Time transfer calibration and measurement data exchange in multi-domain fiber optic networks

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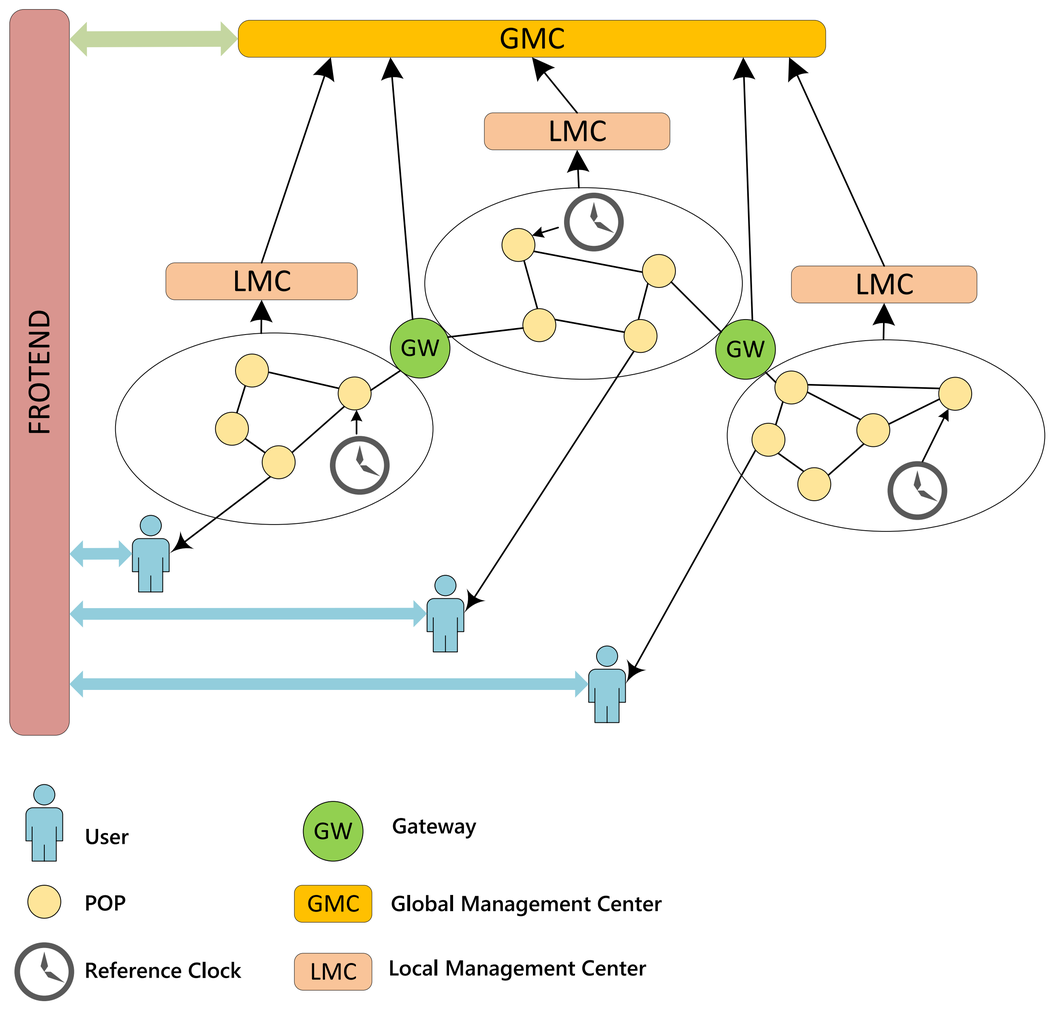
Introduction

Current fiber-optic time transfer systems make possible to achieve accuracy of distributed signals at the level of single nanoseconds and even tens of picoseconds. The continuous progress in the development of fiber-optic time signal transfer systems and clocks (including optical clocks) gives hope for further, significant, qualitative improvements in this area. Unfortunately, the comparison of distant clocks located in different networks brings many difficulties. Therefore, there is a need to develop a system for managing and monitoring these networks and for automatic exchange of calibration data. The proposed system is intended to enable the comparison of multiple remote time sources among themselves in near real time. These comparisons will be possible regardless of the implemented local time transfer solutions in a multi-domain environment - networks managed by separate institutions. End users will also not need to know the exact routing of individual physical connections and the standard of their implementation to determine the final accuracy and uncertainty of the measurement.

Data Exchange Scheme

Main assumptions

The model assumes that remote users (User X) compare their local clocks to the reference clock signal distributed in the relevant domain. Current calibration data (absolute link delay from the reference clock to a given user) will be available at the Local Management Center (LMC). The LMC should contain calibration data, as well as the accuracy and transfer uncertainty of all lines included in a particular time distribution domain. These values must also be updated in real time responding to any failures and dynamic changes in connection configurations. The LMC also includes current measurement data from individual network nodes (reference signal points of presence and regeneration points) as long as they are necessary to determine signal calibration between the reference signal and the end user. The LMC must also contain the same set of information on the connections between the reference clock and the signal exchange point with another domain (Gateway - GW). At the international (multi-domain) level, individual measurement and calibration data will be collected at the Global Management Centre (GMC). By exchanging information with trusted LMCs, the GMC will have full knowledge of the status of individual, cross-domain measurement sessions (status, calibration data, and measurement data). Requests for reservations of individual measurement sessions, reporting of the current status of a given session and provision of measurement data to correctly authorised and authenticated end users will be made via a dedicated frontend.



Functions of individual network blocks

Frontend:

- user authorisation and resource access allocation (scheduling of measurements, access to measurement data, reporting and receipt of tickets)
- access to real-time measurement data and the status of a given connection
- resource scheduling (booking of measurement sessions)

Global Management Center (GMC):

- gathering and processing of measurement data
- aggregation of measurement data from LMC for selected international connections
- update of the status of connections in the multidomain network
- the main source of information for the frontend

Local Management Center (LMC):

- provisioning services on demand
- gathering and processing of measurement data from local domain
- monitoring and updating particular connections status
- support in setting up backup connections in case of primary line failure
- updating of calibration data

Gateway (GW):

- connection point between two different time distribution domains
- requires measuring equipment that continuously records the relative differences of the signals transmitted in adjacent domains
- recorded data should be streamed to the GMC an LMC in real time

Impact

The presumed effect of the system is that multiple reference clocks can be compared with each other in near real time (limited only by data processing capabilities). It is assumed that the raw data will be available after only several seconds regardless of the distance and complexity of the physical connection between distant clocks. The same effect is expected in the case of time distribution to end users providing them traceability to a selected reference clock (even not located in the local domain). The advantage of this system is the ability to share aggregated and continuously changing calibration data without the necessity of sharing the entire physical signal path configuration between a pair of distant end users.

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