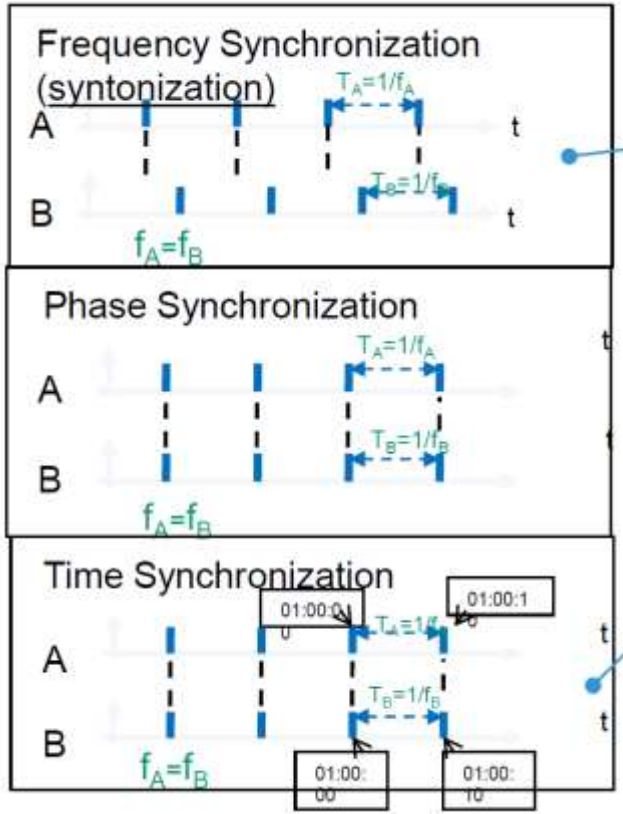
Samtöktun fjarskipta

Snorri Olgeirsson

Taktur og rauntími *(Fr/Ph/ToD)*



Gondola runs 45 times per hour

Train to London will leave at 12:35, 13:25,14:12...

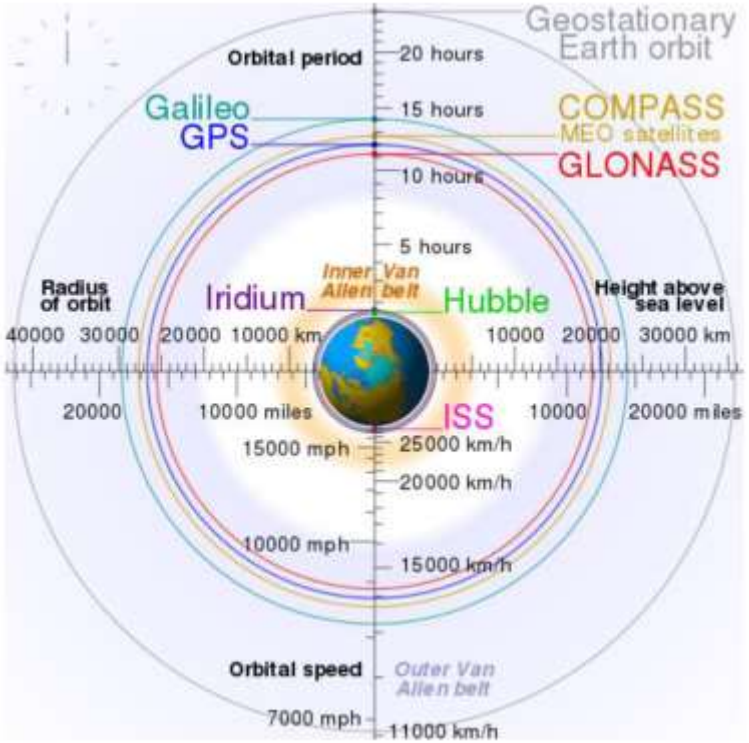
Hvaðan nálgumst við tímann ?

