A simulated model for distribution of precision time signals using wireless mesh networks

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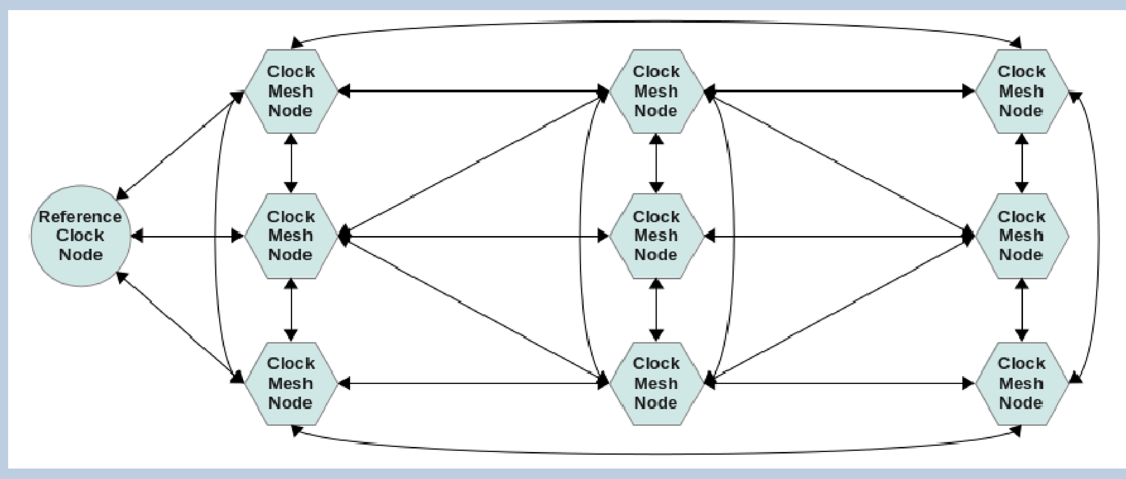
Problem

A key technological component for the development of low cost and easily deployed radio interferometer arrays is a means of distributing a highly precise and stable atomic clock signal. In this research we are going to build a simulated model for a wireless mesh clock distribution. A model will be developed to allow the prediction of wireless clock mesh network performance for precision time and frequency distribution.

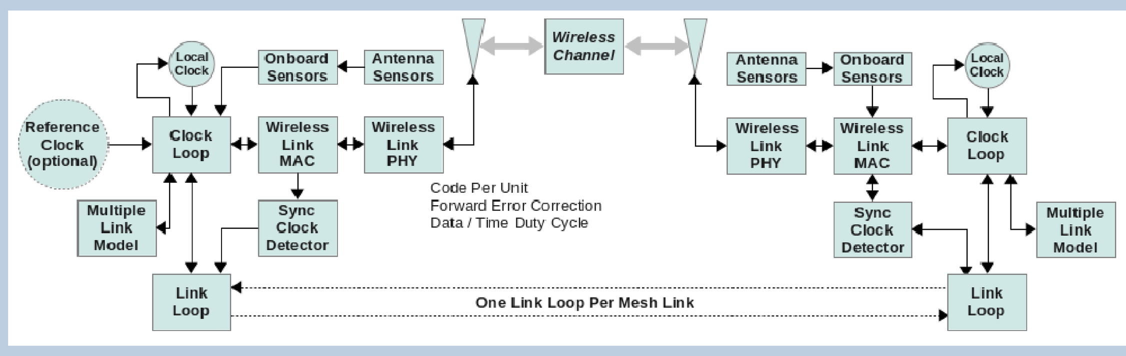
Mesh Clock Network

The model will be used to investigate : Synchronization quality under realistic conditions; the impacts of channel variations on clock synchronization; modulation, control loop, and error correction techniques; the effect of different clock/data capacity tradeoffs; methods for combining information from multiple links; loop tunings for specific patterns of environmental variation.



Clock Mesh Unit Link

The model will allow the evaluation of different modulation, error correction, and feedback methodologies as well as simulation of the effects of transceiver, antenna, and channel variations. It will produce performance metrics such as the distribution in alignment times between clocks, oscillator phase noise, and oscillator first and second order Allan variance.



