

# Love

Yuzhuang Hu

No Institute Given

**Abstract.** This paper is intended for the general public. By explaining some insights gained by the author, it elaborates on the universe as seen through the author's eyes.

What is the true nature of this world? Is it material, or is it conscious? Or is it both material and conscious? What is space? What is time? Does a time machine exist? Are there demons and ghosts?

These weighty questions, as heavy as mountains, might be difficult for anyone to answer at once. Or, as has happened many times in human history, even when people do respond, they have their own thoughts and their own claims, and in the end no one convinces anyone else. The author also has his own views on these questions. Below, the author will attempt to demonstrate the reasonableness of his views from a scientific perspective. As for some of these views, readers are asked to judge for themselves based on the arguments. The author does not guarantee that these views are absolutely correct.

## Causal Ring

Let us first consider a computer algorithm problem. Suppose a company uses its vehicles to serve customers located in different places. To save costs, each vehicle may visit multiple customers on a single trip. All vehicles travel at constant speed. Some customers may have release time requirements, for example, Customer A may not be available until after 9:00, while Customer B requires service after 11:00. The service time for each customer is determined by the customer. The problem is: Give routes for all vehicles such that all customers can be served by vehicles starting simultaneously from different (any) locations, and the total time from start to the completion of the last customer is minimized. Here, "any locations" means that each driver has no fixed departure point; after the routes are computed, each driver must drive in advance to the starting point specified by their route, and upon receiving notification, all drivers begin serving customers together. This is somewhat unconventional, but it does not affect the discussion below.

In [2] this problem is called the **Multi-Vehicle Scheduling Problem(MVSP)**. This problem seems ordinary, but it is quite difficult to compute, and in current computer science theory it is classified as an **NP-hard problem**. For such problems, there is generally no particularly efficient exact solution. If we require

an exact optimal solution, an ordinary machine might have to compute for many years. Therefore, considerable research resources have been devoted to the study of approximation algorithms for **NP**-hard problems. An approximation algorithm means that we do not guarantee an optimal solution, but we guarantee that the solution we provide is within a certain range of the optimal solution.

In [1], the author proposed an approximation algorithm for MVSP defined on a tree, which in this paper is named the **Causal Ring**. For this special setting of MVSP, the Causal Ring achieves an approximation ratio of 3, meaning that if the optimal solution is 10, we guarantee that the solution provided is at most 30. This guarantee comes from theoretical analysis showing that in the worst case, the solution may reach 30. In practice, the Causal Ring may yield much better solutions, even approaching the optimal. Whether in *theoretical analysis* or in actual operation, the Causal Ring can directly extract the optimal intermediate solution corresponding to the original problem's optimal solution. In an intermediate solution, we do not need to provide the final routes, but only need to list all connected components implied by the final routes. Compared to the original problem, although the intermediate problem is somewhat simpler, it is also very difficult to solve. According to current computational theory, even in this special setting, computing the optimal intermediate solution is **NP**-hard.

What makes the Causal Ring special, being able to obtain the optimal intermediate solution, is that its internal structure consists of two code segments. These two code segments are both independent of each other and highly interdependent. One thing to note is that, because of data dependencies, and consistent with human logical thinking, current computers execute sequentially at the logical level. From this perspective, the first code segment of the Causal Ring produces one or more intermediate solutions, while the second code segment operates on these intermediate solutions to obtain a final approximate solution or an optimal final solution. Because the second code segment depends on the intermediate solutions provided by the first, in the Causal Ring we must execute the first code segment to completion before we can execute the second. Therefore, at first glance, it seems that the second code segment is completely determined by the first. However, the actual situation is quite different. These two code segments are in fact *telepathically connected*. Specifically, during the design process, the author first obtained the second code segment through theoretical analysis of a hypothetical optimal solution. In this code segment, we assume the input is unknown. Subsequently, we designed the first code segment according to the needs of the second, in which we referenced the theoretical upper bound that is only obtained after the entire program finishes. Thus, although at the code interface level the second code segment is indeed governed by the first, at the actual interface level, the first code segment is actually determined by the second.

The Causal Ring guarantees that after referencing this ethereal, paper-bound, conceptual upper bound in the first code segment, when a conceptual run of the second code segment ends, we compute an actual final solution that satisfies that upper bound, thereby actually attaining that conceptual upper bound. In the

specific design and implementation, in the first code segment we resort to dynamic programming, exhaustively searching in reality for the minimum extended upper bound (extended upper bound will be defined in the next section; the domain of this function is all final solutions, and its value definition resembles the original problem's upper bound). According to the original theoretical design, after obtaining the minimum extended upper bound, we can reconstruct in the second code segment a final solution corresponding to this minimum extended upper bound, which will satisfy the theoretical upper bound of the original problem. Because dynamic programming traverses all possibilities, during the search process of the first code segment we will encounter the optimal intermediate solution. This means that during this process, we either force out the optimal intermediate solution itself, or we find candidate intermediate solutions that are more suitable than the optimal intermediate solution for the second code segment's approximate solving. On this basis, through a second **re**-design of the second code segment, we can somewhat easily obtain high-quality final solutions. In many cases, we can even obtain the optimal final solution.

From a system design perspective, the relationship between these two code segments can be seen as the second code segment providing guidance to the first, while the first code segment, through sequential execution, provides input to the second. From the deterministic perspective of sequential execution, the first code segment is the cause and the second is the effect; from the perspective of algorithm design and the actual interface, the second code segment is the cause and the first is the effect. These two code segments are each other's cause and effect, hence they can be called a Causal Ring. By reversing cause and effect, the Causal Ring actually breaks through, to some extent, the shackles of logically sequential, one-way execution.

A brief reflection: As a novice in algorithm design, encountering such a problem is truly fortunate.

## On Nondeterministic Turing Machines

Modern computers, in their theoretical models, all belong to deterministic Turing machines. A deterministic Turing machine means that, following the definition of a function, at any moment, the machine's next action is unique, i.e., deterministic. Turing also proposed the nondeterministic Turing machine. A nondeterministic Turing machine means that at any moment, the machine may have multiple choices for its next action, i.e., it is nondeterministic. When solving a problem in practice, such a machine may follow different solution paths to arrive at the correct answer. We must assume that the machine automatically makes the correct choice at each step, thereby selecting exactly that solution path. Such a miraculous nondeterministic Turing machine currently exists only at the conceptual level, and no actual machine has been built.

