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Development of a Secure, Precise, and Traceable Source of Time for Industrial and Financial Applications

John Bernard*, André Charbonneau, Bill Hoger, Hai Pham, and Marina Gertsvolf
National Research Council, Ottawa, Canada

Extended Abstract

There is a growing demand from sectors such as telecom, utilities, finance, and the military for accurate and precise time synchronization. Improved levels of service, new services, and a tightening of regulations have pushed the requirements for time synchronization to levels below 1 microsecond. Whereas in the past, synchronization within an isolated system was adequate, systems today are interconnected and this has led to a demand for accurate timing against a common reference timescale. This is particularly important in the areas of finance where the auditing of high-speed stock trades and other financial transactions has led to new regulations and requirements for high-accuracy time-stamping of trades with traceability to Coordinated Universal Time (UTC).

For many years, National Metrology Institutes (NMI) have been responsible for keeping and disseminating official time in their respective countries. These timescales are disseminated in real time and are designated as UTC(*k*) where *k* refers to the name of the NMI. Each NMI operates atomic time standards which are synchronized to UTC through an exchange of two-way satellite messages or, more commonly, through GNSS common-view observations. The Bureau International des Poids et Mesures (BIPM) combines data submitted from many atomic clocks around the world to produce UTC and publishes the offsets, UTC-UTC(*k*). In this way UTC(*k*) can be traceable to UTC with an uncertainty of under 10 nanoseconds.

The National Research Council (NRC) keeps official time for Canada, UTC(NRC), which it disseminates by a variety of means. However, unknown and variable propagation delays have limited the uncertainty in the traceability to UTC(NRC) at remote sites to 1 millisecond, or worse, far from the emerging requirements of industry and finance. The NRC Remote Clock has recently been developed to satisfy these new demands for accurate and traceable time. This device uses methods similar to those that have been used by NMI's for many years to synchronize their national timescales to UTC. It consists of a high-quality rubidium time and frequency standard, a GPS receiver, a time interval counter, a control computer, and several auxiliary control systems for complete remote control. The Remote Clock is installed at the client's site and provides standard frequency (5 or 10 MHz), 1PPS, and timecode outputs that are suitable for feeding time and frequency servers and are traceable to UTC with uncertainties below 1 microsecond. A similar system is located at our main time laboratory at NRC. The rubidium standard in the Remote Clock is synchronized to UTC(NRC) through GPS-common view observations. Common view data from our laboratory at NRC are uploaded to the Remote Clock every few minutes and combined with similar data acquired by the Remote Clock to ensure synchronization of the two timescales. Careful calibration and control of the rubidium standard provides a holdover uncertainty of less than 200 nanoseconds for periods of up to 8 hours in case of loss of the common-view link. The Remote Clock is controlled and monitored in our laboratory through a secure internet connection. Watch-dog processes continually monitor the generated timescale and watch for disruptions or degradation in the GNSS signals or other anomalous behavior. The Remote Clock can take corrective action in case of a problem and alerts can be issued to both NRC and the client. Our tests have demonstrated that the Remote Clock is capable of providing precise and traceable time at remote locations with an uncertainty limited primarily by the calibration of the GPS antenna/receiver system. An uncertainty of less than 50 nanoseconds is achievable after careful calibration of all components.