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BLUE YONDER COMPUTING IN THE TWENTY-FIRST CENTURY

KNOWLEDGE IS ANATOMY

I'd like to introduce some terms and concepts I've used and modified in my fiction, to lay a foundation for my own desiderata for petaflops computers. Most are familiar, but they may be used in unfamiliar ways.

I'll begin by saying that my principal concern is weather, but I may not mean the same thing using that word that you do.

Theoretical background:

1. The study of evolving systems has become important in sociology, politics, economics, physics, and computing, as well as in biology. The concept of an evolvon (my word) includes any unitary system that takes advantage of growth opportunities through 'learning' and adaptation to changing conditions. Compounded evolvons inevitably interact to form an feedback-rich community: an ecosystem, or *ecos*, plural *ecoi*. Until now, evolvons have been found only in biological systems.

2. Built into any evolvon is a larger-scale drive for expansion and the ability to survive in changing conditions. These qualities demand a learning and self-organizing system similar to that found in the brains of all complex living things. Evolvons within an ecos, and the ecos itself, acquire form and complexity much the same way a baby acquires language. (And ecoi themselves, considered on a larger scale, become evolvons again, in, say, a global, galactic or universal context.)

3. 'Learning' is the process of acquiring information and transforming it into 'knowledge', that is, physico-chemical structures that eventually control or guide physical action. Information is generated by the environment and is encoded by the evolvon into knowledge. In all biological systems, knowledge is stored in dynamic physical structure, whether it be cellular machinery or a full-scale brain.

4. Living things work best when they are, in part at least, self-programmed; that is, when they explore and mature in setting for which evolution has suited them. They adapt or digest information into knowledge, (in essence modeling or "compressing" the environment in cellular chemistry), and use this knowledge to absorb nutrients or energy, reproduce more effectively, and occupy more space.

5. Complex systems, including ecoi, have "weather" and share chaotic properties which make numeric modeling difficult and absolute Leibnitzian prediction impossible. Living neural systems overcome this by relying on rich multi-track processing of information which produces a *hypothesis* or preliminary model. The hypothesis is then compared with further information and the results of action. Success or positive feedback fixes the hypothesis as knowledge, until it is replaced, through another modeling process, usually by more effective knowledge. Knowledge is expressed as behavior.

n biological systems, anatomy becomes behavior.

Implications of Evolvons and Weather for Petaflops Computing

Modeling of complex systems through numeric manipulation involves time-consuming translation of analog into digital data. Brute-force number crunching has led us into new understanding and produced sophisticated new tools. It has also given us tantalizing glimpses of as-yet-impossible tasks. And we still have not broken down the barriers between computer and computer user and programmer. Computers remain tools; programmers remain tool users. Knowledge is important only to tool-users.

Program size tends to expand with computer power, as users feed programmers more sophisticated problems and ask for better answers. Super-fast computers on the petaflops scale will likely force programmers to use new methods to compile and debug computer programs.

With parallel processing systems, programming and debugging can become an enormous burden. One solution could be designing petaflops computers to be neural or neural-like and to self-program, or evolve their own software.

Evolving software has long been discussed and experimented with, but superfast computing may make it essential.

In a petaflops computer's infancy, programmers may first encourage evolutionary development of basic algorithms which survive or are erased according to size (lines of code) and efficiency; these objects, or code evolvons, can then undergo self-assembly into more and more complex problem-solving structures.

(Another name for these routines could be "bugs." Perhaps we should be encouraging bugs in our computers!)

Commonalities of software may not be an issue. It is not difficult to imagine a future in which petaflops computers will be produced in mass quantities and sent off to be educated and to evolve their own individual programming in special factory 'school rooms.' Those computers or thinkers which receive high grades will be passed and delivered to their users. Those which don't, ~~will be delivered to their users~~ I mean, will be wiped and recycled.

It's conceivable that sympathetic designers will look for computers which show aptitude in areas not yet understood or explored. These 'geniuses' will be given special status within the company and studied further.

These self-evolved machines will of course have to speak a common language to each other, and to us.

Now we are blurring the distinction between computer and programmer, between tool and tool-user. Computers will themselves become tool-users as they request more information or capabilities not conceived of in the original design. At some stage, programmers may be relegated to black-box checkers, or 'parents.' Programmers may come to think of their computers as offspring.

Computers will become 'thinkers.' Thinkers may in turn regard their programmers as tools rather than users.

WEATHER

whether or not petaflops computers will be digital or analog, neural or non-neural in design, they will b particularly adept at focusing our information telescopes on problems involving chaotic feedback-rich processes, which I give the general term 'weather.'

Ecoi undergo weather, with equilibrium punctuated by storms of extinction and speciation. Societies also undergo weather; social hurricanes are called wars or revolutions. Money has a kind of weather, with high and low pressure systems, or bull and bear markets, inflation, and recession.

As massive number-crunchers, even neglecting any neural design, petaflops computers could still revolutionize the way we solve problems and model 'weather'. With sufficient computing power, we could take a Feynman approach to problem-solving, with huge numbers of pathways to solutions analyzed by a kind of sum-over-histories. Depending on the criteria for choosing the most likely or desirable solution -- least energy, least money, least action, or whatever rule you want to apply -- a petaflops computer could almost literally collapse the wave function of a problem.

And there's always the possibility that a computed model becomes so large it takes on chaotic properties similar to its original!

Knowledge changes our brains. It becomes anatomy, and anatomy expresses itself as behavior. Ability and knowledge together equate personality. Personality through history becomes culture. Our culture is shaped by the engines of our knowledge. These machines, our offspring and quondam servants, will change all that we know and expand what we can know, and shape all that we will become.

If ever we have faced the challenge of stuffing history into a box, it is going to be with these superfast thinkers.