TIME SCALES ALGORITHMS AND CLOCK PREDICTION

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The definition of the unit of time, the second, of the International System of units (SI), in terms of the hyperfine transition of the Cs-133 atom, allows its experimental realization at the level of 3E-16. That definition has been serving well to the international community since 1967. Primary cesium atomic clocks have improved their accuracy about one order of magnitude per decade, making the time measurement the most accurate measurement of the humankind. The combination of the operation of a number of atomic clocks is of great interest for several reasons. Time scales for critical applications, like national official time, navigation and telecommunications, requires reliability, accessibility, stability and accuracy. To meet these requirements, and considering that single clocks can fail in any moment, it is highly recommended to generate time scales in base of multiple clocks and thus be independent on the operation of any single clock. These ensemble time scales are generated from a series of time difference measurements performed between pairs of clocks. It is expected that the metrological characteristics of such composite clocks, virtual or physical, be superior to those of any individual clock in the ensemble. Because there are many different applications for time scales, there is no unique “best” time scale algorithm. This fact is well illustrated by the international time reference UTC produced by the *Bureau International des Poids et Mesures* and the national time scales UTC(k). The UTC scale is a virtual ensemble time scale (it has no associated physical signal) that is produced by use of a post processing scheme that has delays in its calculation that are imposed by the need of a time scale that must be very stable in the mid and long term (one month and larger). On the other hand, national UTC(k) time scales are local time scales that generate a physical signal in real time. Thus, UTC and the various UTC(k) time scales serve different applications, and different criteria are emphasized in their design. These criteria include the models used to predict clock behavior, the weighting procedure, the periodicity to compute the time scale, the way that clocks are added to and deleted from the ensemble, and so on. Algorithms to combine the operation of atomic clocks play a critical role to successfully combine the operation of atomic clocks depending on the application. Since about a decade, optical clocks have shown a superior accuracy respect to the Cs clocks. The development of new time scales algorithms to combine Microwave atomic clocks (Cs clocks and Hydrogen Masers) with optical clocks, spread on a very large geographical areas, is a very important issue to be addressed prior to adopt a new definition of the unit of time of the SI in terms of an optical atomic transition.