UTC – Co-Ordinated Universal Time

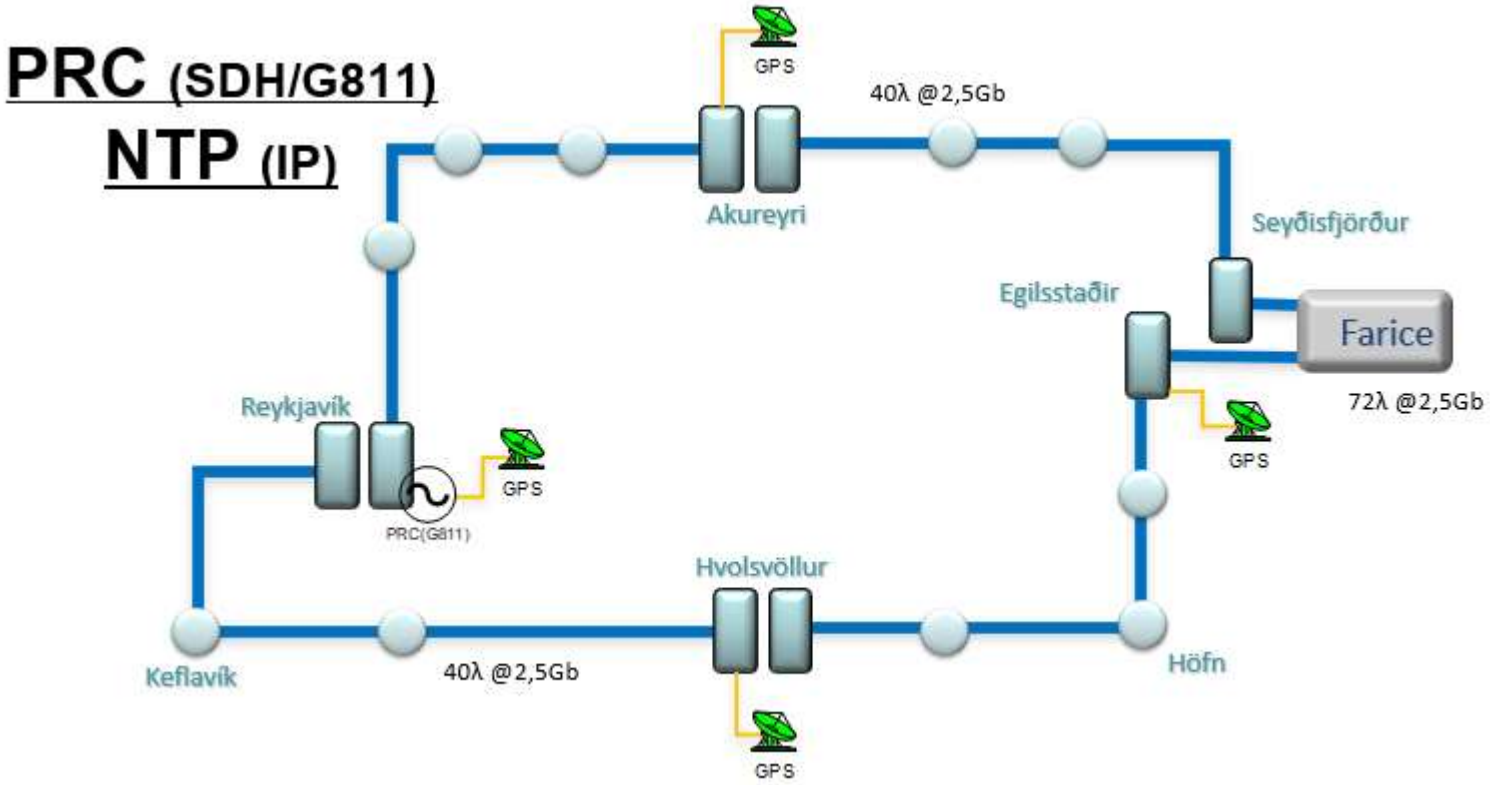
- TAI International Atomic Time
- Weighted Average of over 400 Atomic Clocks
- Over 50 National Laboratories Worldwide
- Leap Seconds Added

GNSS – Global Navigation Satellite Systems

- GPS, Galileo, BeiDou. GLONASS (IRNSS, QZSS)
- 20,000 km in the sky
- Traveling at 3.9 km Per Second