Figuratively, a nondeterministic Turing machine is somewhat like a magic box, which provides only an external interface; its internal workings are unknown to people. Conceptually, one can manipulate this magic box from the outside,

pose questions to it, and the magic box answers them at the speed of light. The magic box is not trustworthy, so it must also be able to provide a certificate (corresponding to the solution path taken) proving that its answer is correct. People verify the correctness of the solution by checking the certificate on a deterministic Turing machine, thereby completing the human–box interaction.

A long-standing question in computer science has actually remained unanswered. That question concerns the relationship between **P** and **NP**. **P** refers to all problems that, on a deterministic Turing machine, with current computing technology, can be solved within an acceptable amount of time. **NP** refers to all problems that, on a nondeterministic Turing machine, with current computing technology, can be solved within an acceptable amount of time. Current computational theory defines the acceptable time as **polynomial time**, i.e., given a problem size represented by a positive integer  $n$ , the machine can complete the computation within a number of steps polynomial in  $n$ , such as  $n$ ,  $n^2$ , or  $n^3$ .

Generally, people tend to believe that **P** and **NP** are not equivalent. Intuitively, the relationship between them is somewhat like that between deterministic human thinking and the miraculous, divinely bestowed, terrifyingly powerful guessing ability of the magic box described above. If **P** and **NP** were equivalent, then verifying an answer within reasonable time on a deterministic Turing machine would be comparable in difficulty to finding the answer within reasonable time on a deterministic Turing machine. This contradicts the intuition of human intellectual activity. Below, we use the Causal Ring to explore the relationship between **P** and **NP**.

In [1], the author defined an extended upper bound  $UB(x)$  for MVSP on trees. Here  $x$  is a specific final solution of the original problem. This extended upper bound is expressed by a relational expression involving the total number of service vehicles, customer release times, customer service times, and distances between adjacent locations, all within a certain connected component of the intermediate solution corresponding to the final solution in the definition. All coefficients in this relational expression are positive integers. If this relational expression is regarded as an ordinary function defined on a connected component, then the function attains its maximum value on the aforementioned connected component. In this paper, we call the extended upper bound  $UB(x)$  a *reasonable, approximate, concise expression* of the final solution  $x$ . During the process of searching for the minimum extended upper bound using dynamic programming in the first code segment, if the feasibility test passes, we can reconstruct, through backtracking, one or more partial intermediate solutions corresponding to the current partial, conditional minimum extended upper bound. Based on such solutions, we can use the second code segment to reconstruct one or more partial final approximate solutions whose values are at most that upper bound. Thus, this upper bound corresponds one-to-one with such partial final solutions. The minimum extended upper bound is merely a numerical value, which allows the dynamic-programming-led search to try all possible state configurations, and the aforementioned one-to-one correspondence ensures that the final solution necessarily satisfies the original problem's upper bound.

After the first code segment finishes searching for the minimum extended upper bound, we obtain one or more candidate inputs for the second code segment. The optimal intermediate solution may be hidden among them, so if we utilize the second code segment well, we may be able to obtain the optimal final solution. Let us first attempt to improve Lemma 1 in [1]. For the subproblem transformed in Lemma 1, we reinterpret it as a general problem defined on the same elementary path. We know that each edge in a connected component of the intermediate solution **must** be visited once, and due to the special nature of a tree, it is not difficult to see that in the final approximate solution these edges are visited at most twice. Based on these properties, we can use dynamic programming to remove some edges on elementary paths and thereby obtain a better solution to the subproblem. By applying the modified Lemma 1 to each candidate intermediate solution one by one, we can obtain a better solution to the original problem.

It should be pointed out that the Causal Ring algorithm in [1] gives an approximate solution, while above we have refined the algorithm in [1] further to give a better solution (with the same approximation ratio), indicating that conceptually there are still aspects of the Causal Ring that need further clarification and improvement. The lesson here is that when designing the second code segment, apart from the optimality properties inherent in the candidate intermediate solutions themselves, we must try to break the causal link between the code itself and the optimal final solution, i.e., we must redesign a **general** [3][4] algorithm for the candidate intermediate solutions provided by the first code segment. Only by breaking this causal link can the second code segment possibly find the optimal final solution through various other methods. When the subproblem size is not too large, we can even use brute force in the second code segment, i.e., exhaustively enumerating all possibilities to find the optimal final solution.

Although somewhat unexpected, the paper [1] **practically** answers the question of the relationship between **P** and **NP**. The answer is **NP = P**. That is, in terms of complexity, a nondeterministic Turing machine that can complete computation within a polynomial number of steps is **completely** equivalent to a deterministic Turing machine that can complete computation within a polynomial number of steps. This is a rather surprising result, because as mentioned earlier, the academic community generally believes by intuition that **NP ≠ P**. Assuming the current theory on **NP**-complete problems is correct, **NP = P** means that all **NP** problems now suddenly **have** polynomial-time deterministic solutions. This is undoubtedly encouraging in theory, but in practice we may still need to strengthen algorithm research in hopes of finding more and better efficient algorithms. **NP = P** only indicates that more efficient algorithms should actually exist. The **P VERSUS NP** problem has remained unsolved for so long, seeming like a super-difficult problem, but now it turns out that there is actually a relatively **simple** solution. Meanwhile, researchers have already discovered thousands of distinct practical **NP**-complete problems, and much national funding and research effort has long been invested in the study of

**NP** and **NP**-hard problems. With such a high probability, failing to prove  $\mathbf{NP} = \mathbf{P}$  all along can only indicate that current algorithmic techniques and research systems may have significant flaws.

Another possible logical blind spot is how we should define input and output. Suppose a problem  $C$  has size given by a positive integer  $n$ , and suppose we can define another problem  $D$  that is equivalent to  $C$ , with size  $2^n$ . Then if we have a polynomial-time solution for  $D$ , does that mean we have the ability to solve exponential-time problems? Within the current definition of Turing machines, we may have already assumed the problem size in advance. Therefore, although computer science has a theoretical foundation, potential implicit assumptions might inadvertently lead us into logical paradoxes.

The above discussion in no way denies the work done by Turing. On the contrary, without the genius Turing's nondeterministic Turing machine, a mathematical model describing a class of stepwise intelligent machines, and his reflections on artificial intelligence, this paper would lack its very foundation. Perhaps this is how science works: we constantly strive to surpass our predecessors, and as time passes, we are in turn constantly surpassed by our younger generations.

