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Application Note

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Synchronisation of the Digital Telephony Network and the Plesiochronous Digital Hierarchy

INTRODUCTION

For the last several decades, the digital telephone switches, or exchanges, have been replacing the analogue mechanical exchanges.

Digital exchanges are more reliable than the analogue exchanges. But they must be kept in close synchronisation with each other, in order to maintain their performance.

For example, if the clock frequency of the transmitter exchange were running faster than the clock frequency of the receiver exchange, then some of the information transmitted would be lost. This phenomenon is referred to as slips.

SYNCHRONISATION OF THE SWITCHING NETWORK

To ensure that all the digital exchanges in the network are closely in synchronisation, either the mutual or master-slave synchronisation strategy is deployed.

In mutual synchronisation, each exchange clock is allowed to drift within tightly specified tolerances. If an exchange clock has drifted outside the mean tolerance of the other exchange clocks that it is connected to, then it autonomously adjusts itself to the mean frequency.

The mean stability of the mutual synchronisation network, and the exchange clocks, is referenced to a Primary Reference Clock (PRC) conforming to ITU-T G.811.

In master-slave synchronisation, timing of all the exchanges in the network is referenced or traced to one or a small number of master clocks, as shown in figure 1.

Each exchange clock is synchronised to a higher-level exchange clock that resides in a higher level of synchronisation. The highest-level exchange clock is synchronised to the master clock.

The number of synchronisation levels in the telephony network is generally limited to only three or four, as shown in figure 2.

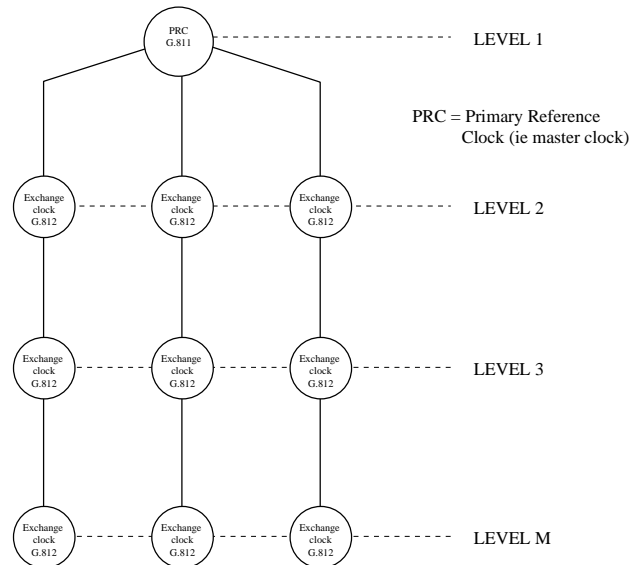


Fig 1: Master-slave synchronisation

The thick lines indicate that the clocks are connected together, and the thin lines are the standby synchronisation trails to the exchange clocks.

The exchange clocks in the national and regional layers are required to meet the performance specified in ITU-T G.812 for the transit clock, and the exchange clocks in the local layer are required to meet the performance specified in ITU-T G.812 for the local clock.

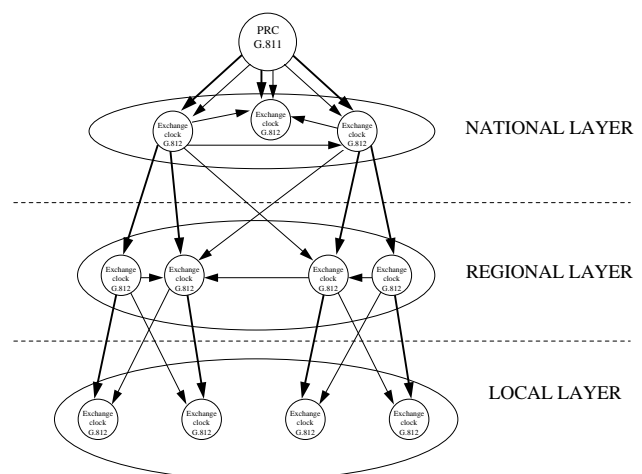


Fig 2: Hierarchy of the master-slave telephony synchronisation network

PLESIOCHRONOUS DIGITAL HIERARCHY

Since the digital exchanges are kilometres apart, they are connected together by optical fibre links. To increase the bandwidth of the optical fibre links, four 2.048Mbit/s signals from the public digital exchanges and Private Automatic Branch Exchanges (PABXs) are multiplexed together to form an 8.448Mbit/s aggregate higher order signal, as defined in ITU-T G.742, G.744, G.745.

