Choices for 5G Data center Synchronization

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Topics

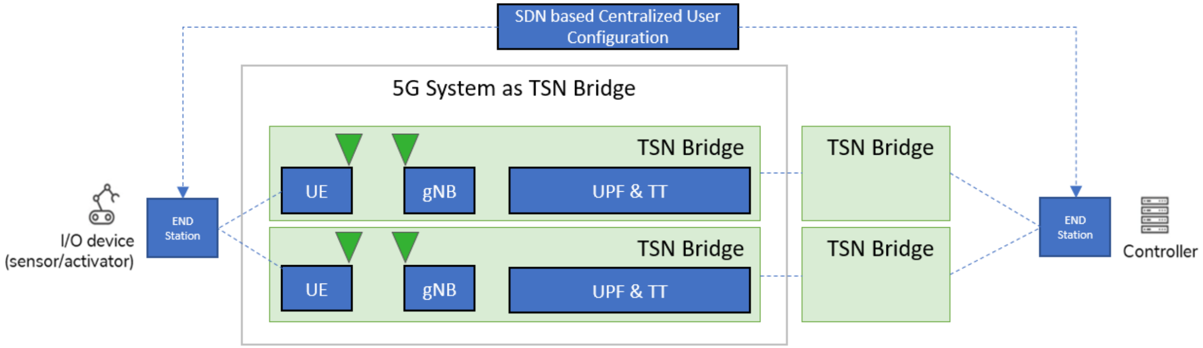
- Synchronisation scenarios
- Key performance parameters
- Choices of frequency references

Application Scenarios

- OCP – TAP community is defining the DC profile for IEEE – 1588
  - HRM

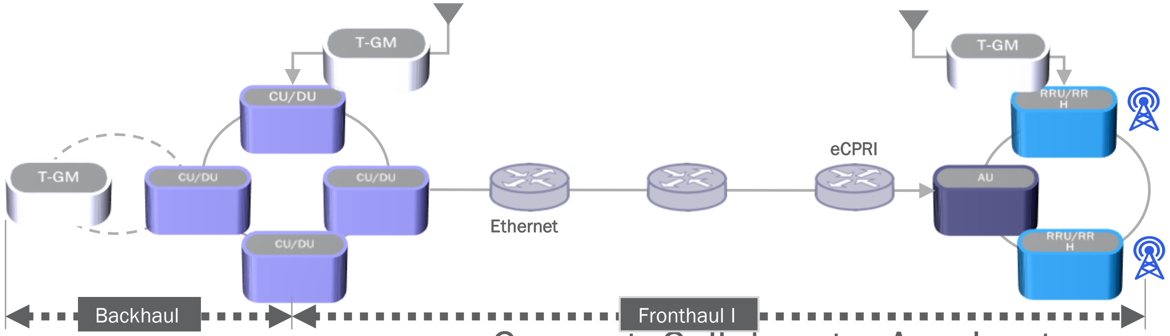
Reference Point	Limit
A	max|TE| ≤ 100 ns
B	max|TE| ≤ 250 ns
C	max|TE| ≤ 1000 ns
D	max|TE| ≤ 5000 ns

- 5G works as “TSN Bridge” for TSN applications
  - IEEE802.1-AS – 2020 with requirements



