*By John Timmer, Ars Technica*

How much information can the world transmit, process, and store? Estimating this sort of thing can be a nightmare, but the task can provide valuable information on trends that are changing our computing and broadcast infrastructure. So a pair of researchers have taken the job upon themselves and tracked the changes in 60 different analog and digital technologies, from newsprint to cellular data, for a period of over 20 years.

[partner id=”arstechnica” align=”right”] The trends they spot range from the expected—Internet access has pushed both analog and digital phones into a tiny niche—to the surprising, such as the fact that, in aggregate, gaming hardware has always had more computing power than the world’s supercomputers.

The authors were remarkably thorough. For storage media, they considered things like paper, film, and vinyl records, and such modern innovations as Blu-ray discs and memory cards. To standardize their measurements across media, they used Shannon's information theory to consider data storage in terms of optimally compressed bits. They also tracked technology, noting that in the year 2000, bits of video were compressed using cinepak, which was far less efficient than the current MPEG-4 format; calculations were adjusted accordingly.

Even so, there are some significant estimations here. "For example," the authors note, "after normalization on optimally compressed bits we can say things like 'a 6 square-cm newspaper image is worth a 1,000 words.'"

Similar sorts of estimates are required for things like broadcast capability and two-way communications, both of which are compiled as bits-per-second figures. The researchers estimate typical consumption of broadcast media to figure out how much of the existing capacity is used, and they figure that, since telecom equipment is run to maximize the use of its capacity, it's usually booked to close to its limit.

Computing capacity is converted into MIPS, and estimates for the total number and class of chips are available. The big question mark here is mostly in embedded controllers; it's hard to estimate both their computational capacity and how many are out there.

So these are pretty rough estimates, but similar assumptions are made at all four time points examined between 1986 and 2007. That should allow comparisons of trends across the time period, even if the absolute values of the estimates are a bit off.

## Storage

Some trends are very, very obvious. Analog video accounted for over half the data stored in 1986 (vinyl LPs and cassette tapes accounted for over a quarter), and video held 86 percent of all stored data by 1993, squeezing out nearly everything else.

By 2000, CDs and digital tape started pushing back, but analog video still stood at 70 percent of all stored data. By 2007, analog video had plunged to a tiny six percent, eclipsed by hard disks, Blu-ray and DVDs, and digital tape.

During that time, total storage capacity grew at about 23 percent annually, and it topped out at $2.9 \times 10^{20}$ bytes—that's about 300 exabytes, or 61 CDs for everyone on the planet.

A similar shift to digital occurred in broadcast media and two-way communications. Back in 1986, 80 percent of broadcast capacity was used for terrestrial TV, although analog cable was already a presence. Today, broadcast TV has fallen to 50 percent; a quarter of the broadcast data is now some form of digital, and analog cable is declining from its peak in 2000.

Two-way communications underwent a far more dramatic shift. In 1986, analog phones handled 80 percent of the data, with digital phones taking the other 20 percent; everything else was a rounding error. By 2000, analog telephony was down to two percent of the world's two-way transmissions.

Digital telephony peaked in 1993 at 67 percent; fixed Internet connections accounted for one percent of usage that year. By 2000, it was up to 50 percent, and it's now at 97 percent. Nothing else cleared one percent.

Two-way communications handled 65 exabytes in 2007, dwarfed by broadcasting, which sent a whopping 2 zetabytes of data. But, while broadcasting is increasing at a linear rate, the advent of the Internet has given two-way transmissions a big boost, increasing the bytes transmitted by a factor of 29 in just 7 years.

## Computation

Computation is probably the most varied mix of hardware of the lot. Back in 1986, pocket calculators represented about 40 percent of all computer capacity, beating out PCs at 33 percent and servers at 17 percent. Even then, gaming hardware held a nine percent share.

Calculators were gone by 2000, when the PC peaked at 86 percent and the mobile phone/PDA first appeared at 3 percent. By 2007, phones held six percent of world processing power, but the big story was gaming hardware, which shot up to a quarter of the total computational capacity, pushing the PC back down to a two-thirds share. Supercomputers are apparently rare enough not to measure.

One surprising result of the research is the amount of total horsepower found in the application-specific space, where the authors considered only DSPs, microcontrollers, and GPUs (GPUs alone account for 97 percent of this category's capacity). And that capacity is huge, about 30 times that of all the general purpose computation hardware. GPUs account for the lion's share of the $6.4 \times 10^{18}$ operations a second that the planet can now perform, and they showed a compound annual growth rate of 86 percent over the study period.

Lest we get too enamored with our technological prowess, however, the authors make some comparisons with biology. "To put our findings in perspective, the $6.4*10^{18}$ instructions per second that human kind can carry out on its general-purpose computers in 2007 are in the same ballpark area as the maximum number of nerve impulses executed by one human brain per second," they write.

Our total storage capacity is the same as an adult human's DNA. And there are several billion humans on the planet.

*Image: Flickr/adafruit.*

*Citation: "The World's Technological Capacity to Store, Communicate, and Compute Information." Martin Hilbert and Priscila López.* Science, *692-693, Feb. 11, 2011. DOI: 10.1126/science.1200970*

*Source: Ars Technica.*

**See Also:**

- Digital Overload Is Frying Our Brains
- Memory Switch Could Enable Brain Hacks
- Forgotten Memories Are Still in Your Brain
- Researchers Want to Add Touch, Taste and Smell to Virtual Reality
- Computer Program Self-Discovers Laws of Physics
- The Future of Robot Scientists