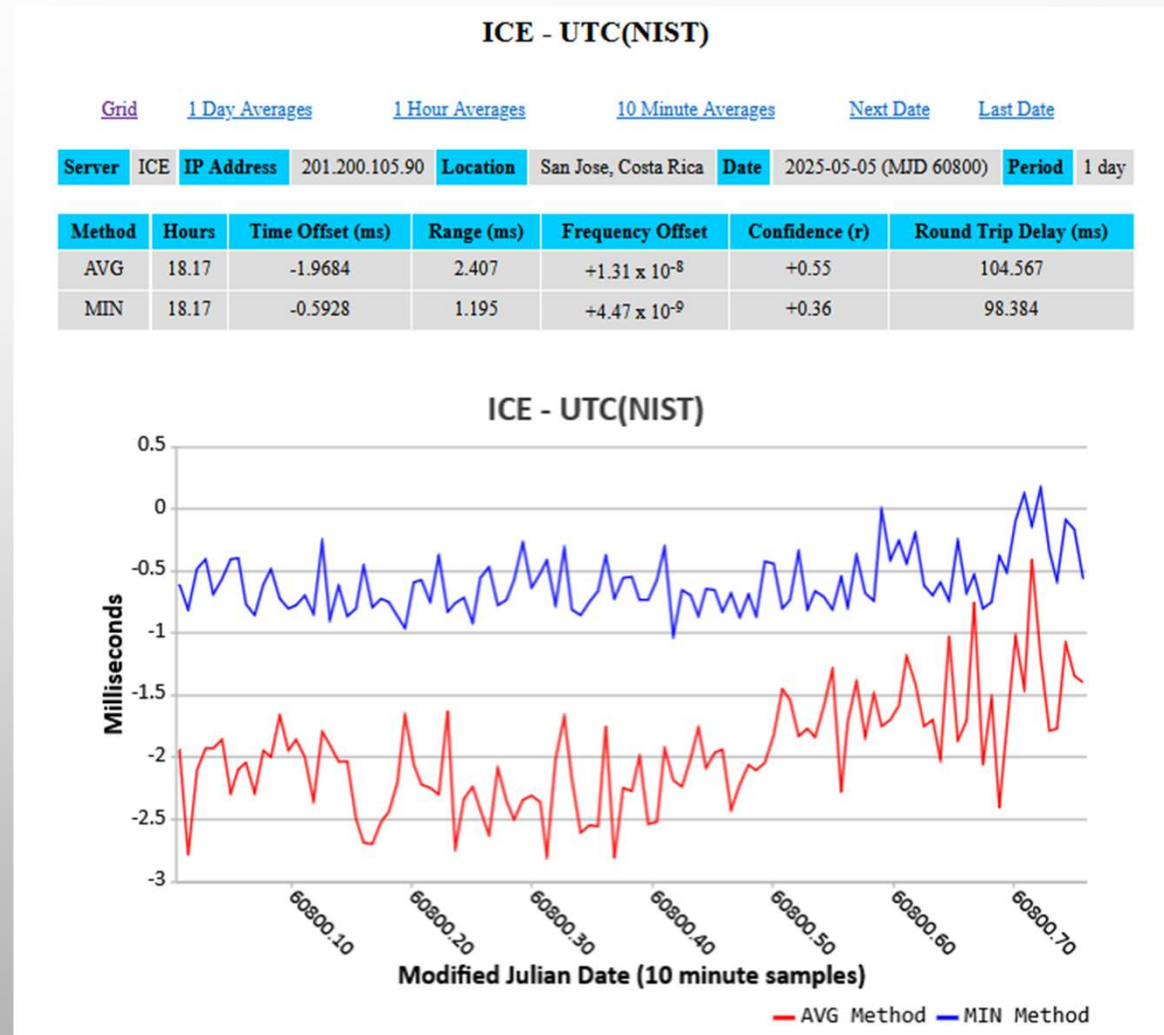
ICE versus IBMET via Common-View UTC(NIST)

Grid	1 Day Averages	1 Hour Averages	10 Minute Averages	Next Date	Last Date	Flip	
Server 1	ICE	IP Address	201.200.105.90	Location	San Jose, Costa Rica	Date	2025-05-05 (MJD 60800)
Server 2	IBMET	IP Address	181.115.177.125	Location	La Paz, Bolivia	Period	1 day
Method	Hours	Time Offset (ms)	Range (ms)	Frequency Offset	Confidence (r)		
AVG	18.00	-1.4927	3.440	+9.70 x 10 ⁻⁹	+0.38		
MIN	18.00	-0.5310	1.395	-9.69 x 10 ⁻¹¹	-0.01		



NTP MONITORING – MEASUREMENT GRID

Clicking a lab name shows a direct comparison of the NIST monitor to the lab NTP server.