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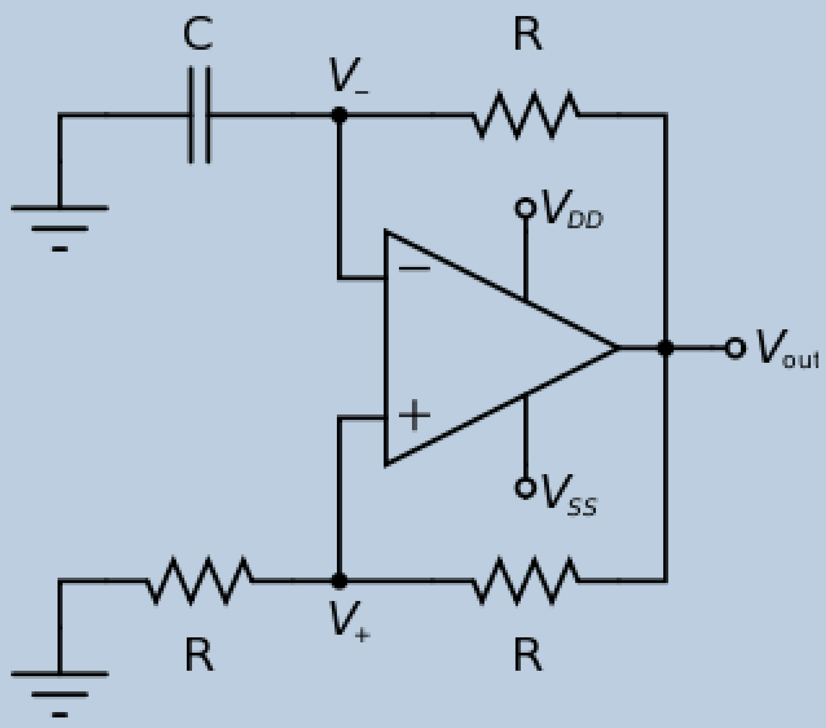
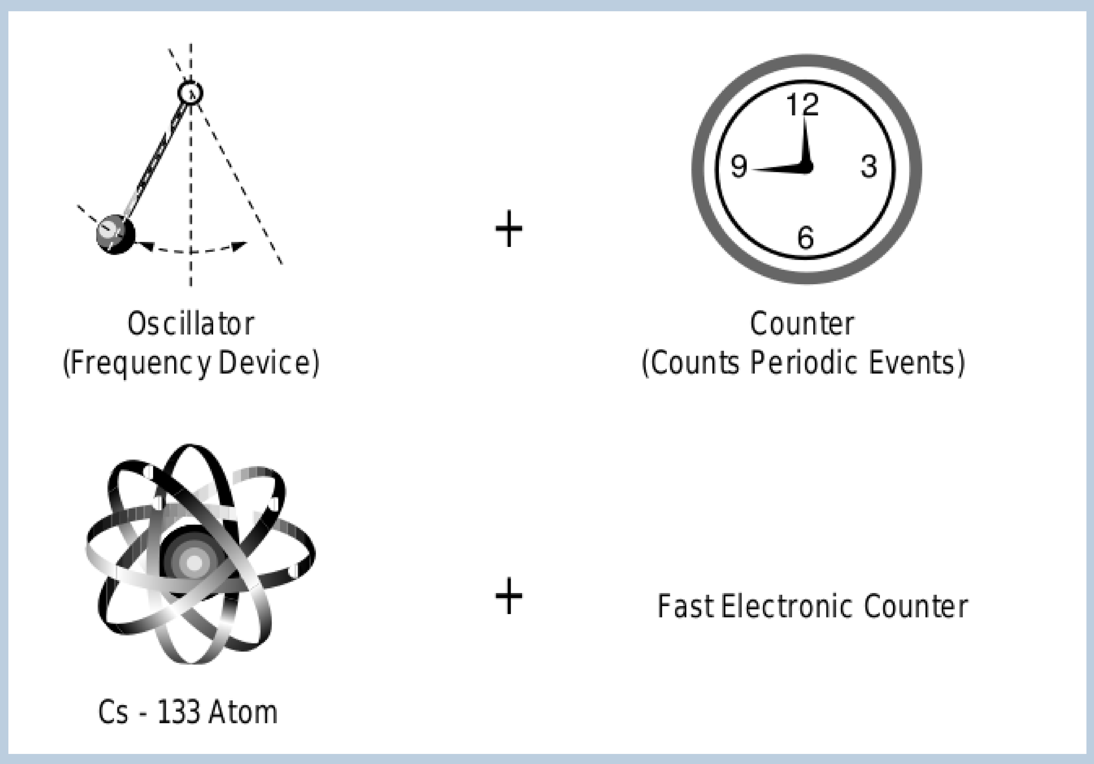
Clocks, Oscillators and Allan Variance

Almost any *clock* may be considered a two-part device, a *Oscillator* (determine the length of the second) and a *Counter* to keep track of the numbers of seconds or clock cycles that have occurred. A oscillator is an electronic circuit that produces a electronic signal. In a analytical way the circuit can be represented by the universal equation $\frac{d^2q}{d\tau^2} + 2\zeta\frac{dq}{d\tau} + q = 0$, with general solution $q(\tau) = A(\zeta,\omega)\sin(\omega\tau + \phi(\zeta,\omega))$. Therefore we can easily model a oscillator just by a sine wave signal. Our initial simple model has the form:

$$\text{Oscillator model} = \text{Sine-wave(phase-from-oscillator} + \text{phase-drift} + \text{phase-noise)}$$

Later on, amplitude variations, noise, and other complications can be added. Four useful measures for describing the quality of a clock are: frequency-accuracy, frequency stability, time accuracy, and time stability. Because no perfect clocks/oscillators exist (materials, environment, etc.), we have to measure the model. Traditionally, Allan variance is used. The Allan variance is defined as $\sigma_y^2(\tau) = \frac{1}{2}\langle(\overline{y}_{n+1} - \overline{y}_n)^2\rangle$. Another common measure is the Allan deviation $\sigma_y(\tau) = \sqrt{(\sigma_y^2(\tau))}$.





GUI matlab

We are working in build the entire simulation with Matlab Simulink, but at the moment there is some detail that we need to figure out. For now, we are going to show a GUI with a oscillator signal graphs in the frequency and time domain and the Allan deviation. The next figure show the GUI.