Snails Are Faster Than ADSL

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

1. Background

Snails are widely assumed to be slow animals. Yet the literature on sluggish speed is surprisingly limited, and only few have actually bothered to measure and record it formally. Further, reported gastropod speeds vary widely with species and circumstance, ranging from 0.000023 to 0.0028 meters per second ([1] and [2], respectively). With that in mind, it is not surprising that the use of snails as data communications agents was not considered up until the research reported here. Indeed, one can hardly reconcile the phlegmatic disposition of slugs[1] with the fantastic speeds at which information is expected to flow over the Internet. Yet as we show below, the negative attitude towards using snails in communications networks is an example of bounded rationality [3] impeding bold and creative engineering.

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 are physically organized in *circular formats*. For example, portable data disks can store anything from 400 megabytes on a low-end CD to over 10 gigabytes on the latest generation DVD. Owing to their spherical geometry, when such disks 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 by 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 systems has not been realized thus far. In particular, to the best of our knowledge, no-one has yet realized that a pair of CDs or DVDs – let's call this data store *d* -- can be harnessed rickshaw–style to a snail – say *s* – and that *s* can then pull *d* from source to destination under the control of a suitable guidance mechanism. The resulting platform can yield an ultra-high bits-per-second data transfer rate, the huge capacity of *d* compensating for the slowness of *s*.

Can such a thought experiment be translated into an actual system that can be deployed in the field? As we report in this paper, preliminary results are extremely encouraging. The paper begins with a description of a prototype architecture for a snail-based data communications system. Next, we describe an actual experiment in which one such system delivered successfully more than 75 billion bits from source to destination, exceeding all known "last-mile" data

[1] Throughout the paper, the terms *snail*, *slug*, and *gastropod* are used interchangeably.

communications protocols in terms of bit-per-second performance. The last section discusses the experiment's results and implications. We conclude with comments on future research directions in the new and exciting field of sluggish data communications systems.

2. Previous Work

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*" [4]. 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.

One notable exception has been a pioneering experiment carried out in Bergen, Norway (1999). The experiment demonstrated the feasibility of the "*IP over Avian Carriers*" protocol – an RFC for delivering data using pigeons, formulated by David Waitzman's [5]. This B2P (Back to Pigeons) line of research was significantly extended by Ami Ben-Bassat, Guy Vardi, and Yossi Vardi [6]. In 2004, Ben-Bassat et al sent three homing pigeons to a 100 kilometer distance, each carrying 1.3 gigabits on tiny flash memory cards, yielding a transfer rate faster than ADSL [7].

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% 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 now turn to describe.

3. 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, inter-connected 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* [8]. The interface between the two modules is implemented by mounting the yoke on the snail's shell. We call the system *SNAP*, standing for *SNAil-based data transfer Protocol* [2]. See figure 1 for more details.

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

[2] 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.

the routine life that the snails normally lead in the university aquarium which is their regular habitat.

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*)

As with most complex engineering projects, the present architecture of the SNAP system evolved from several stages of trial and error. For example, after building our first prototype, we have noticed, to our chagrin, that the frontend module showed no signs of moving anywhere. More specifically, the frontend module was withdrawn into its shell, completely oblivious of the critical role assigned to it in the overall system's architecture. We concluded that two factors instrumental to SNAP's success -- *motivation* and *navigation* – were missing in our original system design. The remainder of this section elaborates on these challenges and what we did to address them.

Motivation: 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 [9,10] and economic mechanism design [11,12], 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*).

Routing: 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 – just in front of its tentacles -- and dragging it gently along the shortest path between the data's source and destination terminals. This particular task was carried out by Yossi Hod, a member of our research team who is also a commercial pilot with a significant navigation experience.

We note in passing that the LGS is in fact an organic wireless *router*: in addition to enticing the snail to move, it also routes it to the desired direction. And indeed, the successful introduction of the LGS router marked the end of our system design. Following some beta tests and dry simulation runs we were ready for the real test – an open experiment in front of a live audience.

