Figure 1. The SNAP system in a feed-forward action. In keeping with the systems engineering principle that interfaces between modules should be transparent, the backend's yoke is connected to the frontend's shell with a piece of transparent scotch tape, not visible in the image. (Photograph by Herbert Bishko.)

Sluggish Data Transport Is Faster Than ADSL

by Ami Ben-Bassat, Israel
Revital Ben-David-Zaslow, Department of Zoology, Tel Aviv University
Shimon Schocken, Efi Arazi School of Computer Science, IDC Herzliya, Israel
Yossi Vardi, Israel

"If everything seems under control, you're just not going fast enough." (Mario Andretti)

We describe an experiment in which a Giant African Snail, acting as a data transfer agent, exceeded all known "last-mile" communications technologies in terms of bit-per-second performance, adding to the many paradoxes of broadband communications.[1] We discuss the unique motivational and guidance systems necessary to facilitate snail-based data transport, and observe with satisfaction that in a society that worships the fittest, fastest, and furtherest, the meek and the slow can sometimes outperform all known competitors, giving rise to the new and exciting field of sluggish data networks.

The History of Snails as Communications Agents

The use of snails as data communications agents was not considered before now. As we show in this paper, the negative attitude towards using snails in communications networks is an example of bounded rationality[2] impeding bold and creative engineering.

Snails are widely assumed to be slow animals. Yet the literature on sluggish speed is surprisingly limited, and few have actually bothered to measure and record it formally. Further, reported gastropod speeds vary widely with species and circumstance, ranging from 0.000023[3] to 0.0028[4] meters per second.

Another cognitive limitation that hindered the employment of snails in data transfer is what we term a *data linearity bias*. As it turns out, most data communications experts are trained to think of a data stream in terms of a linear and logical flow of bits. And yet in reality, many massive data stores like CDs and DVDs are physically organized in *circular formats*. Owing to their spherical geometry, when such data stores fall on a flat surface they tend to roll like wheels for a short distance and then wobble and come to a rest -- a phenomenon that went completely unnoticed in the computer science and electrical engineering literature.

In sum, we observe that most data communications experts (i) are bound to think of snails as inherently slow, mindless, and stand-alone creatures and (ii) seem to ignore the wheel-like geometry of CDs and DVDs. It is therefore not surprising that the immense data transport potential embedded in slug-empowered traction has not been realized thus far.

Previous Work: Low-Level Experiments in Australia

Several sources indicate that in the early days of the Usenet, a certain segment of the network's backbone was implemented by shuffling magnetic tapes in a station wagon in the Australian outback. This has prompted Andrew Tanenbaum to note that one should "*never underestimate the bandwidth of a station wagon full of tapes*."[5] It is rather surprising that in spite of Tanenbaum's stature as a leading data communications expert, this penetrating insight about the feasibility of brute-force data transfer did not get much mileage.

Previous Work: High-Level Experiments in Norway and Israel

One notable exception has been a pioneering experiment carried out in Bergen, Norway, in 1999. The experiment demonstrated the feasibility of a *pigeon-based* data transport system, formulated by David Waitzman.[6] This B2P (Back to Pigeons) line of research was significantly extended by Ami Ben-Bassat, Guy Vardi, and Yossi Vardi[7] in Israel. In 2004, Ben-Bassat et al. sent three homing pigeons over a 100-kilometer distance, each carrying 1.3 gigabits on tiny flash memory cards, yielding a transfer rate faster than ADSL.[8]

Yet the *Wi-Fly TCP* (*Transmission by Pigeons*) protocol of wireless internet has had its limitations. First, pigeons cannot fly through Windows. Second, since they don't fly in darkness either, this method's bandwidth drops to zero 50 percent of the time. Finally, there's the problem of droppings download. We are pleased to report that all these shortcomings were resolved in our new data transfer protocol, as we will now describe.

