Defying Two Invincible Computing Rules to Mitigate Existential Threats to the Future Internet

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Abstract

Although AI and quantum computing (QC) are fast emerging as key enablers of the future Internet, experts believe they pose an existential threat to humanity. Responding to the frenzied release of ChatGPT/GPT-4, thousands of alarmed tech leaders signed an open letter to pause AI research to prepare for the catastrophic threats to humanity from uncontrolled AGI (Artificial General Intelligence). Perceived as an "epistemological nightmare," AGI is believed to be on the anvil with GPT-5. Two computing rules appear responsible for these risks. First, mandating third-party permissions that allow computers to run applications at the expense of introducing vulnerabilities. Second, AGI is potentially unstoppable because of the Halting Problem of Turing-complete AI programming languages. The double whammy of these inherent weaknesses remains invincible under the legacy systems. A recent cybersecurity breakthrough shows that banning all third-party permissions reduces the computer attack surface to zero, delivering a new, completely safe Zero Vulnerability Computing (ZVC) paradigm. Deploying ZVC and blockchain, this paper builds and supports a hypothesis: "Safe, secure, ethical, controllable AGI/QC is possible by conquering the two unassailable rules of computability." Proving the proposed hypothesis will have a groundbreaking impact on the future digital infrastructure when AI/AGI & QC powers the Internet.

Keywords: Ethical AI, Quantum Computers, Existential threat, Computer vulnerabilities, Halting problem, AGI.

1. Introduction

The existential threat to humanity and the "epistemological nightmare" from Artificial Intelligence (AI) is a matter of the moment [**1**]. So is Quantum Computing [**2**]. Both are rapidly evolving as potential tools of destruction that adversaries can potentially exploit [**3**].

For a very long time, AI has been a subject of interest among fiction writers and sci-fi communities. In recent decades, AI has demonstrated the potential to step out of fiction and soon become a reality, replicating human-level intelligence. Human intelligence is as complex as human behavior and cognition. It can be defined in multiple different ways. A machine that can understand or learn intellectual undertakings to the capacity that humans can is characterized as artificial general intelligence (AGI). Machine learning (ML) algorithms have been developed to build a wide range of specialized AI applications that are getting better than humans at specific tasks. Artificial neural networks are being developed to mimic the way human brain works. As the evidence that AI can execute tasks better and cost-effectively accumulates, every industry, directly or indirectly deploying computers, embraces AI. The rapid industrialization of AI is increasingly becoming a cause of concern for its vulnerabilities to misuse by bad actors [**1,3**].

Quantum computing (QC) is a multidisciplinary field comprising aspects of computer science, physics, and mathematics that utilizes quantum mechanics to solve complex problems faster than classical computers. Because of its extraordinary computing speed, QC can easily decrypt today's encryption schemes to break the Internet [**4**]. Since access to the Internet has become as important a need as necessities of life, such as electricity, shelter, potable water, smartphones, communication, etc., life without the Internet is unimaginable. In almost everything we do today, we use the Internet. Therefore, any security risk to the Internet is also considered an existential risk to humanity and needs to be mitigated with some urgency [**2, 4**].

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Whether AI benefits from QC is no more a question now [5] as Quantum Machine Learning has become a dedicated area of research [6]. Intricately intertwined, QC and AI are changing the world at a pace that's scaring the conservatives [1,2,3,4]. Recent advances in large language models (LLMs) that use deep learning (DL) techniques and massively large data sets to understand, summarize, generate, and predict new content. **GPT** (Generative Pre-trained Transformer) is one of the largest LLMs developed by OpenAI. GPT-3.5 was launched as ChatGPT on November 30, 2022, generating an explosion of interest globally [7]. With over 100 million active users in just the first two months, ChatGPT set a world record for the fastest-growing user base of any application in history [8]. On March 14, 2023, OpenAI released the latest generation of large-scale multimodal language model, GPT-4 as ChatGPT Plus [9]. GPT-4 release has caused an uproar worldwide on speculation that the next version of GPT (GPT-5) may actually be AGI. Experts believe the early experiments with GPT4 already show early signs of AGI [10] and that GPT-5 itself may be AGI [11]. Perhaps, that is the reason why thousands of AI experts and stakeholders signed a petition to pause further GPT-5 development for at least six months [12-13] and, within weeks, followed up with another "Statement on AI Risk [14]" asserting: "*Mitigating the risk of extinction from AI should be a global priority alongside other societal-scale risks such as pandemics and nuclear war*." These proclamations have sparked broad discussions and controversies across the world. Prominent academicians and journal editorials warn that "*if we do not control our own civilization, we have no say in whether we continue to exist* [15-16]." With strong proponents on both sides of the debate, whether AI's existential threat is real or just fearmongering [17] is impossible to judge. The pause-AI call may not be unanimous, but opinions on AI risk appear to be unanimous, as reflected by the opinion of a non-signatory expert.