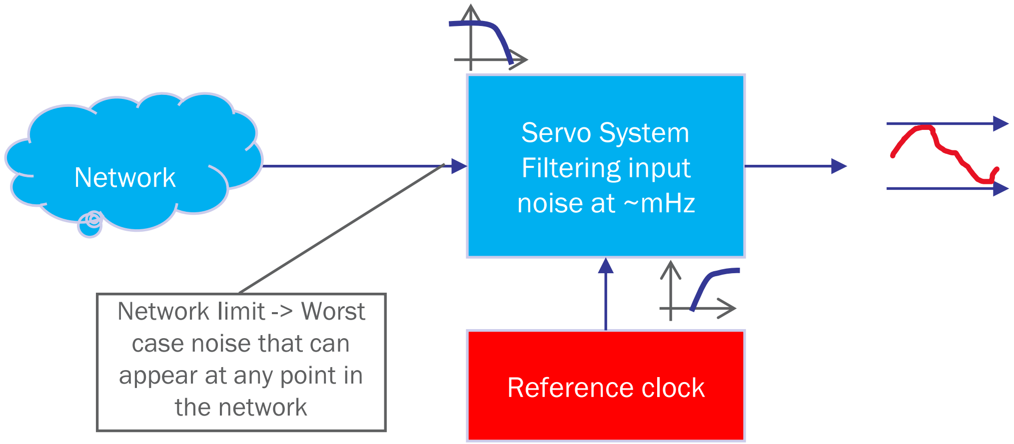
UE – User Equipment gNB – 5G nodeB UPF – User Plane Function TT –TSN Translator

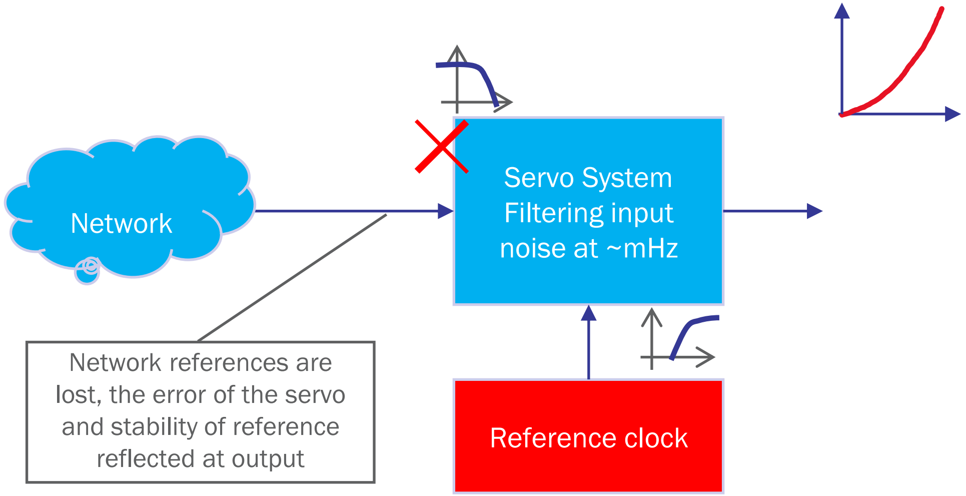
- 5G CU/DU functionality to move to data centers