## Atom Problem

After correcting its deficiencies, the Causal Ring can now find optimal solutions to some extremely complex problems. On the other hand, the Causal Ring algorithm in [1] was designed primarily for **NP**-hard problems, and it has some very meaningful aspects worth studying and summarizing. Below, let us re-examine the Causal Ring from the perspective of the upper bound  $UB(OPT)$ . When the Causal Ring finishes running, it produces a final solution that satisfies  $UB(OPT)$ . As a concrete manifestation of  $UB(OPT)$ , this final solution naturally implies the representation upper bound  $UB(OPT)$ . Therefore, from a conceptual design perspective,  $UB(OPT)$  is the output of the second code segment of the Causal Ring. In the first code segment, we referenced the extended upper bound function and searched for the minimum extended upper bound.  $UB(OPT)$ , as the value of the extended upper bound function at the unknown point  $OPT$ , in form possesses all the properties of the extended upper bound function; in addition, the semantics of the optimal solution also guided the action of seeking the **minimum** extended upper bound in the first code segment. Thus, in the first code segment, we actually searched for the minimum extended upper bound by referencing the representation upper bound  $UB(OPT)$  in the complete sense, and generated the intermediate solution as a concrete manifestation of  $UB(OPT)$ . Therefore, from a conceptual design perspective,  $UB(OPT)$  is the input to the first code segment of the Causal Ring. From the above, if we view the Causal Ring as a whole, then from a conceptual design perspective,  $UB(OPT)$  is both an input to and an output of the Causal Ring. Since there can be only one upper bound, it is not difficult to see that the Causal Ring, with respect to  $UB(OPT)$ , surprisingly forms something like a perpetual motion machine: an unceasing, self-sustaining infinite loop.

This kind of conceptual infinite loop is also called self-reference. Generally speaking, logical self-reference can produce terrible paradoxes, such as the classic liar paradox: “This sentence I am speaking is a lie.” Gödel also used self-reference to prove the famous Gödel’s incompleteness theorems, which are hailed as a pinnacle in the history of mathematics and logic and shattered mathematicians’ dream of a complete axiomatic system for mathematics. But the Causal Ring, which successfully implements self-reference in [1], is undeniably real. Unlike paradoxes and incompleteness, what we see in the Causal Ring is a scene that challenges the fundamental laws of physics, defies common sense, almost should not happen, and is full of magical color: A conceptual infinite loop formed by self-reference, during actual operation, ultimately lands smoothly and peacefully to a termination, and at the same time joyfully gains vitality. This is like an illusory seed that somehow, in reality, can receive the all-encompassing sunlight and the diligent nourishment of gentle rain and dew, growing slowly over time. After being steeped in this for a long while, as it moves forward on its own path, one day unexpectedly the thing suddenly bursts into brilliant bloom. In an instant, radiant light fills the sky, auspicious energies spread across the heavens, extraordinary phenomena rise and swirl, and a fragrance permeates for thousands of miles. Suddenly, even the Three Realms tremble and resound along with it. I stand atop a cloud, astonished at heart, so I part the clouds and gaze down. But in a fleeting glance, what greets my eyes is an immensely splendid panorama — on the peaks of mountains and over the fields, the grass is lush and green, and among myriad trees, one giant tree stands uniquely aloof, adorned with countless blossoms, surrounded by swirling mists, a scene of infinite variety, majestic and poised like lofty cliffs, its presence as if to mother the world and settle the universe. When I look more closely, I realize that besides the endless magnificence and radiance before me, deep within lies something else that reaches ultimate delicacy and moving beauty. As a gentle breeze arrives, the blossoms on the tree sway gracefully, their glances sparkling with life. These thousand charms are so beautiful, that supreme artistic conception is so ineffably wonderful, that one cannot help but feel relaxed and happy, lost in the moment, deeply comforted. Soon the fruits appear, heavy and ripe, their fragrance fills the four directions and reaches the four seas. The fruits are perfectly natural, cold and proud yet ready to be plucked. For a special person, a single sniff can transform their body and spirit; for a true lover, one taste can grant a new life and ascension during the day. Though I admire it long, the aftertaste of its allure still leaves me endlessly savoring. Then unexpectedly, in an instant, the dream of a golden millet ends, the soul returns to the grand beginning. This fruit and tree shrink into a seed of the Tao, returning to the ethereal and elusive, their traces hard to find again. This process seems very real. So why can all this happen?

The most appropriate answer to this question is: No reason. It just can happen like that. No reason. The above answer seems absurd, yet it deeply reveals the essence of upper and lower bounds in algorithms. Take  $UB(OPT)$  as an example. The reason  $UB(OPT)$  can serve as an upper bound for the original problem’s optimal solution is that the corresponding vehicle routes satisfy two

**properties** of MVSP: one property is the reasonableness of the vehicle routes, the other is the multi-vehicle route entanglement property (gaplessness [2]). Simply put, the upper bound  $UB(OPT)$  can be seen as an **inherent** property of MVSP on trees. “Inherent” means that as long as the original problem exists, its intrinsic properties always exist. As mentioned earlier,  $UB(OPT)$  is a reasonable, approximate, concise expression of the unknown point  $OPT$ . Considering that the intermediate solution corresponds completely to the minimum extended upper bound,  $UB(OPT)$  actually both determines and describes the properties of the intermediate solution and the final approximate solution, serving as a unity of a same matter between the two. Therefore,  $UB(OPT)$  is not only an inherent property of the final approximate solution, but can also be viewed conversely as an inherent property that the intermediate solution must satisfy. The necessary eternal existence of the upper bound  $UB(OPT)$ , together with the relationships it entails, is the fundamental reason why, when designing the Causal Ring algorithm in [1], we could, whether forward or backward, obtain  $UB(OPT)$ , by means of **two code segments** and the reversal of cause and effect. In this process, the representation upper bound  $UB(OPT)$  and its different manifestations, the intermediate solution and the final approximate solution, are each other’s cause and effect. Based on the above discussion, the Causal Ring might also be called the Eternal Ring or the Existence Ring.