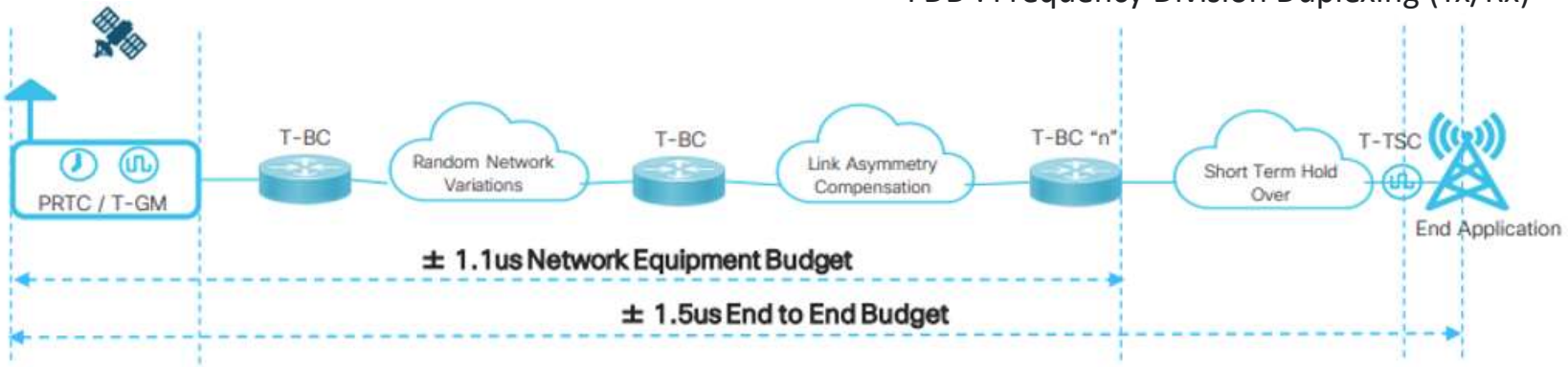


Samtöktun um aldamótin



Kröfur um rauntímaklukku í 5G

TDD : Time-division duplexing (Tx/Rx)
FDD : Frequency Division Duplexing (Tx/Rx)