System Architecture

We propose a data transfer system based on a hybrid integration of a mobile digital data store *backend* and an organically engineered *frontend*. The backend module consists of two CD or DVD disks, interconnected by a light-weight balsa axle and yoke, forming a two-wheeled cart. The frontend module consists of a single *Achatina Fulica*, also known as a *Giant African Land Snail*.[9] We call the system *SNAP*, standing for *SNAil-based data transfer Protocol*.[10] (See Figure 1.)

The snails used for the experiment were supplied by Dr. Revital Ben-David-Zaslow, a marine molluscs expert. Although snails are not protected by the Helsinki committee, we wanted to make sure that the experiment does not compromise their welfare in any way. And indeed, Dr. Ben-David-Zaslow assured us that the effort required to haul the light SNAP cargo is far less than that exerted by snails in a vertical climb, which is what they normally do. Further, Dr. Ben-David-Zaslow pointed out that the participation in the experiment was a welcome diversion from the routine life that the snails normally lead in the university aquarium which is their regular habitat.

Since the snail proper is committed neither scientifically nor professionally to the advancement of data communications techniques, we had to contrive a way to entice it to get moving. After consulting the literature on utility theory[11,12] and economic mechanism design,[13,14] we proceeded to augment the platform with a unique incentive mechanism based on a fresh leaf of *Lactuca Sativa*, also known as iceberg lettuce, hereafter referred to as *LGS* (*Lettuce-based Guidance Sub-system*).

And since data transfer always takes place between two well-defined source and destination points, we had to contrive a way to restrict the system's movement to a pre-determined trajectory. This was done by placing the LGS in the center of the snail's sensory field, and dragging it gently along the shortest path between the data's source and destination terminals. This particular task was carried out by a member of our research team who is also a commercial pilot with significant navigation experience.

Details of the Experiment

The experiment's goal was to demonstrate how the movement of the SNAP system from source to destination in *t* seconds results in transporting data at an overall rate of *b*/*t* bits per second (*bps*), *b* being the number of bits transferred. The actual venue of the experiment was a lunch break during *Kinnernet 2005*, an annual conference dedicated to Internet innovation and organized by Yossi Vardi.[15]

The experiment began with a few minutes of tense silence, disturbed by some cynical comments from the audience. Yet when the wireless LGS router was presented into the scene, the system's frontend module SNAPped into action (excuse the pun), and started moving slowly but consistently toward the LGS, data store gingerly in tow. In fact, at some point the frontend actually managed to bite a small fraction of the LGS. The experiment ended 34 minutes and 10 seconds later, when the data payload was delivered intact from source to destination. At the finish line, an astonishing 37 million bits-per-second data rate was recorded, to the delight of a cheering audience witnessing scientific history in the making.

We note in passing that all measured times were recorded conservatively by an observer on the ground. If measured by the moving snail itself, times would have been a bit shorter, according to Einstein's relativity theory,[16] resulting in slightly greater *bps* rates.

Discussion

An inspection of Figure 2 reveals that SNAP is not only fast -- it is the fastest "last mile" data communications technology used today over the Internet:

Technology	Kbps
V.34 modem	28.8
ISDN	128
ADSL	1,500
Wi-Fly (pigeons)	2,270
SNAP (snails)	37,000

Figure 2: Benchmarking SNAP with other data transfer technologies.

It's important to note that the terrestrial distance covered by SNAP during the experiment (52 centimeters) is irrelevant. That is because data transfer is a continuous affair: once a communications channel is established between two points, packets of bits flow continuously from source to destination. In our case, it can be assumed that a new SNAP system leaves the source every second with a payload of 9.4 gigabytes, yielding a pure delivery rate of 37,000 Kbps.[17] Needless to say, various circumstances such as LGS succulence and slug cross-talk can slow down a multi-SNAP system's actual performance. However, as all Internet users know, the actual speed of any data communications carrier varies around its advertised pure *bps*, and SNAP is no exception.

We conclude this section with some comments on several other characteristics of the SNAP protocol.

Security: Since the SNAP payload is a write-once / read-only CD/DVD media, there is virtually no way to compromise the transferred data. Although the protocol is not immune to data sniffing, we note that unauthorized reading of SNAP data requires stopping a highly motivated LGS-driven giant African snail in its tracks and then dismounting the disks from its harness -- a rather messy affair that potential intruders will most likely want to avoid.