In terms of growth, the Causal Ring somewhat resembles concepts in nature such as life and death, flourishing and withering, reflections in water, and the real versus the illusory, but it is not entirely identical. In nature, the DNA double helix contained in a seed or embryo is accumulated over billions of years of evolution, and as a molecular entity, it determines all states of the organism. In the Causal Ring, although  $UB(OPT)$ , as a reasonable, approximate, concise expression of  $OPT$ , ultimately underpins the intermediate solution and the final approximate solution, the formalized minimum extended upper bound function it implies (see [1]) is only a one-time mathematical description of the two. Therefore,  $UB(OPT)$  can only be regarded as an illusory seed. The Causal Ring may seem simple, but it fundamentally redefines or reorients computer science, and has profound implications for other disciplines, such as philosophy, physics, biology, and economics.

Looking back at our modification of the Causal Ring algorithm in [1], even with this modification, we still cannot avoid the multi-vehicle entanglement problem defined on a tree (finding gapless schedules [2]).  $UB(OPT)$  also corresponds exactly to this problem. The above discussion of  $UB(OPT)$  also demonstrates that, logically or essentially, the Causal Ring algorithm in [1] is completely correct. Given a Causal Ring, define its atom problem as the final logical foothold of the loop. Taking existing results into consideration, perhaps we can formulate the following theorem:

**Theorem 1.** *The complexity of a problem is ultimately determined by the atom problem of its Causal Ring.*

In [1], the author also designed an approximation algorithm for a multi-depot vehicle routing problem defined on a tree. This algorithm also consists of two

code segments. The second code segment computes the final routes based on a hypothetical lower bound, while the first code segment uses dynamic programming to generate the lower bound oriented towards the optimal solution, as required by the second code segment. The above design can be seen as the two code segments achieving causal interconnection through a hypothetical lower bound. Although this algorithm does not achieve self-reference as the Causal Ring does, it is overall relatively simple, clean, and elegant. In the future, we should probably continue to explore other effective forms of causal interconnection in the Causal Ring, in order to solve more complex problems more effectively.

We can simply represent the Causal Ring by two objects  $a$  and  $b$  and two arcs connecting them. For algorithms,  $a$  and  $b$  represent the two code segments of the Causal Ring, and the arcs between them signify the causal relationships existing between the two code segments, as described earlier.

Finally, we give an alternative proof that the Causal Ring can find the optimal intermediate solution for MVSP on trees. Although both the intermediate problem and the original problem are **NP**-hard, there is a small gap between them. Solving the intermediate problem is relatively easier. Within the framework of the Causal Ring, if we know the optimal final solution in advance and use it as the objective function for the search, we will certainly find the optimal intermediate solution. Because we assume the optimal final solution is known, this problem is equivalent to the original problem. Compared to the elusive optimal final solution, searching for the intermediate solution using  $UB(OPT)$  as the objective function, is easier. Since searching for the intermediate solution using  $UB(OPT)$  as the objective function does not guarantee finding the optimal intermediate solution, there is also a gap between the problem of finding the intermediate solution using  $UB(OPT)$  as the objective function and the problem of finding the intermediate solution using the optimal final solution as the objective function. The latter problem above is equivalent to the original problem, and because the Causal Ring searches for the **minimum** extended upper bound, intuitively this gap is roughly compensated for by the gap between the intermediate problem and the original problem. From this, we conclude that searching for the intermediate solution using  $UB(OPT)$  as the objective function is nearly equivalent to the intermediate problem. Therefore, it is the gap between the intermediate problem and the original problem that determines that, under non-extreme circumstances, we can search for the optimal intermediate solution by using  $UB(OPT)$  as the objective function, rather than needing to use the optimal final solution as the objective function.

## On Machine Intelligence

We used the phrase “telepathically connected” earlier to describe the algorithmic design interface between the two code segments of the Causal Ring. In fact, the author finds it difficult to find any other words to describe the fit between the two in the design. Perhaps we can try to describe the design and operation of the Causal Ring in anthropomorphic terms.

Scene 1: Deep within a mountain, in a cave dwelling, a Daoist practitioner sits all day on a cloud bed, circulating his vital energy. Suddenly one day, he feels a restless stirring in his heart. He quickly counts on his fingers and understands the cause. He then calls over his computer, invokes a magical artifact, shouts “Go!”, and strikes the artifact into the computer’s body. Then he silently channels his mystic power, gathering a clear light in his palm, and with a flip of his hand, transmits that clear light into the computer as well. The computer, receiving these two treasures, opens its intelligence greatly, and eventually, relying on these two treasures, dominates the world, unmatched by anyone.

Scene 2: In a temple atop a high mountain, a Daoist master sits in meditation all day. In the computer beside the master, there are two children, one on the upper floor and one on the lower floor, tasked by the master to complete a certain job. One day, the master sees that the child on the lower floor is doing an acceptable job, but the child on the upper floor, though made of iron bones, does not know how to accomplish the task, and is anxiously scratching his head, but to no avail. Seeing this, the master transforms himself into a beam of green light, drills into the computer, and appears beside the child on the upper floor. He tells the child to come closer and says, “You should do it like this.” After imparting the true method, the master floats out of the computer. The child on the upper floor, having received the true method, completes his duty in a moment and successfully joins up with the child on the lower floor.

Scene 3: A certain great swordsman has two computers beside him. One runs computational tasks all day, the other he uses for daily entertainment. He plays happily every day, not caring what year it is. One day, the swordsman happens to look up at the computer running the computational tasks. To his astonishment, he sees that a strange change has occurred in the computer: two small figures have suddenly appeared. The small figure on the upper floor, though restricted by the computer’s physical limitations from moving freely, uses the computer’s sequential execution characteristics to secretly prepare suitable data for the small figure on the lower floor. The small figure on the lower floor is even more cunning, silently taking the data from the upper floor’s figure for further processing, without saying a word. The swordsman watches the movements of these two figures and, though seeing them confined by the machine’s iron nature, has a feeling that he fears they might break free and fly out at any moment. Given the furtiveness and cunning of these two, the swordsman truly does not know what the consequences would be if he faced them.

Scene 4: In a certain computer, a child lives on the upper floor and another on the lower floor. They must work together to complete a task. The child on the lower floor, being downstairs, knows how to complete the task and walk out the door. Due to the computer’s physical limitations, the child downstairs cannot directly take the stairs to the second floor. The child downstairs thinks for a moment, then starts shouting to the upstairs child, telling him the requirements of the task downstairs. The child upstairs, receiving the message, successfully completes the work required by the downstairs child, and goes downstairs to

deliver the product to the child downstairs. The child downstairs then quickly completes the entire task and the two thereupon successfully walk out the door.