G.8272
Class B PRTC ~ 40ns

G.8272.1
ePRTC ~30ns

G.8273.2
Class C T-BC ~ 10ns
Class C T-TSC ~ 10ns

G.8273.2
Class C T-TSC ~ 10ns

G.8273.2 / 802.1CM / eCPRI
$|TE_{RE}|$ = 15ns or 20ns

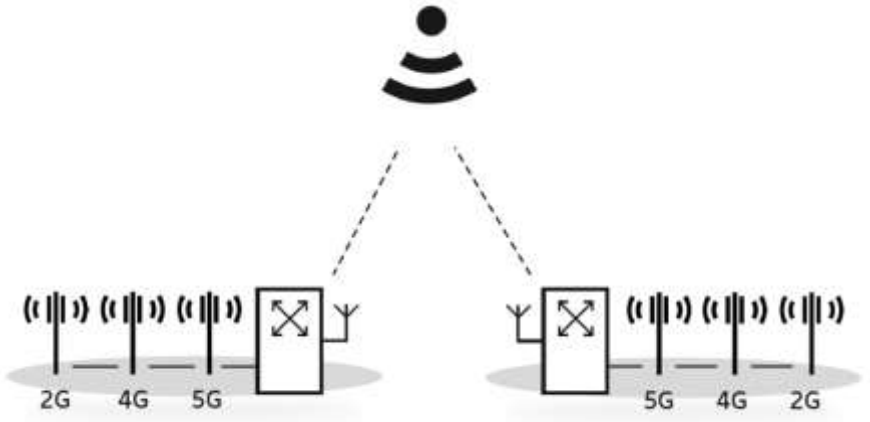
G.811.1
ePRC ~30ns

G.8262.1
eEEC – 7ns MTIE, 1ns TDev

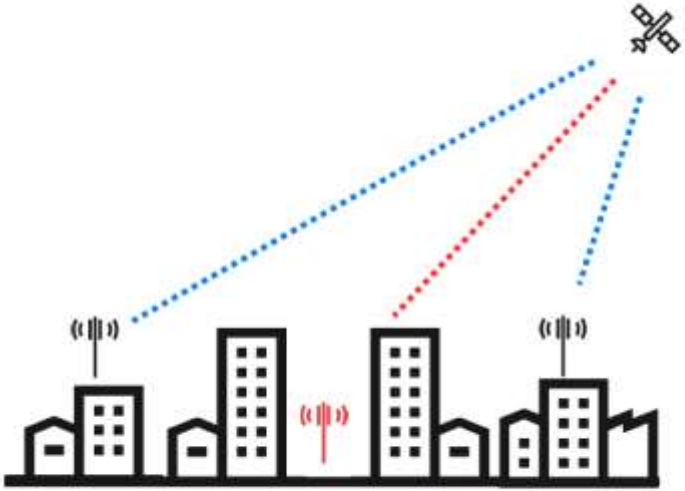
5G „Day 1“ : GNSS á öllum sendistöðum

- *Einn eða fleiri GNSS geta nýst samtímis*
- *Skilar nægilegri nákvæmni*
- *Ekki háð neinu stofnneti*

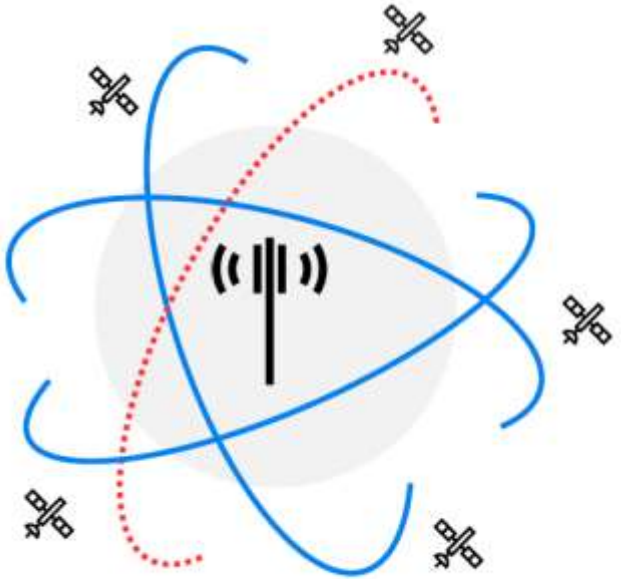
- **Þarfnast ætíð sjónlínu til GNSS og dreifileiðir til allra senda**



