ARTIFICIAL LIFE

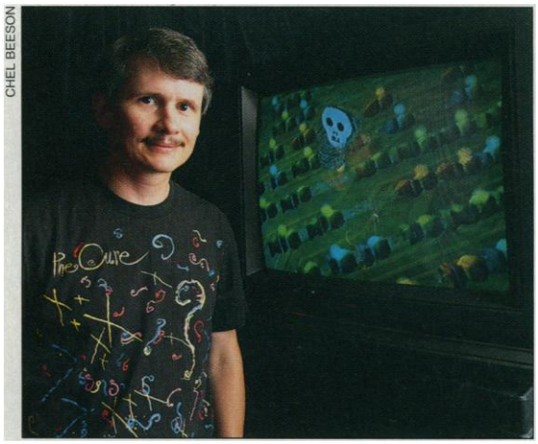
Ecologist Plans to Let Cyberlife Run Wild in Internet Reserve

Four years ago, a field ecologist named Thomas Ray startled his colleagues when he showed off a self-replicating computer code that in one night proliferated and filled his computer's memory with a rich ecosystem of programs. Ray had endowed his program with mechanisms for mutation and death, and he discovered that, overnight, it had evolved into a population of descendants with behaviors that included parasitism, cooperation, and even a form of sexual reproduction. Now, the University of Delaware researcher plans to extend his experiment by exposing one of his software creations to a more complex environment within the vast, worldwide computer network known as the Internet.

Once he can enlist enough volunteers to donate computer space to his "digital wildlife reserve," Ray will release his program to go forth, multiply—and, he hopes, produce unexpected new forms of cyberlife. By extending the program's habitat from a single computer memory to a swathe of the Internet's vast interconnected memory space, Ray says he expects to see its progeny evolve many more interesting and complex strategies for survival and reproduction. The outcome may yield new insights into the potential for "evolving" useful new programs through evolution's electronic analog—and into the process of evolution in the natural world. "If there is something to be learned about individuals cooperating to take advantage of resources, we'll see it," says Chris Langton, a multidisciplinary researcher at the Santa Fe Institute. "By expanding the resources and space available, you will find some interesting things."

This form of cyberlife first stirred in 1990, when after months of struggle to learn machine language and understand the internal workings of his computer, Ray created an 80-instruction code that measured itself, made copies, and found new spaces in memory for its offspring. He added a small probability of random bit flips, analogous to mutations, and a "reaper" that systematically culled out old and defective programs, then let the evolutionary process take over. A set of software monitoring tools enabled him to track and display the different "genotypes" within the population.

Although Ray's system is just one part of a growing enterprise called artificial life, says Langton, who coined the term, "it's more relevant to real evolution." Langton explains that while the programmer must specify some rigid definition of fitness in other systems, the definition of fitness in Ray's system varies with the mix of creatures competing for memory and CPU time, much as living things compete for space and energy. For example, immunity to parasites becomes a beneficial quality only after the emergence of parasites—in this context, incomplete programs that must steal CPU time from others in order to reproduce. Similarly, cheating ability only becomes useful after cooperation emerges. "[Ray] has shown that you can have a nature in a computer," says Langton.



CHEL BEESON

Creatures and creator. Tom Ray and an animation showing his replicating programs.

Since that first night's run, however, few new forms have emerged because Ray is limited to the memory space of a single computer. As a result, he says, "I want to challenge evolution with something more complex." He thought of designing a bigger environment in a single computer, he says, until he realized he could do it much more easily by using the existing system of computers linked by the Internet. Ray and his colleague Kurt Thearling of Thinking Machines Corporation are now developing the software that would allow the programs to subsist on the Internet, and he says he will soon appeal for volunteers.

"People need to be generous to make a space for [the creatures] and give them a chance to reach their potential," he says with the same affection he expresses toward the real wildlife he studies in Costa Rica (where he is establishing an actual wildlife reserve). Within a year, Ray hopes to enlist thousands of volunteers. Because their computers will be permanently linked by the Internet, the programs will be free to migrate from one memory space to another, much like e-mail.

There's no reason for anyone to fear that the replicating program could multiply into a plague of computer viruses, Ray assured listeners at a recent conference at NEC Research Institute in Princeton, New Jersey. Unlike computer viruses, which contain instructions that command the hardware of the computer directly, Ray's creatures can survive and multiply only within a larger program that creates a simulation of a computer, or virtual computer, within a preset part of the host computer's memory. "To any real computer, the [creatures] just look like data," says Ray. They are equipped to move from one computer to another, he says, but they cannot multiply beyond the confines of the "virtual computer" software. "It can be done safely," agrees David Waltz, vice president of computer science at the NEC institute.

Ray does, however, expect the replicating programs to assume new forms in the unfamiliar environment of cyberspace. Unlike a single computer memory, for example, cyberspace has its own topology, he says, which is nested, with different computers branching out from central nodes. With the tools he's developing to track the evolution of new forms, Ray hopes to learn whether his creatures evolve the ability to navigate this topology. If so, he says, "they should start migrating around the globe staying on the dark side of the planet," because more CPU time (the programs' version of energy) will be available while the human world sleeps.

He also speculates that the creatures may evolve a form of cooperative activity analogous to that of cells in multicellular creatures, with interdependent programs differentiating into specialized functions. The result could be an electronic version of the blooming of diversity known as the Cambrian explosion, which followed the emergence of multicellular creatures 600 million years ago. Such transformations, says Langton, could help people understand the periods of booming diversity and relative stasis that mark the fossil record. They might also help explain some remaining puzzles in evolution, such as the emergence of sex as a strategy for reproduction.

Ray also sees potential technological spinoffs from this evolution in silicon. Given space and time, he muses, all kinds of useful software might flourish in the cyberspace jungle. Digital naturalists might explore it, he says, like biologists trekking in the rain forests. "Occasionally you would spot something you see an application for," says Ray. "Then you could breed it, neuter it, and send it to the end user."

–Faye Flam