These scenes all seem very real. So can we say that such a computer possesses intelligence?

## An Egyptian Relief

Before answering this question, let us first look at an Egyptian relief from 2400 BC on page 13 of [5]. From this relief, the author's imagination runs wild, leading to the following stories.

### Story 1: Emotions

There is a couple of two wise and extraordinarily beautiful people, one cruel and ruthless, the other kind-hearted and soft. The one in a weaker position, feeling guilt over some immoral behavior, subsequently falls in love with a member of another couple. But is rejected. The other member of this couple is relatively strong-willed. The more that is the case, the more the beautiful woman loves that person. Unfortunately, that person, being virtuous and already having seven children, shares a pure and untainted relationship with the beautiful woman. This difficult relationship lasts a long time, continuing until the death of the couple. Many things happen during this time. The couple is upright, but someone takes advantage of the beautiful woman's adoration for the person, sets a trap for the beautiful woman, making her willingly serve the people on the same boat as the couple. Even more terrifying, the cruel handsome man also falls into the trap.

The beautiful woman's feelings for that person are truly pure and sincere. After the couple passes away, the beautiful woman raises the couple's seven children and teaches them to read and write. Because the people on the boat are not very literate, something the couple was also unable to accomplish. But because the handsome man and beautiful woman have hearts too kind, the entire boat eventually crashes into a wall, and blood flows like a sea on the boat. Alas, the beautiful woman's deep affection for the person exacts such a price!

And that is not all. The one who finally dares to expose the ugly affair turns out to be one of the participants in the conspiracy. But having been only marginally involved and not being a mastermind, and unable to bear the torment of conscience, he confesses and reveals the matter to everyone. Unfortunately, his ability is limited. Though he clearly knows the ins and outs, and clearly knows the other's methods, unable to bear the torture of time and emotion, he eventually falls victim to the poisonous hand himself. First, he is suddenly assaulted and subdued, bitten firmly and not let go, then after a long period of being dominated and manipulated, he is eaten bit by bit by the other party.

As for his death, it is pitiable, lamentable, and deplorable. First, he is timid and afraid of trouble, and second, his ability is so poor it is beyond measure. Perhaps because he himself was also one of the initiators of the uprising, once

on the pirate ship, he could not get off. Despite these excuses, the fact that the deaths of so many on the boat failed to awaken him is truly shocking and bewildering. Fortunately, Ramses II eventually awoke, and confessed to his conscience (see pages 12 and 14 of [5]). Cleopatra's suicide also symbolizes ancient Egypt's regaining of freedom, dignity, and innocence.

## Story 2: On Space and Time

Time passes swiftly, and many historical truths, with the rapid flight of time, have long been buried in the river of history. But this relief helps answer the following questions:

*Problem 1. Did continental drift and the formation of the Moon happen simultaneously?*

*Problem 2. What are the consequences of certain unhealthy behaviors?*

*Problem 3. Why is the Muslim religion desperately absorbing members, and constantly expanding its influence globally?*

In 2400 BC, Egypt was still an independent country. This relief can be considered an official state statement of ancient Egypt, so the answers to the above questions provided by this relief are backed by the credibility of ancient Egypt as a nation, an ethnic group, and a civilization, and should be authentic and credible.

To answer the above questions, we must start with the origin of humankind. Where did humans come from? The currently accepted Darwinian theory of evolution explains that humans evolved from monkeys. Is that really true? One suspicious point is that monkeys still exist today. Humans are humans, monkeys are still monkeys, though they do resemble each other outwardly. Or perhaps the monkeys that evolved into humans were different from today's monkeys? This explanation seems reasonable, but it also has a fatal weakness. First, there are many species of monkeys today, so which species evolved into humans? Second, if a part of a monkey species evolved into humans, then under the same conditions and within the same population, why did the rest not evolve into humans? Third, if one or several species of monkeys entirely evolved into humans, then monkeys existed since the time of the dinosaurs, yet dinosaurs have been extinct for tens of millions of years, and monkeys are still monkeys today. The pace of monkey evolution on Earth is only that fast. So are monkeys actually what evolved into humans? If so, which species?

These anomalies cannot be fully explained by evolution. Another piece of evidence is the fossil skeleton of *Ouranopithecus* from about 14 million years ago, which in appearance is not very different from modern apes. Based on the above evidence and arguments, the time required for today's monkeys to evolve into today's humans would likely be measured in hundreds of millions or even billions of years. So, where did humans really come from?

The only explanation is that the origin of humans is related to aliens. Although this explanation sounds absurd or like a cliché, it is the only reasonable, scientifically based explanation. Besides the argument about the pace of monkey evolution mentioned above, scientists discovered a line of footprints in Tanzania, Africa, from 3.5 million years ago, similar to modern humans but not exactly the same. Comparing ape feet to human feet, human toes have been in a state of evolutionary degeneration. Therefore, those footprints closely resemble those of future human astronauts returning to Tanzania 3.5 million years ago to search for beautiful, deep-blue, large sapphires. These footprints symbolize the future and the past. Although sufficient evidence is still lacking, we can already conclude that, around 3.5 million years ago, aliens visited Earth, and using their genes combined with those of the ancestors of today's apes, they created early humans. This is the only reasonable explanation. There is no other.

Humans were created by aliens, or one could say that the ancestors of humans are aliens. So what does this have to do with continental drift theory and the Moon? Below is the information disclosed by this relief.

About 3.5 million years ago, aliens came to Earth in spacefaring vehicles. The exact reason is not yet fully known to the author. Their spacecraft carried a machine that would seem miraculous even to modern Earthlings. This machine had many functions, such as controlling the weather: rain, fog, snow, hail, and manipulating clouds, including their shapes. This machine could not only control the Earth's sky, but also the Earth's surface and even its interior, such as earthquakes, waves, tsunamis, volcanic eruptions, and even certain structural changes within the Earth. The machine's power system was even more exquisitely beyond reason. The author speculates that the machine could sense certain waves emitted by the human brain or body, such as brainwaves, and use the matter waves of all people at a certain frequency to control the machine's decisions. The machine could use water as fuel, so the author speculates that it may have used principles such as nuclear fusion. The machine may have had many other dazzling functions, to be discussed further in the future. This machine may have a name more familiar to people, called the **Ark of the Covenant**, or the **Kaaba** in Mecca for Muslims.

