

The Universe as a computer: philosophical speculations on additional similarities.

Tariq Khan
Department of Computer Science
University of Nebraska at Omaha,
Omaha, Nebraska, USA

*"And when I have understanding of them, I shall have understanding of computers.
And when I have understanding of computers, I shall be the Supreme Being!"*
--Time Bandits

With the Holographic Paradigm, in essence, the entire Universe becomes representable as 2-dimensional data on the inside of a finite (critical point that it is non-infinite) surface area of a very large sphere - see recent observational data supporting this shape of the Universe over past models suggesting a flat Minkowski or De Sitter shaped Universe.

The comic expression, in the business world, that "everything in existence can be put into a spreadsheet," might not be so far from the truth after all. So, let's examine this analogy. When working, let's say, on an excel spreadsheet, there reaches a point where the laptop computer's CPU computational resources run out, even if the spreadsheet size does not exceed the maximum size, for example if one inputs a command to modify all the cells in a very large matrix within the spreadsheet. Now the spreadsheet software might crash or hang as the processing works to complete all of the requested work, but our Universe, by comparison, is always consistent (as far as we have observed) and dynamic i.e. moving forward in along an "arrow of time." Of note is the exception of black holes where the flow of time is believed to not exist. Black holes and really wonder of our Universe and perhaps hold the key to our reality or any possible reality beyond. They seem to exist almost as a curtain or veil, quite literally, behind or beyond which we cannot see an implied "outside" or the gears of our Universe or multiverse or in theory a Platonic meta-verse.

If we continue with this spreadsheet analogy let us compare the spreadsheet cell processing limit with say an attempt to "keep track of" a large number "quantum entangled" particles i.e. keeping track of all these "relationships." Prescient work by MIT's Seth Lloyd, as detailed in his book *Programming the Universe*, note that the physics of building "the ultimate computer" will, via the laws of General Relativity (gravitation) and thermodynamics, end up with that extremely dense and hot incredible computer hitting a limit at which point it becomes... a black hole! Now most would interpret this situation as the gravitational mass of the computer ultimately leading to the collapse of the system into a black hole. But perhaps this is not the most accurate description of these events. Perhaps it is the case where, if that computer had not been prevented from increasing its processing speed (it was collapsed into a black hole), then it would have become faster than the processing speed of the Universe itself. Perhaps the Universe then is thus designed with this as the true intrinsic design limitation. In essence, to ensure that the Universe remains internally consistent, and perhaps with any metaphysical mechanism always hidden, the Universe has a built in law that a computational system can never exceed the Universe's "performance" for, if it did, it might create violations to the consistency of the Universe?

Now naturally we assume here that the Universe is a computer (quantum or otherwise) but this idea is not so outlandish considering other aspects of our Universe analogous to a computer. Just consider these many agreed upon points in modern physics and cosmology:

- in special relativity it is the communication of "information" that is forbidden from exceeding the speed of light.
- the speed of light itself is another limit and is the critical benchmark upon which attributes like matter and energy and distance are defined, derived from $e=mc^2$ algebra.
- quantum mechanics depends on observers that we can consider a form of processing as they can cause the decoherence or collapse of quantum states, or Universes to split, or at least decisions to be made given a binary choice.
- every fundamental particle is exactly identical implying encoding as an a priori given and a sort of video game or computer screen simulation "pixilation" analogy.

- Quantum Mechanics, as we understand it, requires the use of infinite numberline complex numbers that, as far as we can tell, do not or cannot physically exist in a finite Universe - implying an external reality "where" our Universe is encoded, instantiated, or simulated in or from or upon. Granted the very nature of language must be considered in attempting to describe that which lies beyond perhaps akin to the famous quote from Wittgenstein.
- the aforementioned Holographic Paradigm was derived from research of thermodynamics and black holes where the surface area and not the volume of the black hole contains all of the information to describe or encode the system - again leading us full-circle back to our spreadsheet analogy.

But with our spreadsheet example, to prevent it from locking-up or crashing, the user must often perform "bulk" actions like filter or delete actions to "cleanup" areas in order to free-up computational resources which are the true limiting resource in the processing actions of our spreadsheet work. Again, simply build a large 150,000 cell or row spreadsheet and see if it never crashes when attempting to modify every cell or value. Again, in this concept of preventative bulk clean-up actions or delete actions we see a real-world analogy to... black holes!

In short, maybe the limiting factor of the Universe, that could be kept "working" or "available" via black holes as "clean-up" mechanisms, is a "maximum computational rate" of performance that cannot be exceeded - just like our Hertz measured processors in our PC CPU. In essence, like a computer, where the CPU needs RAM memory (and power) or rather will not work perfectly if it runs out of it, perhaps there exists a real-world analogy where black holes really exist primarily to prevent the Universe from "running out of operational memory" or from crashing, i.e. if black holes did not exist, the Universe might have situations where it simply (like our spreadsheet processing) will "fail to perform" and thus become inconsistent. Can we thus produce, or deduce, the Universe's processing power given the physics (thermodynamics) of black holes, General Relativity with gravitational constants, Special Relativity with the speed of light "c" from $E=mc^2$, and Quantum Mechanics with Planck-scale distance and time minimum values. These concepts again are discussed in Seth Lloyd's books and papers, but my goal is to speculate on "why" the Universe is constructed the way it is and perhaps why certain items like black holes exist and to propose philosophical aspects or areas of further analysis.