ENTERING SERVER PARAMETERS

Enter NTP Server Parameters

Only the first 12 NTP servers will appear in the measurement grid.

Name	NIST	Address	132.163.96.2	Site	Boulder, Colorado
Name	AMAZON	Address	0.amazon.pool.ntp.org	Site	Cloud
Name	NRC	Address	132.246.11.227	Site	Ottawa, Canada
Name	CIM	Address	ntp.cim.gob.sv	Site	El Salvador
Name	ICE	Address	201.200.105.90	Site	San Jose, Costa Rica
Name	INTI	Address	ntp.inti.gob.ar	Site	Buenos Aires, Argentina
Name	INM	Address	ntp1.inm.gov.co	Site	Bogota, Colombia
Name	GOOG	Address	time4.google.com	Site	Cloud
Name	ONRJ-1	Address	200.20.186.94	Site	Rio de Janeiro, Brazil
Name	ONRJ-2	Address	200.20.186.75	Site	Rio de Janeiro, Brazil
Name	CENAM	Address	200.23.51.102	Site	Queretaro, Mexico
Name	IBMET	Address	181.115.177.125	Site	La Paz, Bolivia
Name	CNME	Address	190.143.214.252	Site	Guatemala City, Guatemala
Name	CNMEP	Address	200.46.54.209	Site	Panama City, Panama
Name	INACAL	Address	38.43.133.194	Site	Lima, Peru
Name	CMEE	Address	181.198.20.226	Site	Quito, Ecuador
Name	SP	Address	193.11.166.2	Site	Boras, Sweden
Name	ICE-1	Address	ntp1.ice.go.cr	Site	San Jose, Costa Rica
Name	ICE-2	Address	ntp.ice.go.cr	Site	San Jose, Costa Rica
Name	REF-UTC	Address	132.163.96.10	Site	Boulder, CO
Name	INDOCAL	Address	200.88.51.108	Site	Dominican Republic
Name	MS-WIN	Address	time.windows.com	Site	Cloud
Name	NPLI-1	Address	14.139.60.106	Site	India
Name	NPLI-2	Address	14.139.60.107	Site	India
Name	UTE	Address	200.40.248.50	Site	Montevideo, Uruguay
Name	BSJ	Address	66.249.155.4	Site	Kingston, Jamaica

Save Data ☐ ON

1 pps delay (ns)

Server used to set clock

Save

Cancel

MONITOR COMPUTER HARDWARE

Windows PC with Timing Module:
MicroChip bc635PCI-V2 PCI
Time and Frequency Processor



- 10 MHz TCXO (and external input option)
- 1 PPS input for sync
- 100 ns clock resolution
- Current time (days to 100 ns) can be accessed across the PCI bus with no PCI bus wait states (which allows for high-speed time requests)

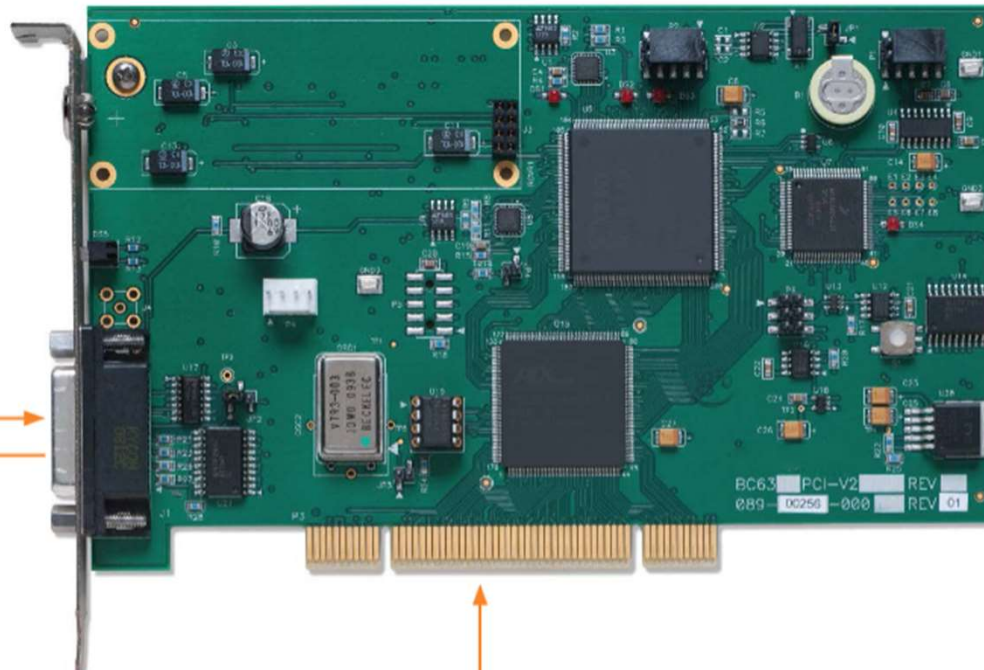
BC635PCI-V2 PCI TIME AND FREQUENCY PROCESSOR