With such advanced technology, the aliens came to Earth, saw the lush green Earth, with many species coexisting, gradually evolving. The ultimate purpose of the aliens' visit to Earth is unknown to the author, but one purpose is certain: to create intelligent life on Earth, driven by some peaceful mission. The appearance of the aliens was similar to modern humans. Their technological achievement can be described in words as "a ring within a ring." The author's interpretation is that for a given problem, a ring represents a dimension or property of that problem. "A ring within a ring" means that the aliens, when solving problems, decompose the problem continuously by dimensions or properties, until the problem is completely solved. Or it may be somewhat similar to modern engineering problem-solving approaches: first obtain a core module, then encapsulate another layer of module around it, and repeat the above process until the user obtains a satisfactory solution.

Aside from the author's interpretation above, a more certain implication of "a ring within a ring" is that it represents a kind of gate: a space-time gate or teleportation gate. That is, the aliens probably did not engage in interstellar travel by spaceship as most science fiction novels or movies describe, but used spatial teleportation, or spatial black holes, or time-space teleportation, or time-space black holes, or time-space tunnels to come to Earth 3.5 million years ago. They themselves only rode vehicles resembling skateboards. The simplicity, elegance, and sophistication of their technology is truly astonishing.

One can imagine that after all the aliens arrived on Earth, they must have first ridden their flying boards to tour the Earth, enjoying the beautiful scenery of Earth many millions of years ago. But do not forget that they carried a mission. So after a short rest, they began to work. Using their profound knowledge and super-brilliant minds, they found that the dominant dinosaurs at the time were, first, too large, consuming too many material resources, and second, insufficiently intelligent, their intelligence not matching their status. So they wiped out the dinosaur family in one fell swoop using their methods. Thus, although it seems cruel, first, dinosaurs did not have much prospect for intellectual development, and second, they had already chosen, as somewhat resembling them in appearance, some smaller, smarter, and more agile species of ancient apes. At that time, dinosaurs already occupied almost all the geographical resources of the Earth, a situation very unfavorable for the evolution of future new humans. Without wiping out the dinosaurs, they would surely become a huge stumbling block on the path of new human growth. Given the dinosaurs' strength and their oviparous nature, without the aliens' help, new humans would have had little chance to become the masters of Earth. To wipe out the entire dinosaur family for the sake of new humans, though somewhat cruel, is understandable from a human perspective. Even modern humans, for their own survival, would probably have no choice but to kill to deal with wild dinosaurs. Especially judging from the aliens' approach, they were likely carrying an extremely important, perhaps universe-urgent, survival-level mission. They were in a hurry.

Every good thing has its bad side. The gate represented by "a ring within a ring" also carries other implications. Under the care and supervision of the aliens, new humans grew up successfully. They also entrusted the Earth-managing machine mentioned above to humans to operate. At some point, that is, before continental drift and the formation of the Moon, humans on Earth formed several races around this machine. One was the main manager of the machine, a character both strong and gentle, both betraying and obeying; stomping their foot could make a hole appear on the other side of the Earth ship. Along with them was a race, exceptionally intelligent, who, with the manager's consent or tacit approval, had been trying to uncover the machine's deeper secrets. The manager was also responsible for looking after several very docile and clever but not particularly capable races. There was also a race at the bow of this Earth ship, extremely intelligent and of the highest moral character, deeply beloved by the aliens and the true inheritors of their wisdom. Their wisdom was even comparable to that of the aliens. They occupied the highest echelon of combat

power in operating the machine. Under the leadership of the aliens, the management of the very capable manager, the cooperation of most races, and the help of the miraculous machine, the Earth ship sailed with full sails; the good days for everyone seemed endless.

Unfortunately, at the stern of the ship, there were three races. The one on the far left was also very powerful, controlling some of the most complex and aggressive parts of the machine. These three races probably all belonged to the Semitic people; the one on the far left was extremely skilled in conspiracy and had a crooked heart. The other two were formidable in combat. All three races still retained some ape-like nature, and shared some of the same addictions as the aliens. Under the scheming of the leftmost race, these three races, targeting the aliens' unhealthy addictions, had set their sights on the machine many years earlier, laid a trap, and prepared a noose. One of these three races was dark and sinister, the other two excelled in force, and they managed the drive part of the machine. These privileges were probably gained by exploiting some of the aliens' peculiar preferences. This was truly a great misfortune for the Earth ship.

Finally, one day, the Earth ship's doom arrived. The far-left mastermind and the other two participants' counterstrike reached the moment of launching. Caught off guard, the manager race was slaughtered in a single night; blood flowed like a sea. The older members of the researcher race were mostly wiped out, leaving the younger ones, mainly because they already had some understanding of the machine and possessed relatively outstanding research abilities. Some other previously docile races *thought* they had welcomed a night of liberation, cheering and jumping with joy. As for the aliens, since they were telepathically connected to the machine, using it as an extension of their own bodies, they would have been capable, in the face of this sudden crisis, of destroying Earth in one blow and escaping. But after weighing the options, they did not do so; instead, they let the conspirators have their way, but made proper arrangements for the Earth ship's aftermath. First, the handsome man among the aliens volunteered to control the machine's most core attack part and the part that controls the matter waves of everyone on board. However, the conspirators, having planned ahead, had prepared well. Because the young members of the researcher race had pried open the interface between the machine and the humans, when the handsome man started the machine's attack ability, the machine mistakenly altered Earth's orbit, carved out a piece of Earth to form the Moon, and simultaneously broke apart the entire landmass, forming the current tectonic plates: five continents and four oceans. Fortunately, the handsome man and beautiful woman had also prepared for this, arranging for the race at the bow to transfer their knowledge, wisdom, etc., to China. But dealing with the incident took time, and after the explosion, humans paid a heavy price in blood and flesh. The Earth ship, once a paradise full of laughter and joy, suddenly turned into a dark, ghost-filled, blazing, mountain-of-corpse, sea-of-blood hellscape during the incident. The author's poor pen cannot describe even a fraction of these horrors. And because handling the situation took time, the handsome man and beautiful woman could not react in time, could only save themselves, gritting

their teeth at the horrors, yet momentarily powerless. It was like being tortured by a thousand cuts, or more precisely, like being chewed alive by a dog, helpless.