Áskoranir þegar einungis er stólað á GNSS



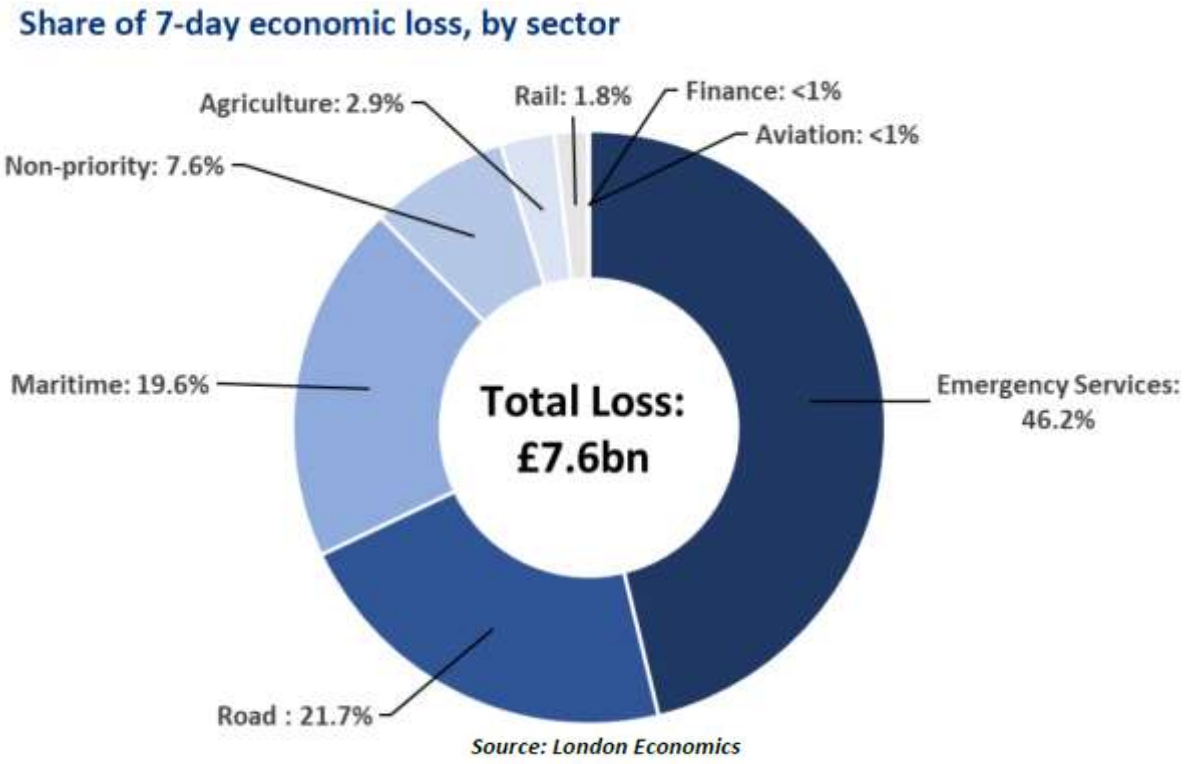
Performance in urban canyons



Jamming and spoofing on the rise

Hlutverk GNSS (PNT)

- *Staðsetning*
- *Leiðsögn*
- ***Tími***



Helstu áhættuþættir fyrir útfalli GNSS

- ***Veikleikar í móttakara****(Jamming/Spoofing/Meaconing)*
  Móttakari kaffærður/ fölsun /afvegaleiðing
- ***Umhverfisþættir***
  Sólstormar, geimdrasl, speglanir, tíðnitruflanir
- ***Mannlegir þættir***
  Vinna við jarðstöðvar, röng kerfisvirkni, miðlægar kerfisbilanir

Hvað ef GNSS bregst ?
Höfum við eitthvað sem getur gefið okkur réttan tíma ?

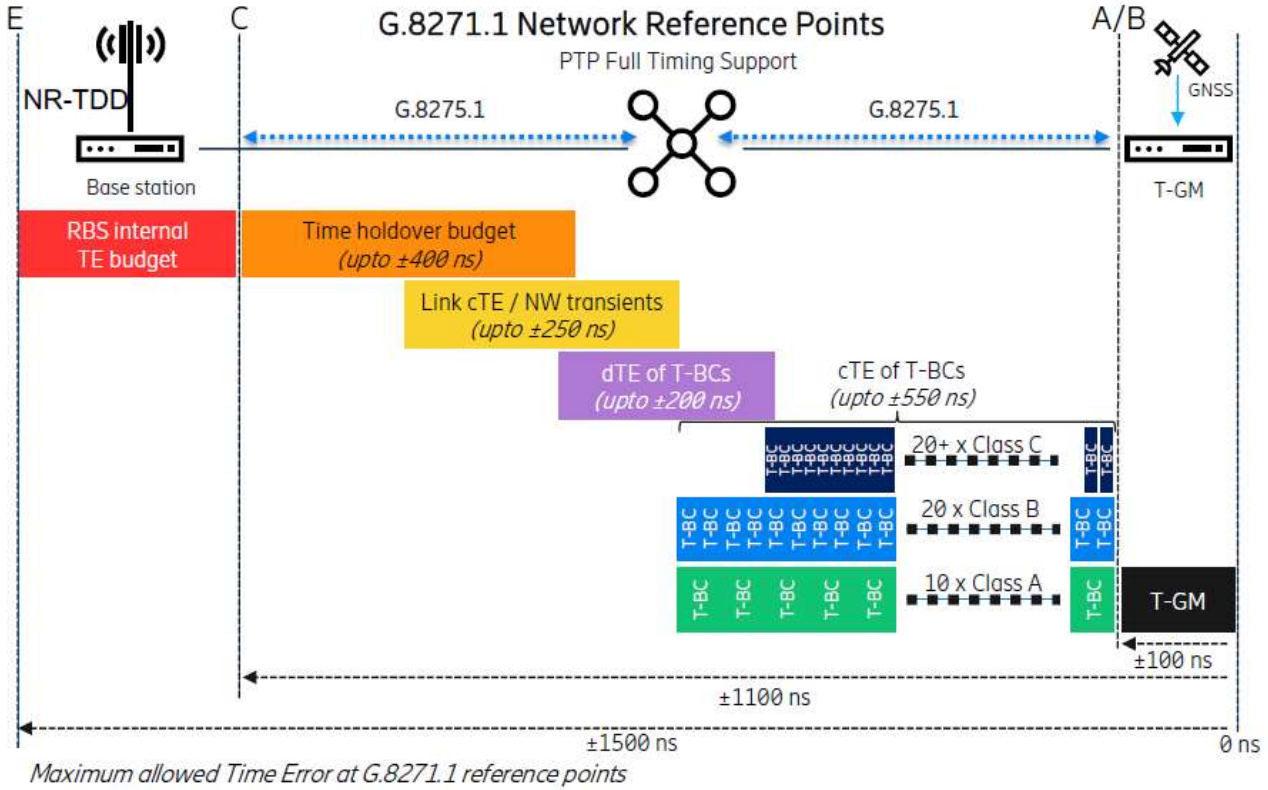
Technology	Accuracy
NTP timing servers (NPL)	≤ 1ms – 30ms
NPL MSF 60 kHz radio signal	10ms
PTP	10ns (1*10^-5ms) – 100ns (0.0001ms) – but dependent on network setup and clock used as a timing source
NPL-*Time*	100ns (0.0001ms)
eLoran	100ns (0.0001ms)
Locata	2.5ns (2.5x10^{-6}ms) – potentially much better
Omnisense S500	100µs (0.1 ms) – possibly up to 10ns (1*10^-5ms) in the future
Iridium STL service	Compatible with IEEE-1588 standards: 10ns-100ns