Modularity: An inspection of Figure 1 reveals that the system's frontend and backend modules are completely independent of each other. As a result, each module can be replaced at will, requiring no changes in the rest of the SNAP system. For example, new DVDs with large data capacities can easily replace the backend module, leaving no impact whatsoever on the pulling snail. Likewise, the snail frontend can be replaced with no impact on the backend. For example, the combination of a *Red-Rimmed Melania Snail*[18] with the latest generation DVD can result with a new *RGB* technology (*Red* snail, *Green* LGS, *Blue* ray data).

Scalability: With more than 30,000 snail species in nature, the range of possible SNAP system configurations is mind-boggling. It is safe to say that a SNAP system can be custom-tailored for every application and budget in terms of desired data speed and LGS consumption.

Quality of Service/Denial of Service: One unique feature of SNAP is that QoS can be easily regulated by the system's operator: the plumper the LGS, the larger will be the data transfer rate. Yet in some regions, most notably France, culinary habits may pose a denial-of-service (DOS) problem. In particular, French users will have to choose whether they want to be served a data cargo or an escargot. On the other hand, dietary kosher laws will ensure that DOS problems will never occur in DOS neighborhoods.

Given the attractive operational features of the SNAP system, we will not be surprised if some readers of this article will venture to turn SNAP into a for-profit data communications enterprise. A word of caution is in order. As it turns out, the use of *wheels* in any commercial application may be a violation of intellectual property law. In particular, in 2001, Mr. John Keogh, a lawyer, was issued patent #2001100012 from the Australian Patent Office for "*a circular transportation facilitation device*", more commonly known as *a wheel*.[19] Therefore, commercial SNAP system operators may have to deal not only with the temperamental vagaries of a Giant African Snail, but also with possible law suites filed by an Australian patent lawyer.

Future Work

It is quite obvious that the weakest point in the current SNAP architecture is the LGS. In particular, the need to employ a skilled human LGS operator is clearly cumbersome and expensive. With that in mind, we are now working on a new, self-propelled version of the system, called SNAP II (see Figure 3). As can be seen from the figure, of the two design problems described in section 3 -- motivation and navigation -- SNAP II provides an elegant solution to the former while not addressing the latter.

We conclude that the navigation challenge of self-propelled SNAP II systems, as well as unstable levels of service in France, remain open problems for future work in sluggish data communications research.

Notes

1. "The Many Paradoxes of Broadband," A. Odlyzko, *First Monday*, vol. 8, no. 9, September 2003, http://firstmonday.org/issues/issue8_9/odlyzko/index.html.

2. *Judgment Under Uncertainty: Heuristics and Biases*, Daniel Kahneman, Paul Slovic and Amos Tversky (editors), Cambridge University Press, Cambridge, 1982.

3. “Snails Without Shells,” Branley Allan Branson, *The World and I*, vol. 11, no. 5, May 1996, p. 166ff.

4. *The Guinness Book of World Records* 1998, C.T. Stanford, Guinness, 1997, p. 144.

5. *Computer Networks*, A. Tanenbaum, Prentice-Hall, 1988.

6. “IP Over Avian Carriers with Quality of Service,” David Waitzman, RFC Archive, The Internet Society, April 1, 1999, http://rfc.sunsite.dk/rfc/rfc2549.html.

7. “PEI (Pigeon Enabled Internet) Is Faster Than ADSL,” R. Ben-Bassat, Y. Vardi and G. Vardi, *Internet 2004 Conference Proceedings*, http://www.notes.co.il/benbasat/5240.asp.

8. “Pigeons Bandwidth Advantage Quantified,” Timothy, *SlashDot*, March 31, 2004. http://science.slashdot.org/science/04/03/31/2224227.shtml?tid=126&tid=133&tid=186&tid=95.

9. *Giant African Land Snail Photo Gallery*, http://achatina.ru/Photo/Page.Eng/Fulica.htm

10. We decided to omit the “D” and the “T” from the SNAP acronym, since these letters are already overused in data communications protocols, e.g., TCP, TTY, DSL, DVD, etc.