> *"AI is out of the bag – it cannot and will not be stopped or paused, for better or for worse. Our best bet is to develop proactive before-the-event policies, risk management frameworks, and safeguards, along with aggressive and accelerated development of the compliant side of AI developers to ensure that the 'good' side stays ahead [18]."*

1.1 Will AI go rogue in 2023?

Whether AI will go rogue in 2023, 18-53% (27% global average) of 24,471 adult respondents of a recent survey across 34 countries answered YES (**Fig. 1**) [19]. If the perception that a rogue AI program will

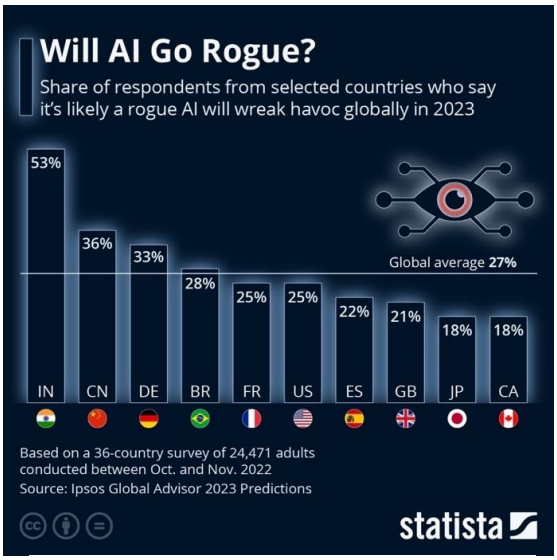

Fig. 1. A survey of 24,471 adults from 36 countries. Source: Statista.com

cause problems worldwide within this year is so high, then its future likelihood cannot be just dismissed. When the general perception regarding the dangers of AI is unprecedented, and when thousands of the world's top tech luminaries sign not one but two open letters within weeks, and the world's first AI regulation gets closer to being legislated [20], the concerns of 'existential threat from AI' needs to be addressed with some urgency. As the debate for and against the impending threats intensifies, the need for securing our digital infrastructures is real and immediate. Human accessibility to immensely powerful tools like superhuman AI and QC can never be without apocalyptic risk to humanity. Unless technological advances are not moderated and democratized, the risk of their misuse can never be ruled out.

Surprisingly, there is so much chatter on AI's existential risk but very little or virtually nothing on why AI threat is technically unassailable. The problem can only be adequately addressed if the exact cause of the problem is identified. Before we tread that journey, it is essential to understand what safe, excellent, or responsible AI means.

1.2 What do robustness, resilience, ethics, and security mean for AI?

We must first understand that AI is not a monolithic term when considering safe and responsible AI. AI is a phenomenon that needs to be seen in a more nuanced way through the lens of its evolutionary stages comprising of ANI (artificial narrow intelligence), AGI (artificial general intelligence), and ASI (artificial super intelligence) [21]. Its robustness, resilience, and security must be evaluated at each of these evolutionary stages to assess its full potential and risks. Today, we have already achieved ANI, and as we move towards AGI and eventually ASI, the burden on the parameters for robustness, resilience, and security gets heavier. Since the future of AI is predicted to be in quantum computing [22-23], additional vulnerabilities of quantum computing as an amplifier of the existential risk [24] cannot be ignored in defining those parameters. All those considerations are considered in articulating the problem statement for structuring this perspective. The terms AI and AGI are interchangeably used throughout this article to imply risky aspects of AI.

