The Case for Cross Disciplinary Research on Time Aware Applications, Computers and Communication Systems

Summary of A White Paper, September 18, 2013
Available from http://tf.nist.gov/seminars/WSTS/TAACCS/

Executive Summary

A new economy built on the massive growth of endpoints on the internet will require precise and verifiable timing in ways that current systems do not support. Applications, computers and communications systems have been developed with modules and layers that optimize data processing but degrade accurate timing. State-of-the-art systems now use timing only as a performance metric. Correctness of timing as a metric cannot currently be designed into systems independent of hardware and/or software implementations. To enable the massive growth predicted, accurate timing needs cross-disciplinary research to be integrated into these existing systems. Different criteria are needed for different endpoints on the network, such as: accuracy versus stability for time, phase and frequency synchronization. In addition to accuracy, security issues represent another critical need. In many cases, having assurance that the time is correct is a more difficult problem than accuracy. Security issues include protection from attack, and having means to verify that the time is correct.

We summarize this research in terms of six layers:

1. **Oscillators** in the network will require a range of tradeoffs among performance, power and cost, as well as ensembling methods, that challenge the state-of-the art

1. **Time Transfer Systems** will need to deliver signals to orders of magnitude more endpoints than currently, with both specified accuracy and integrity, and by traversing both wired and wireless systems. Many systems will be enabled if the network delivers time as a service.

2. **Time Aware Networks** will need development in a number of areas:
   - **Network equipment** hardware and software will need designs that support and utilize time awareness
   - **Time awareness and control in networks** creates both new options and research requirements for propagating and using timing signals
   - Time awareness is a critical factor in **controlling latency** in networks, which is crucial to tele-surgery, online gaming, the financial industry and many other real-time applications
   - **Performance monitoring** is required for maintenance and service-level agreements, and is greatly enhanced by synchronization

- **Spectrum bandwidth utilization** can be optimized with precision timing

4. **Timing support** for applications will need cross-discipline research in the following areas:
   - Hardware and software support of **predictable execution** will need to balance the depth of change in systems with cost and implementation
   - Timing across **interfaces** will require standards and latency control both between CPU and in crossing network domains
   - **Scale** issues in supplying time to large numbers of systems

5. **Development environments** will need the ability to specify timing accuracy independent of the hardware that systems are running on

6. **Applications** can make innovative use of time, and will further stimulate the development of these other items.

Much research is already being done on these various developments. Cross-discipline research is needed to enable communication across the disciplines involved, and to initiate and perform the research that is missing. Only a partnership of government, industry, and academia can respond with the breadth of priorities necessary. In the past, timing has been worked into systems without a unified design. The rapid growth of new endpoints on networks demands over-arching standards and designs for distributing and maintaining time, phase and frequency with the required accuracy, stability and security appropriate for each endpoint.