ZDENEK CHALOUPKA @ TIMING SOLUTIONS LTD

DAVID FLEMING @ NSAI

BUILDING A NATIONAL TIMING GRID FOR IRELAND

TIMING SOLUTIONS – EXPERIENCE

- Timing Solutions Ltd is a start-up company hoping to introduce innovative ideas to the telecom market.
- Zdenek pronounced closely to [Stenek], yeah, I know...
- One man show, but more than 12 years of experience in telecom timing:
 - u-blox (GNSS chip vendor) Head of Timing Product team.
 - Common View Time Transfer feature design and implementation.
 - Timing reference infrastructure design using Passive Hydrogen Maser clock (algorithms & HW).
 - ITU-T Q13/15 Network synchronization and time distribution performance group delegate.
 - ESA Research Fellow
 - Next generation requirements for Galileo Services.
 - Delegate for ITU-T Q13/15 Network synchronization and time distribution performance group delegate.
 - 3GPP RAN and SA contributions.
 - EBTIC (BT managed research center) Senior Researcher
 - Timing and synchronization algorithms for 4G.
 - Contributing member of IEEE P1952 Resilient Positioning, Navigation, and Timing User Equipment Working Group. WG is led by US DHS.

CRITICAL INFRASTRUCTURE & GNSS

- Time and timing distribution has become increasingly important for Critical Infrastructure sectors such as communications, energy, transportation, emergency and financial services, and cloud data centers.
- The most common time distribution methods are: packet-based (PTP, NTP) over wire/fiber media, or GNSS using RF signals over the air. These two methods are usually used in combination as, for example, PTP/NTP is most often traced to a GNSS receiver.
- Due to this over-reliance on GNSS any GNSS failure could have a potential to adversely impact national economy. A study done in UK showed a price tag of £1 billion per day for a five day disruption*. The report assumes telecom networks have long holdover capabilities (> 5 days).



* HTTPS://LONDONECONOMICS.CO.UK/WP-CONTENT/UPLOADS/2017/10/LE-IUK-ECONOMIC-IMPACT-TO-UK-OF-A-DISRUPTION-TO-GNSS-FULLREDACTED-PUBLISH-S2C190517.PDF

GNSS THREATS

- GPS UTC Offset Anomaly January 2016 lasted 12-24 hours, introduced 13µs timing error, caused by a software bug. The reason why it took so long to find and recover:
 - Slow monitoring feedback loop.
- Galileo Broadcast data error July 2019 lasted 7 days, caused by several unlikely factors happening at the same time. The reason why it took so long to find and recover:
 - No operational backup available.
 - Slow monitoring feedback loop!

Event Summary Table

	Network Type	Region	Qty GPS Elements	Notes
Customer A	Fixed Line	UK	Large	Generated nearly 2000 alarms and standing condition events throughout duration
Customer B	Transport Comms	UK	Small	Customer in panic mode as systems in holdover
Customer C	Fixed Line	Global	Large	Nearly 2500 alarms generated during event. Roughly 40 elements entered holdover due to lack of backup inputs.
Customer D	Fixed Line	UK	Small	Element in holdover
Customer E	Transport Comms	UK	Small	TimeSource only systems. Caused local switches to go into free run.
Customer F	Mobile	UK	Medium	No adverse impact. All systems have backup network feeds and Rb clocks
Customer G	Private Network	UK	Small	System backed up by Caesium
Customer H	Mobile	UK	Medium	Difficult to determine number of affected elements but majority of elements have backup sync feeds taken from another Telecom operator.
Customer I	Fixed Line	Sweden	Medium	Affected all SSU 2000 units
Customer J	Mobile	UK	Medium	Some TimeSource inputs reporting high MTIE and MTIE alarms on SSU2000
Customer K	Mobile	UK	Medium	All SSU2000 disqualified GPS inputs. Systems reverted to line timing traceable to another carrier

Table: Chronos Technology, on-line https://www.gpsworld.com/world-dodges-gps-bullet/

WHAT CAN WE DO?

- There is a high number of independent Cesium atomic clocks in Ireland.
- In case of GNSS failure those atomic clocks provide a very long-term stability and would guarantee that over a 14-day period those clock would drift as little as 200 ns apart (if properly steered and conditioned).
- However, over a longer period of times those atomic clocks would inevitably drift apart, as there would be no common time scale available (currently provided by a GNSS, most likely GPS, to be specific).
- In case the GNSS provides inaccurate information (e.g. the incident from January 2016, where UTC derived from GPS was biased by -13 µs), atomic clocks could be affected too.
- Each individual atomic clock provides great value to its owner, but having them combined, or interlinked, would enable creation of a much more resilient timing infrastructure National Timing Grid of Ireland.

NATIONAL TIMING GRID – PHASES & BENEFITS

- In the "zeroth phase", we are looking for participants and contributors. Please spread the word: the more clocks, the better.
- In the first phase we assume the following services will be available for immediate benefits of the participants:
 - **Near real time tracking of stability** against other atomic clocks providing **early warnings** in case of performance degradation.
 - Direct traceability to UTC through UTC(NSAI) instead of UTC through GNSS (e.g., UTC(NIST) through GPS time).
 - PTP link stability evaluation.
- The second phase will focus on the following services:
 - Any feedback implementation (improvements) etc.
 - IEEE 1588 PTP links verification and monitoring.
 - Improved holdover in case of GNSS degradation through a common timescale observation and steering.
 - GNSS time stability observation (GPS, Galileo, BeiDou, GLONASS) and failure detection.
 - Improved robustness to GNSS failures and glitches.
- Third phase:
 - Any feedback implementation (improvements) etc.
 - Options for sub-nanoseconds time transfer: 1588 PTP WR links.

NATIONAL TIMING GRID – REQUIREMENTS

- What is required for the initial testing phase?
- Atomic clock (Cesium, or better). We could consider including Rb atomic clocks too, but their stability is too short to really benefit NTG.
- A high quality GNSS receiver with Common View Time Transfer capability (will be provided by Timing Solutions Ltd for free, if needed).
- A good antenna (L1/L2/L5 capable) with an unobstructed sky view.
- IPPS signal with 3V or 10/5/2.5/IMHz with IV RMS.
- Means to provision the data to NSAI/Timing Solutions Ltd., i.e., internet connection.

NATIONAL TIMING GRID – ARCHITECTURE



NATIONAL TIMING GRID – NTG NODE IN RACK IU FORMAT



NATIONAL TIMING GRID – NTG NODE IN SMALL FORM FACTOR



¹ Device receives IP using DHCP protocol.

² SMA connector is biased (actively powered to feed an antenna), please provide DC block if necessary.

³ Blinks when device successfully locks on GNSS signal and 10MHz input signal.

Dimensions: 45x68x93mm

NATIONAL TIMING GRID – LIST OF ACTIONS

- Call for participants and contributors! Please help spread the word: the more clocks, the better.
- Discuss internally:
 - Installation requirements: splitter/new antenna, internet connection options, cables and connector types (SMA/SMB/BNC/N).
 - Think about requirements for now and for the future.
 - Timeline equipment installation, site access, connectivity, etc.

NATIONAL TIMING GRID – SUMMARY

- NTG is to serve as a resiliency measure for timing and synchronization infrastructure.
- The NTG will bring the following services for immediate benefits of the contributors:
 - Near real time tracking of stability against other atomic clocks providing early warnings in case of performance degradation.
 - Direct traceability to UTC through UTC(NSAI).
 - PTP link stability evaluation.
- We are looking for contributors so spread the word, please.



Thank you for your attention!