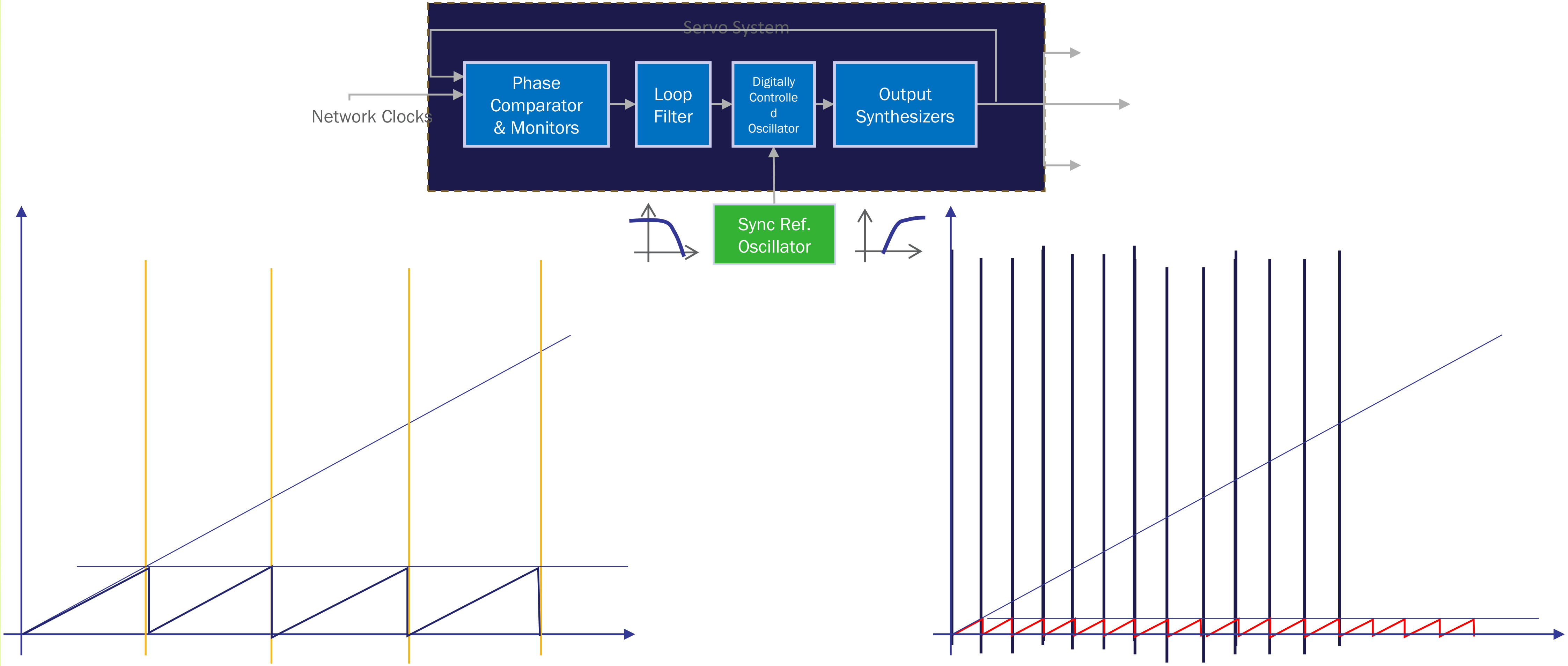
Key parameters for synchronization

- Dynamic Error => Filtered network noise + High Pass component of Oscillator error
- Holdover=> Ability to keep the output error within certain limits for certain time when references are lost





Dynamic Error



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Dynamic Synchronisation

- Radios (overall) – 40 to 400ns According to IEEE 802.1CM and ITU-T G.8271 specifications
  - The network side of the radio expects for 5-20ns error
- Switches deploy T-BCs Type C/D – 5ns to 15ns error
  - Front Haul requirements demand T-BC – Type C and D like clocks
- CU/DU equipment - T-BC with Assisted / Partial or Fully supported clocks – 5ns ~20ns
  - Multi-Band GNSS systems achieve ~20ns error values
- GM clocks – Uses GNSS reference - ~20ns
  - Multi-Band GNSS systems achieve ~20ns error values

- Loop bandwidth requirements of 10-75mHz on G.8262 like networks
  - Higher bandwidth for G.8262.1
- Loop bandwidths of 50-100mHz proposed by G.8273.2 like clocks
  - Assumes physical layer support
- Assisted
  - GNSS inputs require 10-30mHz filter
- Partial
  - Assumes no physical layer support - <1mHz loop bandwidth common
- GMs have GNSS references
  - GNSS inputs require 10-30mHz filter

