

Terraforming Cyberspace

Jeffrey M. Bradshaw

Institute for Human and Machine Cognition
University of West Florida
40 South Alcaniz
Pensacola, FL 32561
jbradshaw@ai.uwf.edu

During the 1940s, under the pseudonym of Will Stewart, Jack Williamson published a series of fictional stories describing a process for attaching atmospheres to planets in order to make them capable of sustaining life. 'Terraforming,' the term he coined for this activity was first picked up by other science fiction writers. Eventually, it captured the imagination of a small but zealous core of scientists, space advocacy groups, and segments of the public who began focusing on Mars as the most likely target for transformation and eventual colonization. The May 1991 issue of *Life Magazine* ran a cover story describing a 150-year plan for a Martian metamorphosis through orbiting solar reflectors that would melt polar water, surface factories that would produce needed gases in the atmosphere, and the ultimate planting of hearty plant species as the temperature approached the freezing point of water. Today many articles, books, and Web sites continue to develop the theme.

Cyberspace is currently a lonely, dangerous, and relatively impoverished place for agents [1]. Consequently, most of today's agents are designed for short insignificant lives and a small and relatively static world. Though promoted as collaborative, agents do not easily sustain rich long-term peer-to-peer relationships, let alone any semblance of meaningful community involvement. While their features for secure reliable interaction are often touted, there is no social safety net to help agents out when they get stuck, or worse yet to prevent them from setting the network on fire when they go off the deep end. Despite the fact that agent designers want them to communicate at an "almost human" level, agents are cut off from most of the world in which humans operate. Though capable of self-directed mobility, they are hobbled by severe practical restrictions on when and where they can go. Ostensibly endowed with autonomy, an agent's very existence can be terminated unceremoniously by the first passerby who happens to find the power switch.

In short, the kinds of agents that we want—full-fledged citizens of the wired world, equipped with their own stamped passports and Berlitz traveler's guides explaining foreign phrases and places that allow them to hail, meet, and greet comrades of any sort in an open networked landscape and, if not able to team up on a project, at least able to ask intelligibly for directions—these kinds of agents, alas, exist today only in our imaginations (and, of course, in the vision sections of our research proposals).

What will it take to terraform cyberspace? At a bare minimum, pervasive life support services (relying on mechanisms such as orthogonal persistence and strong mobility [7]) are needed to help ensure the survival of agents that are designed to live for many years. Beyond the basics of individual agent protection, long-lived agent communities will depend on "social institutions" to ensure their rights, enforce their obligations, and offer help when needed [2][5]. Although some of these capabilities exist in embryo within specific agent systems, their scope and effectiveness has been limited by the lack of underlying support at the network and system layers.

Fortunately, the basic infrastructure on which we can build the solutions to these problems is becoming more available. Designed from the ground up to exploit next-generation Internet capabilities, *grid-based* approaches aim to provide a universal source of dynamically pluggable, pervasive, and dependable computing power, while guaranteeing levels of security and quality of service that will make new classes of applications possible [3]. By the time these approaches become mainstream for large-scale applications, they will also have migrated to ad hoc local networks of very small devices [4].

Tomorrow's world will be filled with agents embedded everywhere in the places and things around us.

Providing a pervasive web of sensors and effectors, teams of such agents will function as *cognitive prostheses*—computational systems that leverage and extend human intellectual, perceptual, and collaborative capacities, just as the steam shovel was a sort of muscular prosthesis or the eyeglass a sort of visual prosthesis. Thus the focus of AI research is destined to shift from Artificial Intelligence to *Augmented Intelligence* [6].

Once we have terraformed cyberspace, agents will be freed from their current role as short-lived visitors on the wire to permanent colonists in a virtual world where we can feel comfortable with not knowing or caring exactly where they are being physically hosted. They will truly live among us and we will wonder how we ever lived without them.

References

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