3.4.4 Synchronisation Planning

Another important aspect of detailed transmission planning is the synchronisation plans. Usually networks are designed using mixed technologies (SDH and PDH). In mixed networks that do not have proper synchronisation planning, 'clicks' are heard owing to bit errors in the data service (see Figure 3.22). SDH networks themselves do not require any synchronisation for proper operation. The reason is that the SDH payloads are easily transferred within the network while the frequency differences can be taken care of by a pointer mechanism. Pointers provide the mechanism for dynamically accommodating the variation in phase of the multiplex section into which they are to be multiplexed. Thus, when both PDH and SDH equipments are present in the network, degradation takes place due to the pointer movements. If the synchronisation planning is done properly, then these 'clicks' due to bit errors disappear.

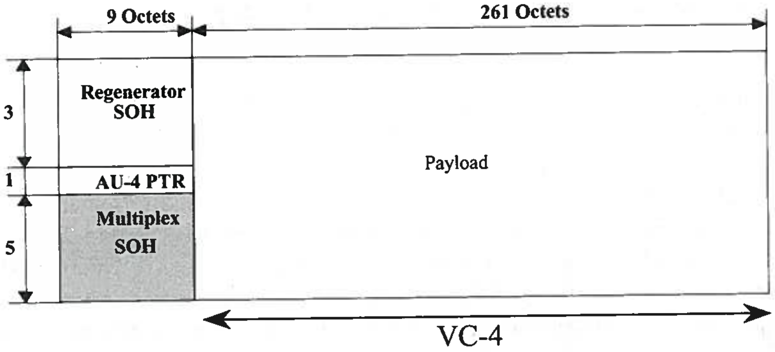

Figure 3.22 SDH frame for STM-1 interface. The frame size of an SDH frame is 260 (bytes) × 8 (bits) × 9 (rows) and the frame is transmitted $8000\,\mathrm{s}^{-1}$, so the payload bit rate is 149.76 Mbps. The first column in the virtual container is the VC-4 path overhead (POH) and the header consists of regenerator and multiplex section overhead (SOH) and AU-4 pointer fields

Another reason for the need for synchronisation is that there are equipments/systems other than the SDH and PDH in the network, such as base stations and other transmission equipments. The internal clock of these equipments is not very accurate, so external synchronisation is needed for movement of 'click free' calls through the network. The required accuracy for the GSM networks is of the order of 10^{-8}. The quality of the clock is important in determining the quality level of synchronisation within the network.

There are three clock levels recognised by the ITU-T G.803:

- PRC (primary reference clock)
- slave clock (synchronisation supply unit or SSU)
- SEC (SDH equipment clock).

The primary reference clock usually provides the clock for the whole network, thereby acting as the master. The accuracy of the PRC is very high – usually of the order of 10^{-11}. The specification of suitable clocks which can act as the PRC is in ITU-R recommendation

G.811. As the PRC is the master, it is advisable to have a redundant source (i.e. two PRCs, with one clock in standby mode). Caesium clocks are a typical example and are (usually SSU) highly accurate, but their high cost may be unacceptable in small networks.

Slave clocks are used in conjunction with the master clock. These clocks are always locked into the clocks of higher accuracy (e.g. caesium) through the network. They are also known as 'refresher clocks' because they may be used in long chains to refresh the timings. They also have the capability to stand in for the master clock if the latter is lost temporarily. The accuracy of slave clocks is of the order of 10^{-8} based on ITU-T recommendation G.812. The major advantage of such clocks is their low cost, but lifetime may be limited.

The SDH equipment clock has an accuracy of the order of 10^{-4} based on ITU recommendation G.813. Usage of such clocks is recommended for SDH networks. Mixed networks (that have PDH equipments) should not use this clock for timing distribution as it may degrade the signal quality.

Synchronisation Planning Principles

As cellular networks are *mixed* networks, they generally follow the master–slave technique of distributing the clock signal. In this method, a higher-level clock synchronises the lower-level clock. The latter further distributes the timing signal as shown in Figure 3.23. The MSC receives the clock from the PRC and distributes it to the BSC. The BSC then further distributes it to the base stations, which further distribute the timing signal.

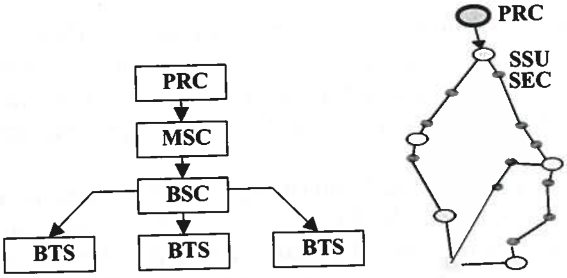

Figure 3.23 Clock distribution in a typical cellular network

Topology has an important place in synchronisation planning. Long chains of timing distribution should be avoided. There should not be more than 10 SSUs in the chain, and the number of SECs between two subsequent SSUs should not be more than 20. This implies that the maximum number of G.813 clocks in the synchronisation chain is 60, and the maximum number of G.812 clocks is 10.

If there are loops in the network, then engineers should make sure that there is no loop of the timing signal, to avoid a timing loop.

Synchronisation should be protected. There should be more than one source of the timing signal for each network element. The clocks should be derived from reliable sources such as SDH equipment, rather than from 2 Mbps signals from the leased lines whose accuracy is not known.

Implementation of the Synchronisation

The PRC is generally the source of the timing signal in a cellular network. The clock should be re-traceable back to the source. For loop protection, MCB and LCB bits in TS31 (or any other time slot) are used. If an MCB (master control bit) is used, this indicates whether or not the clock timing is based on the master, with '0' indicating that it is based on the timing sent by the master and '1' indicating that the timing is not based on the master. If synchronisation is based on the master–slave technique, then MCB '1' also indicates that there is some fault with the flow of the timing signal and the equipment is not receiving timing from the master. The LCB (loop control bit) would indicate '0' when there is the possibility of a timing loop, which means that if there is a loop topology in the network, the LCB would be '0' indication that the timing loop is not there (based on the principle of synchronisation planning explained above). As every element should have more than one clock source, so the LCB indicates from where the equipment should take its timing signal. So:

- MCB: 0 – signal is based on the master clock
- MCB: 1 – signal is based on some other clock (e.g. internal)
- LCB: 0 – synchronise slave from master, no possibility of timing loop
- LCB: 1 – do not synchronise slave from master (e.g. there may be possibility of a timing loop).

3.4.5 Transmission Network Management Planning

Network management systems (NMS) can be of many types. They may be able to manage the whole network or may be specifically for management of the transmission element. Generic applications of network management systems include network element (and configuration) management, security management, alarm management, performance and fault management.

Network element (NE) and configuration management functions may include controlling the NE, collecting and providing the data to the NEs. This function also makes integration of the NE to the network possible. The alarm management function enables the user to collect the alarms from the NEs. These alarms indicate the status of these NEs. The fault management function detects failures and schedules the correction of these faults, apart from testing and bringing back the faulty NE back into working condition. The generation of the performance behavioural reports of the network and its elements is done by the performance management function of the network. And finally, prevention and detection of misuse of the network from breaches of security is taken care of by the security management function of the NMS.

Network management functionality is based on master–slave protocols, and planning of the network management system starts with the choosing of the master. The NMS can act as the master and the NEs as the slave. Sometimes, network elements such as the base station controller or the base stations can also be the master. Once the master is defined, the management bus and its transfer method is decided. Then the next step is to decide the parameters for each of the network elements that the master will control.

Each master that is chosen has its own capability of managing a number of network elements. The capacity may vary from managing just a few NEs to hundreds of NEs. Apart