Tímanákvæmni staðgöngukerfa

Precision time Protocol (PTP)

- *Nákvæmni upp á 10-100ns*
- *Þarfnast burðarnets*
- *„Timestamping“ í búnaði, ekki í hugbúnaði eins og NTP*
- *Mikilvægt að tímauppsprettan komi ekki eingöngu frá GNSS, heldur þarf gott „holdover“ að vera til staðar*
- *G.8275.1 – Fullur tímastuðningur frá burðarneti*
- *Þarf helst Cesium taktgjafa sem uppsprettu með GNSS*

NR-TDD taktur sem byggir á PTP

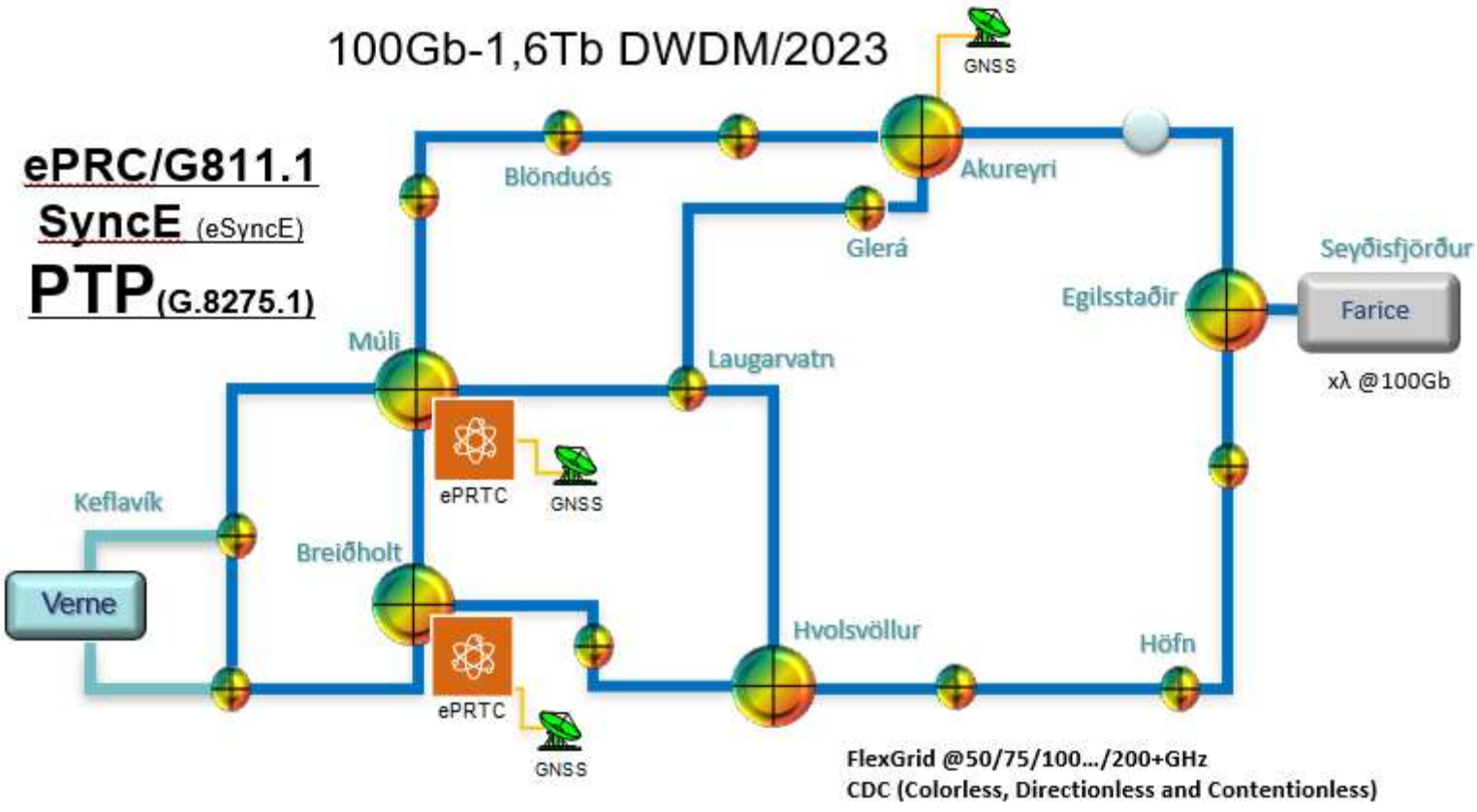


Maximum allowed Time Error at G.8271.1 reference points

Munurinn á takt og rauntíma

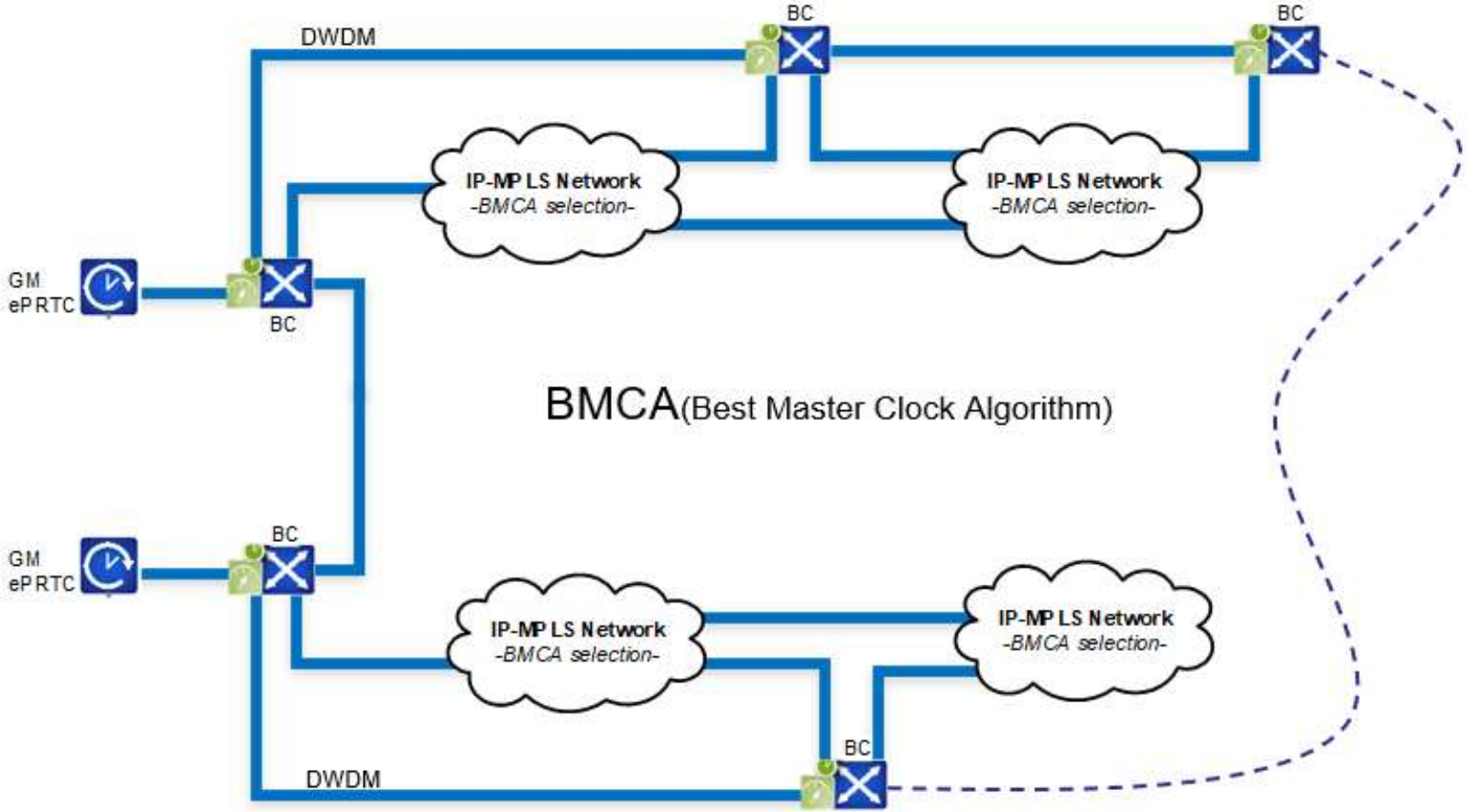
- *Mun auðveldara var að flytja takt yfir burðarnet*
- *Einnig mun auðveldara að viðhalda takti (holdover)*
- *Flutningur á rauntímaklukku kallar á sérhæft burðarnet og hönnun*
- *Heildar tímakröfur eru orðnar mun þrengri*