4. Experiment

In order to test the SNAP system we placed it on a flat surface -- a table. Our goal was to demonstrate how the movement of the 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. As we elaborate later in the paper, the terrestrial distance covered during the experiment (52 centimeters) can be factored out from the *bps* calculation and is thus irrelevant to the system's reported performance.

The actual venue of the experiment was a lunch break during *Kinnernet 2005*, an annual conference dedicated to Internet innovation[3]. More specifically, the experiment was conducted in front of 150 Internet hackers, geeks, and aficionados, known for their skeptical attitude toward so-called "new technologies".

5. Results

The experiment began with a few minutes of tense silence, disturbed by some cynical comments from the audience. Yet when the 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 has 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 mega bits-per-second data rate was recorded, to the delight of a cheering audience witnessing scientific history in the making.

5. 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.

[3] The conference is held near the Lake of Galilee (Israel), whose Hebrew name is "Kinneret".

It's important to note that the actual distance covered by SNAP during the experiment 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[4]. 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, when new DVDs with larger data capacity will be available in the market, they 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* [14] 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 plumpier 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, due to dietary kosher laws, 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 may venture to turn SNAP into a commercial data communications enterprise. Before doing so, 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* [15]. 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.

[4] Each Giant African Land Snail contains male and female reproductive organs and can produce up to 1,200 eggs a year [13].

6. 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 (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.

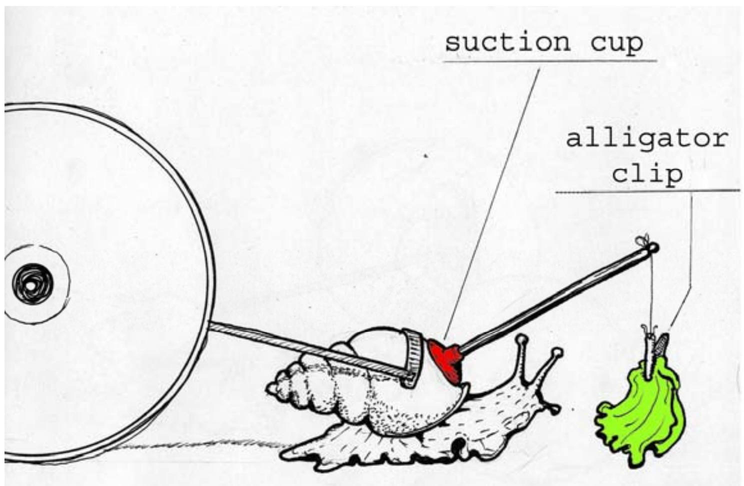

Figure 3: In SNAP II, the LGS router is attached to a look-ahead device mounted on the frontend's shell. When the snail moves forward, so does the LGS (*drawing by Uriel Miron*).

Appendix A: Mathematical Model

We use the following symbols:

b = data size, in bits

s = data transfer duration, in seconds

With this notation in mind, the system's performance is defined as follows:

$$bps = \frac{b}{s} \text{ bits per second}$$

Since each DVD stores 4.7 gigabytes, we have, in our case:

$$b = 4{,}700{,}000{,}000 \cdot 8\ bits \cdot 2\ disks = 75{,}200{,}000{,}000\ bits$$

The SNAP system took 34 minutes and 10 seconds to complete the data transfer:

$$s = 34 \cdot 60 + 10 = 2{,}050 \text{ seconds}$$

Thus the actual system performance for SNAP is:

$$bps = \frac{75{,}200{,}000{,}000}{2{,}050} = 37{,}682{,}926 \text{ bits per second}$$

To promote accuracy, the actual division of the two constants was carried out using both an *HP 30s* scientific calculator and *Excel 2003 SP1* program. Both tools yielded the same result.

We note in closing that all measured times were recorded 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.

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