Synchronisation of networks using the Global Positioning System (GPS).

S. P. Drake

The Global Positioning System (GPS) is a space-based radio positioning system which provides suitably equipped users with highly accurate position, velocity and time data. This service operates globally, continuously and under all weather conditions. GPS receivers operate passively, thus allowing an unlimited number of simultaneous users. The satellites are placed in six orbital planes with four operational satellites in each plane. The satellite orbital planes have an inclination relative to the equator of 55 degrees and a height of 20,200 km (10,900 miles). The satellites complete an orbit in approximately 12 hours.

The satellites transmit on two frequencies: $L_1 = 1575.42 MHz$ and $L_2 = 1227.6 MHz$. The satellites transmit their signals using spread spectrum techniques, employing two different spreading functions: a 1.023 MHz coarse/acquisition (C/A) code on L_1 only and a 10.23 MHz precision (P) code on both, L_1 and L_2.

GPS is often seen as a navigation tool, but its uses can be much more widespread. In particular it can be used to determine the Universal Time Coordinate (UTC) to within 100 nanoseconds. As a consequence, a network, spread over the entire globe, can remain synchronised efficiently and cost effectively.

The motivation for synchronising a network is two-fold; one is to facilitate frequency hopping, another is to allow time division multiple access (TDMA).

In frequency hopping networks messages are transmitted in a broad spectrum by hopping rapidly, in a pseudo-random manner, through a range of frequencies. Unless the frequency hopping pattern and rate are known such transmissions are very difficult to intercept or interfere with. However, in order for this to work effectively, all members of the network must be synchronised. Failure to synchronise means that receivers are at the right frequency but at the wrong time.

Time division multiple access networks are used when groups of users are on the same network, but are not necessarily talking to each other. In such a case, time is divided into frames; each time frame is then divided into time-slots. Every group in the network gets a certain number of time-slots within a frame. If network members are not synchronised with the network they will not be able to determine which time-slots are theirs.

This work evaluates the operational impact of integrating GPS as a synchronisation tool into data-link networks. This is done by calculating the probability that a network will remain synchronised with and without GPS. Using this information it is possible to determine the maximum possible hop rate for frequency hopping networks. Similarly it is possible to ascertain the minimum period for time-slots in time division multiple access networks.