A Distributed Virtual Time System for Embedded Linux Devices

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Abstract:

The successful operations of modern electric power infrastructure are dependent on reliable and efficient communication networks. This calls for a simulation-based platform that provides robust features and controllability for evaluating network application designs, as well as facilitating the transition from in-house research ideas to deployment on real systems. This work focuses on creating a hybrid testing platform combining electric power simulation with Linux network devices such as hosts and switches. This system supports a distributed communication network using real networking hardware to support high fidelity analysis of communication network applications and their impacts on the power systems. The challenge in designing such a hybrid system is in the synchronization of combining real networking devices to an electric power simulator. We implement a solution for this synchronization challenge through a virtual time system.

Our main contributions are in the design of a distributed virtual time system for Linux devices with precision controllability of the execution of the systems. In other words, pausing and resuming any specified processes in the perception of their own virtual clocks. An efficient system clock has to minimize the overhead of its own operation, ensuring the accuracy of the system. We demonstrate how to utilize hardware interrupts to communicate between linux devices for rapid synchronization of the distributed virtual time system. We also show that this approach is efficient, and scales linearly with the number devices. Additionally, we evaluate the system performance to measure the impact of the virtual time system and synchronization overhead on the throughput and latency of the communication devices.

Keywords:
Electrical Power System Simulation; Network Emulation; Software-Defined Networking; Smart Grid; Microgrid