11. *Theory of Games and Economic Behavior*, John Von Neumann and Oskar Morgenstern, Princeton University Press, 1944.

12. “Modular Utility Representation for Decision-Theoretic Planning,” M.P. Wellman and J. Doyle, *Artificial Intelligence Planning Systems: Proceedings of the AIPS Conference*, 1992.

13. “Economic Mechanism Design for Computerized Agents,” H. Varian, *Proceedings of Usenix Workshop on Electronic Commerce*, 1995.

14. “Algorithmic Mechanism Design,” N. Nisan and A. Ronen, *Proceedings of the STOC Conference*, 1999.

15. The conference is held near the Lake of Galilee (Israel), whose Hebrew name is “Kinneret.”

16. “On the Electrodynamics of Moving Bodies,” A. Einstein, *Annalen der Physik*, vol. 17, no. 891, 1905.

17. Each Giant African Land Snail contains male and female reproductive organs and can produce up to 1,200 eggs a year. From “*FAQs About Giant African Land Snails*,” http://massnrc.org/pests/pestFAQsheets/giantafricanlandsnail.html.

18. “*Red-rimmed Melania Snails and Mosquitofish*,” http://community.webshots.com/photo/20968533/20969994zGelyrDvJk .

19. “*Background to the Wheel Patent ,”* http://news.bbc.co.uk/1/hi/world/asia-pacific/1418165.stm. [EDITOR’S NOTE: For this achievement, Mr. Keogh and the Australian patent office were awarded the 2001 Ig Nobel Prize for Technology.]

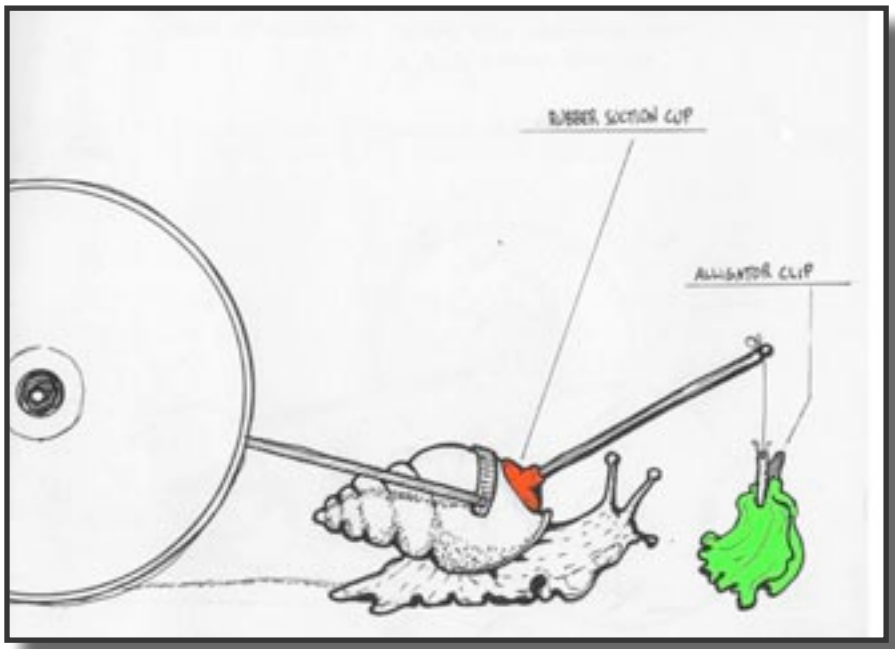

Figure 3. In SNAP II, the LGS router is attached to a look-ahead device mounted on the frontend’s shell. When the snail moves forward, so does the LGS. (Drawing by Uriel Miron.)

Acknowledgements

We thank Yedidya Vardi and Shlomo Abayoff from the Ron Vardi Center for Gifted Children in Rishon Lezion for constructing the cart module of the SNAP system, Talma Vardi for caring for the snails’ well-being during the experiment, and Yossi Hod from El Al Airlines for operating the LGS during the experiment.