Let us again consider our Universe as inside a boundary horizon that is a sphere. Again, assuming the Holographic Paradigm, then our entire three-dimensional Universe is akin to a hologram created from information encoded on the surface of that two-dimensional sphere. So, let us again consider the amazing observational evidence where, 1) every electron is exactly the same and, 2) our reality, built upon Quantum Mechanics appears to be, or to "enforce," consistency. One may think they can trick or circumvent the Universe e.g. Delayed Choice Quantum Eraser experiment photometers and interferometers (from John Wheeler), but the Universe so far seems to always "win" in these experiments and it even goes so far as to "erase" the past to ensure it will remain consistent and not violate foundational quantum mechanical laws. This is an incredible result from which one could imagine a Platonic Universe, where a priori coding "is", that contains all Universes, where exists the only infinity, and that "enforces" this consistency across every universe in the multiverse).

Now let us also remember that there is no true or perfect vacuum, i.e. actual absolute "empty space," at least within our quantum mechanical constructed Universe. Following from the Heisenberg Uncertainty Principle, if our Universe was a true vacuum, then we would "know" any location in the vacuum and, at the same time, know exactly the momentum with the latter as zero. It seems as if nature is subservient or enforcing a ruleset that was either pre-determined or necessary to enforce consistency of the entirety. The existence of virtual particles is considered proven fact and has been demonstrated, perhaps most eloquently via the Casimir Effect.

Let us also consider recent research from a pair of extremely bright minds (Leonard Susskind and Juan Maldacena 2013) where their worked coined the term "ER=EPR" which stands for Einstein Rosen (bridge or wormhole) = Einstein Podolsky Rosen (famous paper argument about "quantum entanglement" and "spooky action at a distance"). This latest research paper attempts to resolve the blackhole firewall paradox regarding information. The idea, in general, is that spacetime (everywhere) is actually stitched from a mesh of every particle being quantum entangled to another particle via super small wormholes.

Note also the resemblance of graphs of Dark Energy's rate of expansion to the graph of increasing link counts of fully-meshed networks. At least in regards to the expansion of the Universe (as observed in work to measure the acceleration expansion rate of Dark Energy), graphs of data showing the Dark Energy expansion rate are close to the $n(n-1)/2$ computer networking graph (perhaps analogous to the number of quantum entanglements) of the number of links (total connections/relationships) required to maintain a fully-meshed network as the number of nodes in the network increased. While particles, change location in space and position in time, they also change in terms of a degree of complexity or inter-connectedness or the number of relations or nodes "connected" to it (or maybe again considering quantum entanglement, the total count of entanglements now or now and in the past in a Universe that is processing and tracking state). Thus, perhaps the increasing rate of expansion of the Universe via Dark Energy could be actually just spacetime itself dynamic (and processing like a computer) with an increasing number of connections or perhaps the entire Universe literally is a fully-meshed network perhaps with quantum entanglements starting at the Big Bang.

Let us again consider our Universe to be "processing" since our attempts to "trick" it, or to find any flaw or violations in fundamental quantum mechanical tenants over the years, has always failed. The Delayed-Choice Quantum Eraser experiments have shown that our quantum mechanical reality is dynamic with, in theory, states being tracked akin to data being processed with past, present, and future analogous to input, calculation, and output. So if we assume our holographic boundary or, whatever lies beyond, is processing and tracking states and relationships of these particles and entanglements (wormholes), then our boundary is going to have a lot of "stuff" to keep track of while, at the same time, ensuring there is never any errors or inconsistencies. Following this train of thought, one could imagine that this level of complexity or this amount of processing workload might be the reason we have a universal speed limit represented as the speed of light "c" and why it has the value it does. In essence, this could provide the "why" answer to the existence of a constant speed of light as it might literally represent the maximum limit or rate that our Universe boundary can process changes in information related to the state and relationships of every particle and wormhole (quantum entanglement). In short, the fastest that our 2-D holographic boundary can process this "information" (that is measured by an observer, so it must be consistent) is the speed of light.

Now remember gravity attracts stuff- actually basically everything. So if we keep attracting more and more stuff (in theory creating more and more relationships and particles closer to each other thus allowing more and more changes and changes occurring faster and faster thus leading to a vast increase in the number of states and relationships to keep track of) we get denser and denser until a threshold is reached. Here it is as if our Universe "pulls the curtain" to prevent any observer from seeing a processing "abort" or "runtime error" or, in essence, the processing might stop and we have our information washed out into a black hole boundary - or perhaps our Universe simply crashes behind the curtain of the black hole. It is as if the Universe cannot keep-up, so it removes all those relationships and removes it from the "video screen" of any possible observer. It throws up a boundary curtain - an event horizon of a black hole. But we remain consistent and there exists no "beyond" our Universe's processor rate capability. Seth Lloyd at MIT in his book about the Universe as a quantum computer did calculations on the limits of a perfect computer. He details how it gets faster and hotter and hotter and denser until it becomes... a black hole.

Thus, returning to the original analogy, we now have supporting evidence for the analogy of how the existence and creation of black holes is similar to deleting spreadsheet cells in a program to prevent the failure of the program. If there is too much "stuff" and a crash would be imminent, our Universe literally removes it from "the screen" of any observer. It is as if our Universe must remove it. If not, our primary rule of consistency could be broken and our primary processing limit of the speed of light could be violated which again, since this could lead to processing faster than our proposed maximum Universal processor rate which could lead to the not permissible inconsistency, i.e. the Universe would not be able to "keep up with" any violations or to create blackholes when or where needed to "hide" or prevent them.

If we believe or can prove some or any of these proposals to be true, then our Universe should not be viewed then as "behaving like" a computer or a program or simulation, but rather that it actually is one.