Inputs

- AM time codes
- DCLS time codes
- External events (3x)
- 10 MHz
- 1 PPS
- GPS (bc637PCle model)

Outputs

- AM time codes
- DCLS time codes
- Programmable alarm
- (strobe/time compare)
- $\ll 1$ PPS to 100 MPPS rates
- 1PPS
- 1, 5 or 10 MPPS
- Oscillator control voltage



Over the PCI Bus

- Precise time
- Event interrupts
- Alarm interrupts (time compare/strobe)
- Programmable interrupt rates
- Configuration and control

A decorative graphic on the left side of the slide, consisting of a network of light blue lines and circles of varying sizes, resembling a circuit board or a neural network, set against a dark blue background.

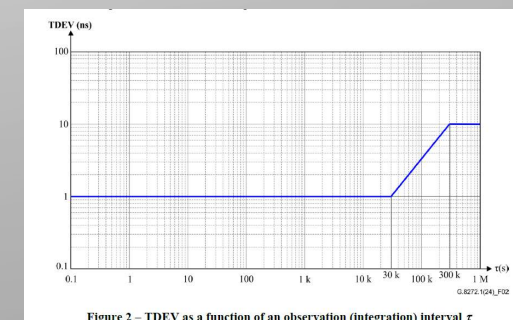
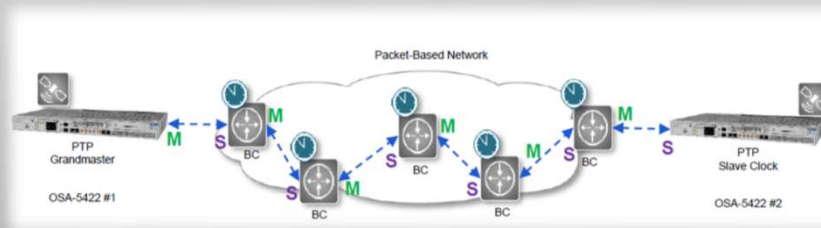
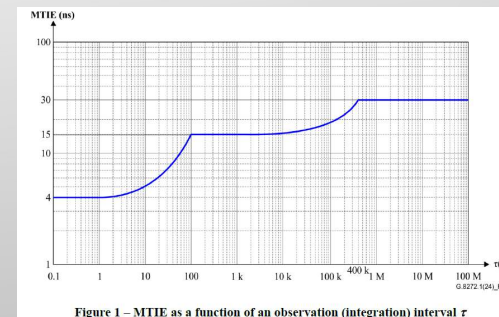
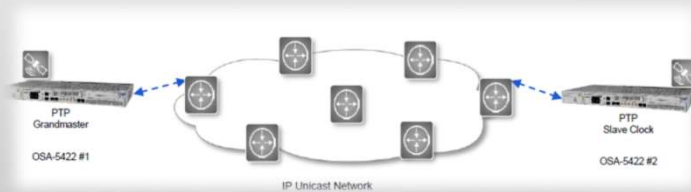
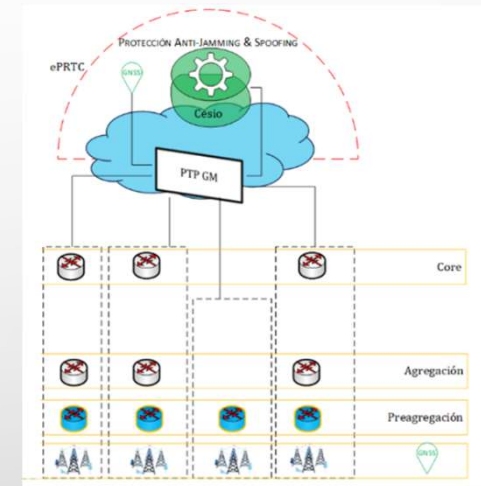
DISCUSSION ON PTP

(Open Forum)