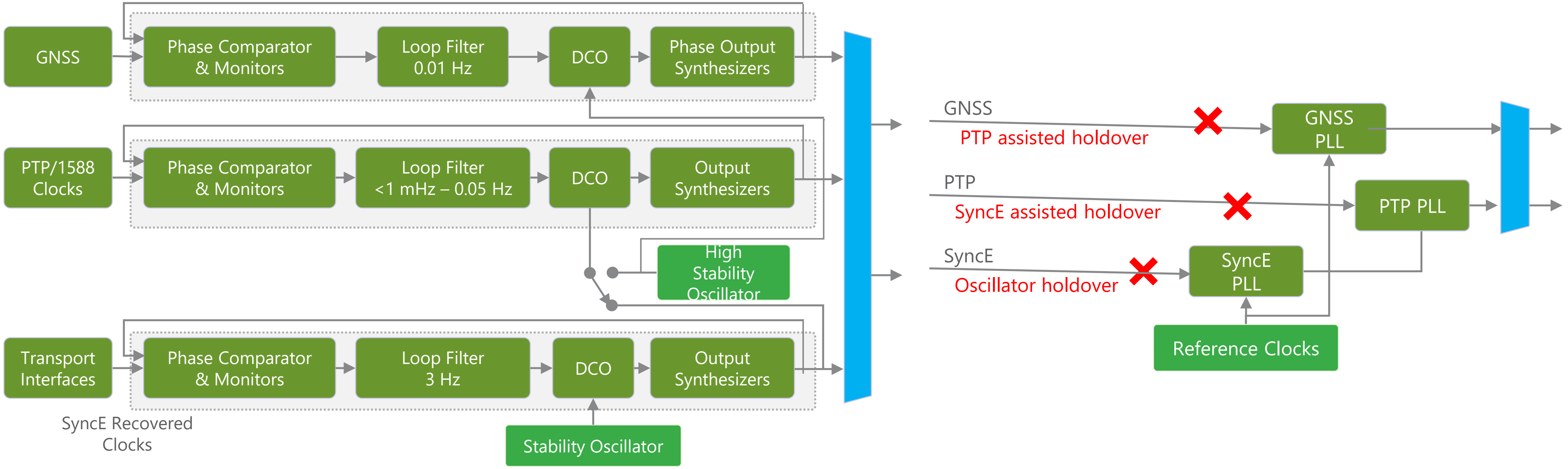
Requires an oscillator with ~0.1ppb/degC frequency sensitivity

Choices of references

- For handling dynamic performances

OCXO /HTCXO	TCXOs	Hybrid TCXOs	Mini-OCXOs
Frequency Vs Temperature Performance	±10 ~100 ppb (-40 to 105°C)	±5 - ±20ppb (40 to 85°C)	±8 ppb (40 to 95°C)
Footprint	**7 x 5 mm**	7 x 5 mm	9 x 7 mm
Frequency Sensitivity to temperature	5-10 ppb/°C	0.1 ppb/°C	0.1 ppb/°C

Holdover



$$\text{Phase Holdover}: x(t) = x_o + (f_o + \text{average}(\Delta f_{env} + \Delta f_{HT} + \Delta f_{RW}))*t + \tfrac{1}{2}* \Delta f_{age} * t^2$$

x_o= Initial phase offset
fo: The initial fractional frequency offset (ppb)

Δf_{env}: sum total of the changes in frequency (ppb) due to environmental factors (including temperature, input voltage, output loading, pressure, humidity, acceleration etc.)

$\Delta f_{Age:}$ Systematic deviation over time

Δf_{HT} : Effect of hysteresis on holdover

Δf_{RW}: Random frequency noise not associated with environmental effects or long term aging
Aging: The long term change in frequency over time (ppb/day)

Choices of references

- For handling Holdover

OCXO /HTCXO	Mini-OCXOs	SMART OCXOs	PPS DO
Frequency Vs Temperature Performance	±5 ppb (40 to 85°C)	±0.5 to 3 ppb (40 to 85°C)	±0.25 ppb (40 to 85°C)
Footprint	7 x 5 mm	25 x 22 mm	25 x 22 mm
Ageing performance	0.35 ppb/day	0.2 ppb/day	0.002 ppb/day
Holdover Performance (1.5us)	3-4 Hours	6-8 Hours	24 hours

Summary

- New applications drive high-performance synchronization systems
- Dynamic performance and Holdover are key parameters
- Depending on the requirements, a variety of synchronization reference technologies are available to select from

THANK YOU