	200nsec	400nsec	1.1usec	1.5usec	5usec	10usec	16ppb
Quartz	1 hours	2 hours	4 hours	5 hours	8 hours	14 hours	1 month
Quartz HQ+	4 hours	8 hours	14.5 hours	16.5 hours	1.5 days	2 days	0.5 years
Quartz HQ++	10 hours	17 hours	1.5 days	2.2 days	4.4 days	6.6 days	>1.5 years
Rubidium	1 day	1.8 days	3.5 days	4 days	8 days	12 days	> 5 years
Cesium	3.1 days	4.6 days	12.7 days	17.3 days	1.9 month	3.8 months	∞
Cesium + GNSS	25 .2 days	43 .2 days	4.2 months	5.7 months	1.6 years	3.2 years	∞


100Gb-1,6Tb DWDM/2023
ePRC/G811.1
SyncE (eSyncE)
PTP(G.8275.1)
GNSS
Akureyri
Blönduós
Glerá
Seyðisfjörður
Egilsstaðir
Farice
xλ @100Gb
Múli
Laugarvatn
ePRTC
GNSS
Keflavík
Breiðholt
Verne
Hvolsvöllur
Höfn
ePRTC
GNSS
FlexGrid @50/75/100.../200+GHz
CDC (Colorless, Directionless and Contentionless)

OTC til að lágmarka ósamhverfu *(Optical Timing Channel)*

- *Halda sem mest sömu leiðum(path), lágmarka skipti yfir á lengri leiðir*
- *Vinna á lægsta lagi- óháð PDV vegna IP/Ethernets*
- *Nýta einn þráð til að útiloka ósamhverfu tengt vegalengd ljósþráða (Tx/Rx)*
- *Minnka „dispersion“ áhrif með víxlun tíðna*


DWDM
BC
BC
IP-MPLS Network
-BMCA selection-
IP-MPLS Network
-BMCA selection-
GM
ePRTC
BC
BMCA(Best Master Clock Algorithm)
GM
ePRTC
BC
IP-MPLS Network
-BMCA selection-
IP-MPLS Network
-BMCA selection-
BC
DWDM

Takk fyrir