Re: Variations on XTAL clock AND time synchronization

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Date: 02/19/05

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>Jerry G.,
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>Thank you for your valuable answer.
>In a project I need to have time synchronization between a set of computers
>where some of them are networked together on a LAN (no internet) and some
>others are running stand alone. I am planning to use the
>one−pulse−per−second (1PPS) signal from the GPS receivers. The networked
>computers will have one GPS receiver and all the other stand alone computers
>will have their own GPS receivers. GPS receivers will generate 1PPS signals
>to interrupt the computers to set their internal time clocks. Applications
>will use the computer timer (get the time of the day). I want to model (some
>how, but I do not know how) the probable variation that a computer clock may
>have between 1PPS signals.

For those computers which are LAN'ed together, you should certainly consider running NTP. The commonly−used "ntpd" daemon for Unix and Linux and etc. will handle the inter−system coordination, and also has drivers for most GPS and similar external clock systems (including the PPS input).

The PPS pulses are infrequent enough, and subject to enough jitter, that the drivers will need to do a fairly significant amount of low−pass filtering before using the pulse information to calibrate the internal clock.

>Would anyone comment/argue/recommend/suggest/propose how one can model the
>variation on a PC clock frequency ?

As I understand it, you're going to be dealing with at least two separate "clocks" per PC.

One is the on−board date/time−of−day clock chip, which is typically driven by (or drives) a 32.768 kHz quartz low−power "watch crystal". These usually seem to have accuracies in the 10−15 seconds per month range, like a cheap wristwatch. This part of the hardware is designed to provide a coarse setting of the date and time when the system is booted, and as I understand it the interface to the chip usually does not provide a way to read or set the time to any precision greater than +/− 1 second.

The other is the system's main CPU or bus oscillator, which is divided down and generates interrupts at a predictable rate (many per second) and/or is used to run a high−speed counter within the CPU itself. This is also a quartz−crystal oscillator. It has a higher readout precision than the clock chip, but you have to be careful about using it... if you try to track the time−of−day by counting clock interrupts (as I believe Linux does) you can "lose time" if another device driver, or the BIOS itself, locks out interrupt processing for more than a few milliseconds.

These two clocks/oscillators are not correlated with one another as they're driven by separate quartz crystals. Both are subject to error and drift due to temperature changes, but there's no guarantee that the two crystals have identical or even similar temperature coefficients of change.

The Unix "ntp" daemon software is able to estimate a given system's amount of clock error and keep a record of the amount of drift (in parts per million), and will load this value and use it to tweak the clocking when the system is booted.

As to modelling the error you see on a PC's clock: you're going to have to deal with several sources of error. To a first approximation, you can consider the PPS data to be "short−term jittery, but long−term stable". The 60 Hz powerline frequency is similar... jittery in the short term due to noise, somewhat drifty over the course of a day, but quite stable in the average over the long term.

The PC's quartz crystal oscillators are probably at about the opposite end of the spectrum − quite stable in the short term, with a fairly constant amount of error (in PPM) in the long term, and some amount of temperature−related drifting around in the middle.

You might find it useful to review the information on Brooks Shera's page at http://www.rt66.com/~shera/index_fs.htm − he discusses the construction of a system which uses a GPS receiver's PPS signal to discipline a high−stability quartz crystal oscillator.

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