Can you spare the time?

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For centuries, we’ve survived with wristwatches that kept time accurate to within a few minutes per year. Yet early in 2016, a timing signal broadcast an error of only 13 microseconds, which in turn disrupted telecommunications and other networked computers around the globe. How could such a small error, an amount of time equivalent to 1/25,000 of an eye blink, cause such problems?

The concept of a clock is simple enough: combine an oscillator and a counter and you’ve got yourself a clock. But that is where the simplicity ends. The study of timing delves deep into decades of research regarding physics, lasers, relativity, synchronization protocols, and, of course, large red countdown displays.
Clocks come in all shapes and sizes as well as accuracies and precisions. The earth is a basic albeit imprecise clock that marks our passing years and birthdays as it rotates around the sun. On our arms, wristwatches contain circuitry that counts the specific number of times a quartz crystal vibrates each second and then moves the second hand accordingly. Atomic clocks, such as those based on rubidium and cesium, are substantially more stable than quartz at the expense of cost, size, and weight. Indeed, cesium oscillators are typically accurate to better than one second in a million years! One of the most accurate atomic clocks in the U.S. lives at the U.S. Naval Observatory (U.S.N.O.), which is the same organization that sets and disseminates the official U.S. time.

A remarkable fact about time today is that you probably already have a timepiece nearly as accurate as the U.S.N.O. without any of the hassle. That is because in addition to position, the Global Positioning System broadcasts accurate time from U.S.N.O. to any GPS receiver, your smartphone included. And, while you’re probably more familiar with the ability of GPS to guide your way through Washington D.C. traffic, you can also think of your smartphone as your very own pocket-sized atomic clock.

The real magic of GPS time is its ability to synchronize the myriad networks of computers that now underpin every aspect of modern life. Consider banking, where time is money. Financial institutions employ GPS time to maintain accurate stock prices and synchronize trades, and high-frequency traders exploit time to their advantage by rushing to make trades before their competitors.

GPS also supports critical infrastructure. Cell phone base stations, the backbone of cellular infrastructure, operate synchronously to relay calls, texts, and cat memes without delay. Internet service providers push synchronized timing through vast networks of routers, switches, and hubs to all connected devices. And, the electric power grid delivers the correct current and voltage to customers based on GPS-synchronized measurements throughout the grid. Future smart cities with real-time consumption monitoring and smart utilities will employ timing to further improve the efficiency of utility distribution.

It’s no wonder that the demands for ever more accurate timing have made devices susceptible to smaller and smaller errors like the 13 microsecond error experienced last year. While we live in the land of hours and seconds, microseconds and nanoseconds are all the rage to our electronics. And, that’s worth taking some time to think about.

Image: taken from Unsplash.

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