BIPM - SIM UTC SUMMER SCHOOL 7-9 MAY, QUERÉTARO

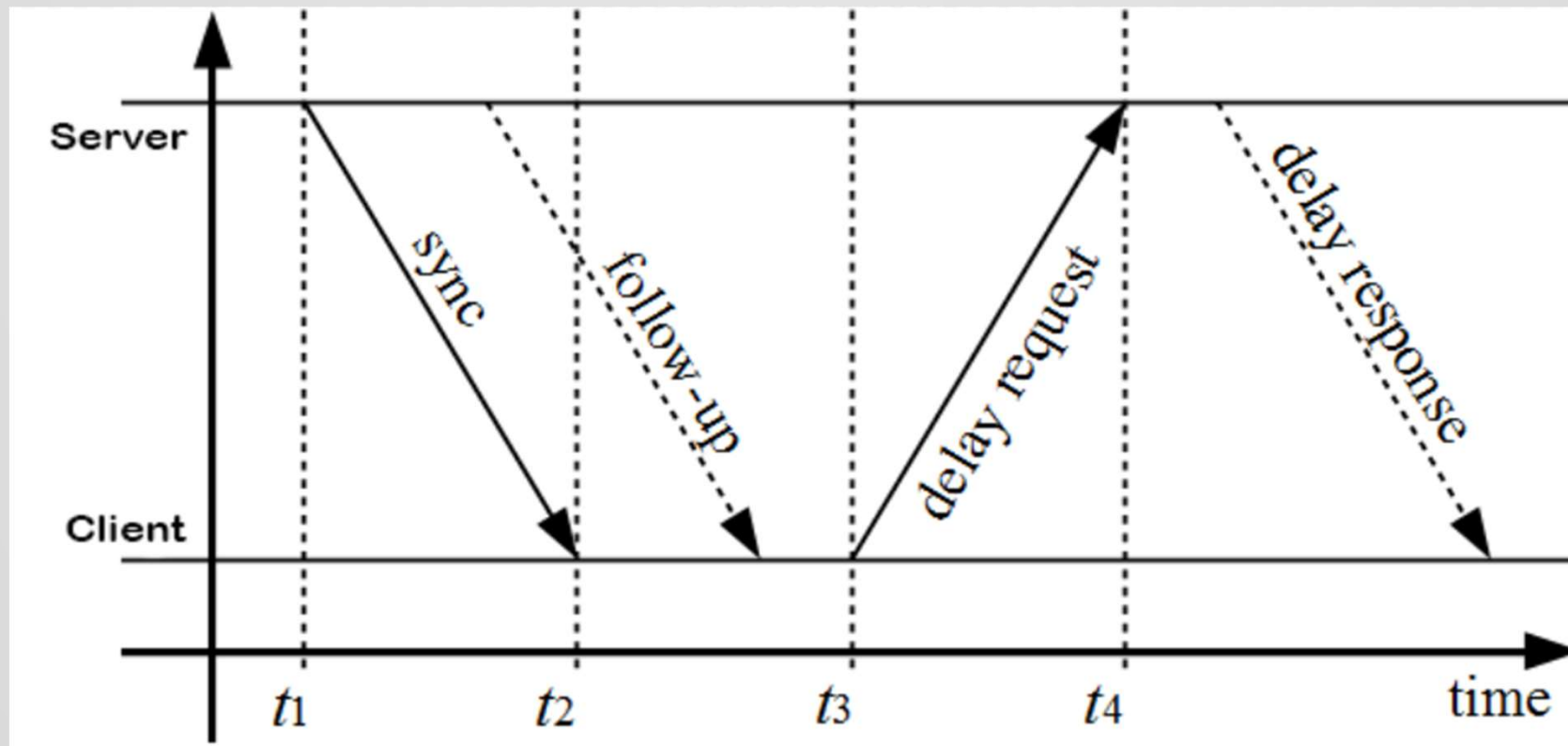
BRAINSTORMING

- NTP, PTP and Future Synchronization Requirements?
- Primary reference clock (PRC)
- Grand master
- Boundary clock
- Profiles (frequency, phase, time)
IEEE 1588 v2, G8265.1, G8275.1



PTP - PRECISION TIME PROTOCOL

IEEE-1588



NTP COMPARED TO PTP

NTP

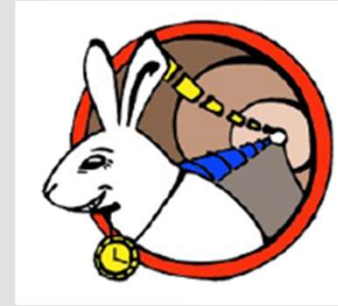
Software packets
Single transaction
Assumes symmetry
Used on wide-area network
On the order of milliseconds

PTP

Hardware measurements
Many times per second
Characterizes network/jitter
Used on local or private network
Can be nanoseconds

PTP is not much better than NTP on a wide-area network
NTP can be tens of microseconds on a local network

WHITE RABBIT



Synchronous Ethernet (SyncE) + PTP

Frequency transfer over physical layer ethernet or optical fiber.
Local oscillator in PLL with received frequency

Arbitrates PTP communications, adds enhancements

White Rabbit estimates link asymmetry

Can result in sub-nanosecond synchronization.