Note that the bit rate of the aggregate output of the multiplexer is slightly higher than four times of the nominal bit rate of the tributary inputs. The reason is because the Plesiochronous Digital Hierarchy (PDH) multiplexer must cater for the highest bit rate variations of the tributary signals.

To compensate for the phase and frequency differences between the plesiochronous (i.e. nearly synchronous) tributary input signals and the (free-running) equipment clock of the PDH multiplexer, a bit justification (positive or negative bit stuffing) mechanism is used.

Redundant bits are inserted or exacted in the aggregate signal, on a per (multi) frame basis. The bit justification mechanism is also applied to the third order (34.368Mbit/s) and fourth order (139.264Mbit/s) PDH multiplexers, as defined in ITU-T G.751, G.753, and G.754.

An important point to note is that the phase and frequency characteristics of the PDH demultiplexed tributary signal closely resemble the characteristics of the pre-multiplexed tributary signal, i.e. $f_{n'} = f_n$, as shown in figure 3. Therefore the 2Mbit/s exchange signal, and the embedded exchange clock signal, is transparently transported over the PDH network.

Additionally, there is no restriction to the number of higher order multiplexing equipment that can be cascaded between the exchanges.

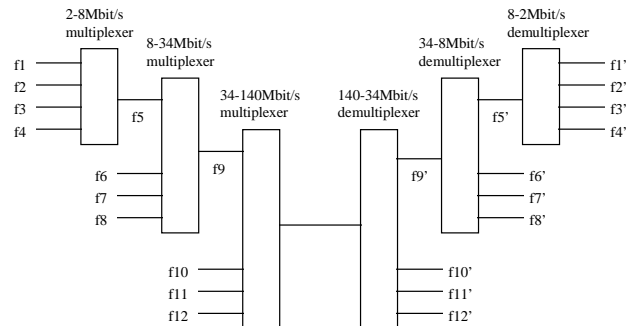


Fig 3: Plesiochronous digital hierarchy

DISTRIBUTED EXCHANGE SYNCHRONISATION

It is permissible for all the exchanges in the network to be synchronised from a (large) number of master clocks, conforming to the ITU-T G.811 specification. The introduction of the Global Position System (GPS), and other off-air systems, has made this a cost-effective option as shown in figure 4.

The OSA 5548 Stand Alone Synchronisation Element (SASE) is used as a low bandwidth slave clock to reduce the short-term deviation of the GPS receiver output.

It is however essential to include Cesium technology at the G.811 layer to ensure that the network reference is compatible with G.811 at all times, even in the event of total loss or degradation of GPS reception. This also provides telecom managers greater control of their synchronisation platform.

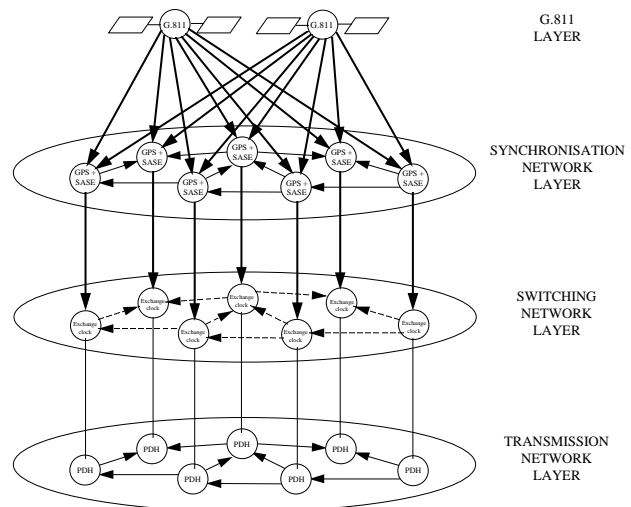


Fig 4: Distributed synchronisation using GPS

REFERENCES

- | | |
|---|--|
| ITU-T G.742, G.744, G.745
Second order digital
multiplexing equipment
operating at 8448 Kbit/s | ITU-T G.811
Timing requirements at the
outputs of primary reference
clocks suitable for
plesiochronous operation of
international digital links |
| ITU-T G.751, G.753
Third order digital
multiplexing equipment
operating at 34368 Kbit/s | ITU-T G.812
Timing requirements at the
outputs of slave clocks
suitable for plesiochronous
operation of international
digital links |
| ITU-T G.754
Fourth order digital
multiplexing equipment
operating at 139264 Kbit/s | |