VisibleSim Manual

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April 23, 2015

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VisibleSim is a general discrete event simulator (DES) for modular robot systems.

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VisibleSim supports local clock simulation. We present here the programming API and the clock model. The model

5.1 Programming API

5.2 Clock model

We used hardware Blinky Blocks to compute realistic clock models. Blinky Blocks are eqquiped with a micro-controller ATxmega256A3 that holds a 16-bit Real Time Xounter (RTC). The RTC can be plugged to different oscillators. We choose to study clock behaviour using the most precise internal oscillator available: a 32.768 kHz calibrated RC oscillator with a precision of 1% and a resolution of 1 ms.

RC oscillator are known to drift apart linearly. Voltage

The set of blocks were powered with 5V and 0.36A.

5.2.1 Systematic model for clocks

[1] proposes a general model for oscillators:

$$x(t) = x_0 + y_0 t + \frac{1}{2} D t^2 + \epsilon(t) \tag{1}$$

where t is the simulation time (real-time), $x(t)$ is the local time, x_0 is the time offset, y_0 is the frequency offset, D is the frequency drift and $\epsilon(t)$ is the random noise. $\epsilon(t)$ is not deterministic. [2] assume that $\epsilon(t)$ follows a Gaussian distribution $\mathcal{N}(0, \sigma^2)$.

5.2.2 Experimental values

We acquire Compensate communication delays. At most 2-hops.

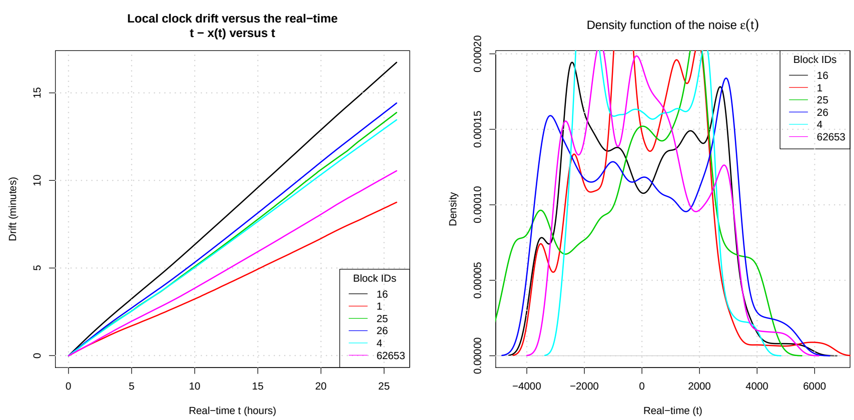

Figure 1: Local clock drift (t - x(t)) and noise ($\epsilon(t)$) distribution.

Parameter	Min	Mean	Max	Standard-deviation
D	1.613992e-11	-1.179717e-11	-7.991859e-12	3.060884e-12
y_0	0.9896537	0.9922277	0.9949096	0.001851285
x_0	-5984.141	-3532.051	-785.9812	1921.629
Residual standard error	1688.103	2080.197	2423.646	294.832

Figure 2: Parameters

The parameters D, y_0 and the residual standard error seems normally distributed. As a consequence, we randomly generate clock parameters according to normal laws with the correspong mean and standard deviation.

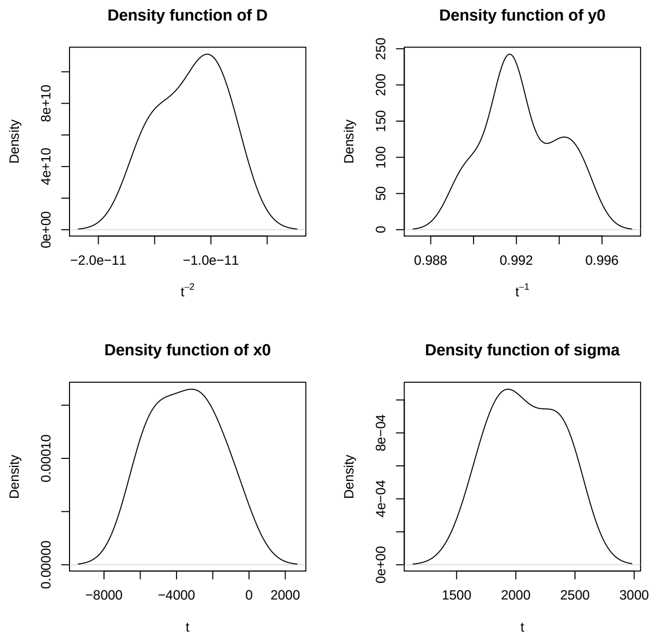

Figure 3: Parameter distributions.

5.3 Clock simulation in DES

[3] explains how to enhance DES with efficient local clock simulation.

References

[1] David W Allan. Time and frequency(time-domain) characterization, estimation, and prediction of precision clocks and oscillators. *IEEE transactions on ultrasonics, ferroelectrics, and frequency control*, 34(6):647–654, 1987.

[2] Liangping Ma, Hua Zhu, Gayathri Nallamothu, Bo Ryu, and Heidi Howard. Understanding linear regression for wireless sensor network time synchronization. In *Proceedings of the 2007 International Conference on Wireless Networks, June 25-28, 2007, Las Vegas, Nevada, USA*, pages 325–328, 2007.

[3] Felix Ring, Anetta Nagy, Georg Gaderer, and Patrick Loschmidt. Clock synchronization simulation for wireless sensor networks. In *Sensors, 2010 IEEE*, pages 2022–2026. IEEE, 2010.