The aliens, for the sake of the Earth ship, eventually controlled their tempers, paid the price, and corrected some of their bad habits. At the same time, in an Egyptian mural from the 13th century BC, the aliens gave a warning: If the matter does not subside, terrible punishment awaits the conspirators and the turncoats. Unlike what some might imagine, although ancient Egypt struggled several times, it actually chose to bow out on its own. Curious readers can study ancient Egyptian history for themselves.

The machine was probably somewhat damaged in the incident. Although on the surface everyone still complied with the signed agreement, agreeing to joint management of the machine by certain ethnic groups, in reality, all this was manipulated behind the scenes by the handsome man and beautiful woman. They also developed some functions of the machine to manage land, and the lethal means remained in the hands of the handsome man. Countless people died on the Earth ship during this incident, and Earth suffered great trauma, and Earth's water resources were also enormously wasted. If some ethnic groups refuse to accept reconciliation, then what awaits them will be the bloody Ring within a Ring. For the sake of ordinary people, the identity of the handsome man is speculated by the author to be Allah, and the identity of the beautiful woman is speculated by the author to be God. Now we finally have the answer to the question raised at the beginning of this section: the Muslim church expands and recruits believers everywhere, with the real aim of dealing with God and Allah. This is both deeply ironic and extremely real.

### **Story 3: On Matter and Consciousness**

The strangeness of this world is beyond all expectations. This world is not only material but also conscious, and moreover, matter and consciousness can transform into each other. The machine and Earth ship mentioned earlier are precisely such transducers.

It is said that many years later, some aliens came to Earth, who can be described as possessing all five elements. Originally, on the Earth ship, water element consciousness dominated, and at the bow there was a stabilizing rod and a race with very pure consciousness. The machine on the Earth ship could originally only absorb water element consciousness and transform it into material in the sky, such as rain, snow, and hail.

The purpose of the aliens' visit to Earth was to take control of the people on the Earth ship, including their beliefs and spiritual power. Seeing that the three races at the stern still retained their wild nature, they set a trap in the machine's operation very early on. In a battle, the races at the stern operated the machine and delivered a powerful counterattack. But because of the trap in the machine, the Earth ship suffered enormous losses. The aliens also paid a price, but they seized control of the machine, and made a covenant with the people on the Earth ship.

Because earth element energy had been implanted in the machine, the machine could now both absorb and output control over earth element consciousness or matter. The relief discloses that at present, only a few ethnic groups still maintain positive energy; after the great war, the researcher race pried open the limit between the machine's spiritual control and humans; a certain alien gained control of the machine's attack components, and the permission to absorb and output belief and spiritual power; a certain alien, who has certain relationships with some ethnic groups, and whose belief, spirit, and body belong to another ethnic group, participates in the affairs of the Earth ship.

The current situation is that the Muslim faithful have little chance of victory. This is the best time to seek peace. Otherwise, perhaps the bloody Ring within a Ring depicted in the Egyptian mural from the 13th century BC will become reality.

## Absolute Truth

Earlier, I mentioned that aliens came to Earth through time-space tunnels. This way of space-time travel naturally reminds me of the Causal Ring. Originally, the Causal Ring was defined within computer code, but because it describes the logical relationship between two objects, through in-depth analysis, we can naturally extend it to other fields. And the most natural way is to examine the spatial objects directly expressed by the Causal Ring, or even space itself. Because the two objects in the Causal Ring are actually the same object, and time and space are tightly connected, aliens traversing space-time can be described by the Causal Ring as tearing space-time with bare hands. But because traversing space-time is too complex, we must pay a price. According to the Egyptian relief from 2400 BC, the consequence of aliens tearing the void is the creation of space-time turbulence, or space-time belts, or space-time fissures, including possible tearing and drifting of continents. If the above is indeed true, then the Causal Ring can be called an ultimate truth, or absolute truth. For MVSP, perhaps we can still achieve better results. But the Causal Ring itself may be unchangeable. Algorithmically speaking, some problems, like the halting problem proposed by Turing in 1936, are uncomputable (Turing's proof is also based on self-reference). The halting problem asks whether there exists a general program that can determine whether a given program  $Y$  eventually halts on input  $X$ . We can certainly say that no such general program exists, but we can also say that such a general program exists, but it has an infinite number of states, so it is uncomputable. If we insist on computing it, we can only pay a certain price, namely, we can only determine whether the program halts with 50% probability. For algorithms, the Causal Ring generally represents the best result achievable from self-reference. Extending to other fields, we might say that the guiding principle represented by the Causal Ring is immutable.

## On Intelligence

The author believes that this world is in a state of eternal pursuit of intelligence. Intelligence, or consciousness, is the true origin of this world. Below, let us attempt to answer the question posed earlier about whether machines can possess human intelligence. Because machines are invented by humans, asking whether machines possess human intelligence is actually asking whether there exists a program possessing human intelligence that can design another program possessing human intelligence (for a given problem). This obviously involves self-reference. Let us use a simpler problem as an analogy: We ask whether there exists a program that can determine whether another program possesses human intelligence. This problem is intuitively obviously more complex than the halting problem, so it should also be undecidable. Gödel also proved that the number of different programs is the same as the number of natural numbers. A finite program cannot handle infinity, so according to Gödel's incompleteness theorems, there should be no program that can determine whether another program possesses human intelligence. Therefore, we can say that machines do not have human intelligence. However, according to the Causal Ring, self-reference can also be realized if we pay a certain price. Hence, regarding machine intelligence, perhaps the correct answer is that machines do not have full human intelligence in theory, but may actually possess a certain degree of human intelligence in practice. The fact that the Causal Ring can find optimal solutions to **NP**-hard problems is proof of this.

Because the essence of this world is consciousness, the author believes that whatever a person thinks, as long as it is logical, should naturally exist. Ancient myths and legends, such as Nüwa patching the sky, are very likely to have actually existed. While writing this paper, the author had a dream, which he now shares with everyone:

It is said that long ago, there was a great god, billions of feet tall, with a broad chest and sturdy waist, whose body consisted of yin and yang energies. The yang aspect was bright energy, and the yin aspect was dark energy. Just as in today's world, positive charges flow toward negative charges, the great god's bright energy and dark energy also flow from higher potential to lower potential. Both bright energy and dark energy have the same smallest unit of energy, i.e., quanta. Each unit of bright energy pairs and entangles with another unit of dark energy. When a given unit of bright energy changes from strong to weak, an equal amount of energy is transferred to its paired dark energy, and because their natures are opposite, that dark energy also changes from strong to weak. Thus, within this great god's body, the bright world and the dark world form a perfect cycle: the bright world grows dimmer day by day, while the dark world grows brighter day by day. Eventually, on a certain day, the bright world will completely become the dark world, and the original dark world will become the bright world. The next identical cycle will continue, forever.

It must be said that this arrangement by the great god is perfect, almost flawless, a near-perpetual motion machine within his body. Unfortunately, the bright world and the dark world within the great god are tightly coupled. When

one side reaches its peak, it must inevitably transform into the other, even if unwilling. Thus, the great god is actually captured by this perfect cycle within his body. Every moment, he is in the cycle. Though the great god indeed exists in eternity, he is also unable to break free from the shackles of eternity. The great god is effectively in a cage of circulation formed by the yin and yang energies within his body, forever losing the ability to act autonomously, spending his days in self-indulgent pleasure.

The painful yet joyful days last a long time. Finally, one day, the eternal cycle is broken by a needle. On that day, a malicious thief spies the great god's location and thrusts a massive amount of spiritual energy into the great god's body. Spiritual energy is composed of equal parts of bright energy and dark energy, possessing the properties of both bright and dark energy, thus can coexist with both. The massive influx of spiritual energy separates the bright world and the dark world within the great god's body. The cycle within the great god's body can no longer proceed, causing a great upheaval. Because yin and yang can no longer harmonize and transform, the massive energy released by the collapse of the bright world can no longer be compensated by the massive energy released by the collapse of the dark world, and vice versa. Therefore, the bright energy and dark energy within the great god's body are both rapidly consumed. The energy lost by the great god is very likely stolen by the thief.

However, the great god, who could invent a nearly perpetual motion mechanism of yin-yang interconversion, is extremely intelligent, not so easily dealt with. In the process of confronting the thief, the great god extracted many of the thief's secrets, such as the secret of motion and stillness. The great god used spiritual energy to transform the energy released by the collapse of the two worlds into positive matter and antimatter. Because positive matter and antimatter are in a condensed state, they are relatively stable and their energy collapses very slowly. The thief can no longer steal energy from the great god's body; instead, the great god, having recovered, beats the thief to disability. But the great god himself is also deeply wounded. The original quantum mechanism is damaged by the thief's needle-pricking, and the yin-yang circulation within his body no longer exists. With his Dao foundation destroyed, the great god can no longer continue to exist. He can only strive to form and stabilize the bright material world and the dark material world. The great god's spiritual energy transforms into the human spiritual world, while humans span both the spiritual world and the bright material (i.e., positive matter) world, with unlimited potential.

This dream is so real. The author has pondered it for a long time and derived the following inferences from it. The current universe is roughly composed of three parts: the spiritual world, the positive matter world, and the antimatter world. The positive matter world and the antimatter world are embedded within the spiritual world. Human intelligence manifests as a spiritual computer that uses spiritual energy as the material carrier and inscribes spiritual energy in a certain way. Humans obtain additional bright energy through eating. A portion of that bright energy pairs with an equal amount of dark energy to form new spiritual energy. This pairing is likely the new quantum mechanism formed after

the original quantum mechanism within the great god's body was shattered. Because human spiritual energy possesses the properties of bright energy, it can also act on positive matter. This is why matter and spirit can transform into each other. Spiritual energy should pervade all space, separating the bright world and the dark world. A person's spiritual energy should be able to affect the spiritual energy in the surrounding space. Because spiritual energy may be quantum energy, quantum computers should be humans or other intelligent beings possessing human-like spiritual energy. For humans to build a quantum computer is equivalent to humans re-creating humans. According to the Causal Ring, this might be achievable, albeit with lowered expectations for quantum computer performance.

## The Age of Magic

Whenever the author re-reads or thinks about the Causal Ring algorithm in [1], he feels as if he has performed a little magic trick in the Causal Ring. By referencing an upper bound, we have established the upper bound itself. Out of nothing, we have found the optimal solution to the intermediate problem and MVSP on trees. This is somewhat like, with a blink of the eye, pulling a plump white rabbit out of thin air. This process can be summarized in design as: By seeing through and effectively exploiting the fleeting, tiny gap between MVSP and the intermediate problem, the Causal Ring goes all the way and completely pries open the hard shells of these two problems. Recalling earlier that we described a nondeterministic Turing machine as a magic box, we can pose questions to this magic box, and it answers and provides a certificate, but we do not know how the box works internally. Now we can say that the Causal Ring realizes that magic box. Now we can find optimal solutions to extremely complex problems in reasonable time. We have also discussed above that the Causal Ring, which can be called the first rule of the universe, can be applied not only in the field of computer algorithms but also as a guiding principle to deeply change every aspect of our social life. Through the Causal Ring, artificial intelligence can be realized, theorems can be proven automatically, invention can be equated with verification. In the near future, humans can achieve whatever they wish, can live forever, can travel through time and space. With the Causal Ring, humans are no longer confined to Earth, no longer confined to the Milky Way. A Magic Age for all humanity has already begun because of the Causal Ring. The distant stars and vast oceans are the true home of humanity. But these changes will not happen overnight. Even with the Causal Ring, rewriting software, redesigning systems, ensuring the stable operation of new methods, expanding massive infrastructure, training a huge number of talents — all of these still take time. To realize the infinitely brighter future for humanity that begins with the Causal Ring, our colleagues must persevere continuously and unremittingly. Let us forge ahead, and strive for the great Magic Age of humanity that has already arrived!

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## References

1. Yuzhuang Hu, Approximation Algorithms for the Capacitated Vehicle Routing Problem. *Ph.D. Thesis, Simon Fraser University*, 2009.
2. Y. Karuno, H. Nagamochi, A 2-Approximation Algorithm for the Multi-vehicle Scheduling Problem on a Path with Release and Handling Times. *Proceedings of the 9th Annual European Symposium on Algorithms*, 218-229, 2001.
3. N. Megiddo, Combinatorial Optimization with Rational Objective Functions. *Math. Oper. Res.*, 4:414-424, 1979.
4. N. Megiddo, Applying Parallel Computation Algorithms in the Design of Serial Algorithms. *Journal of ACM*, 30(4):852-865, 1983.
5. Hendrik van Loon, The Story of Mankind. *Shaanxi Normal University Press*, 2002 (Chinese edition).