1.3 When will Q-Day arrive?

In 2016 NIST (National Institute of Standards and Technology) published a report on the rising threat to the encrypted Internet data by quantum computers and the catastrophic impact that would have on the integrity of the global IT infrastructure [4]. Following the NIST report, experts have warned of the apocalyptic Q-Day when QC will have enough computing power to decrypt state-of-the-art encryptions and break the Internet [25].The exponential growth in QC has opened the possibility of performing attacks based on Shor's algorithms and Grover's algorithms that threaten the PKI and hash functions in the near future [26]. QC may still need to be mainstream, but there is a big push to bring it to the mainstream soon [27]. In a recent survey, 74% of IT professionals believe QC with sufficient Qubits to break legacy encryption algorithms will arrive in five years [28]. According to a Y2Q (years to quantum) clock launched by the Cloud Security Alliance last year, the Q-Day may be just under seven years when QC will be able to crack current encryption **(Fig. 2)** [29]. The timeline estimates projected for AGI, QC, and when smart cities become a norm more or less culminate around 2030 [30].

Fig. 2. Countdown to Q-Day (Y2Q). Credit: Cloud Security Alliance

2. Problem Statement & the Hypothesis

Whether AGI or QC, their integration into our smart cities and lives is imminent. A UNESCO report predicts that smart cities will shape our societies by 2030 [31]. This paper investigates a fundamental research question that essentially transcends all information technology-related fields directly or indirectly impacted by AI, QC, and cybersecurity. Two frontiers of research in computer science meet in the brand-new field of quantum artificial intelligence [32], and cybersecurity is the backbone of any successful digitalization of society [33]. AI and QC are very active fields with an overwhelming speed of new developments. The processing power to create the human brain is enormous, but QC might be our gateway to successfully creating AGI in the future [34]. Like AI, QC also presents its own existential risk via its ability to break the Internet with its decryption capacity [35-36]. Cybersecurity is the common denominator in the success of both these fields. Hence, whether it is the future of AI or QC, cybersecurity remains at the epicenter of its real-world implementation. With that backdrop to the problem that AI/QC faces today and in the near future following hypothesis is formulated:

Safe, secure, ethical, and controllable AGI/QC is possible by conquering the two unassailable rules of computability with Collective Artificial Super Intelligence (CASI).

The hypothesis may appear ambitious, but it is grounded in solid science and supported with empirical evidence. All AI systems are essentially computer programs, and as such, they inherit the limitations imposed by the rules of computing. A computer's greatest strength is also its greatest weakness. What makes them so powerful, widespread, and valuable also places a fundamental limit on what they can do and the problems they can solve. This limit cannot be broken in the prior art, even with supercomputers or quantum computers. It is built into the very nature of computation. What is this intriguing paradoxical quality? Well, there are not one but two paradoxes (**Fig. 3**). The existential threats to humanity from AI and QC are routed in those qualities of computation that render computing

systems vulnerable and cannot be circumvented in the current state-of-the-art. These rules of computation are:

1. Third-party permissions are mandatory in building present-day computer hardware and software [36-38]. These permissions make it possible to run a wide range of applications from third-party vendors but are also responsible for the vulnerabilities that bad actors often exploit. That is why all legacy computers remain vulnerable [38].

2. As a basic computability rule, deciding whether a specific Turing machine should halt or run infinitely is undecidable [39-40]. Termed as "the Halting Problem," this phenomenon renders AI/AGI unstoppable and uncontainable if it goes rogue [41]. Turing proved that "*a general algorithm to solve the halting problem for all possible program-input pairs cannot exist* [42-43]."

Both paradoxes remain invincible under the legacy computing systems and remain the principal cause of AI/AGI's existential threat to humanity. In other words, there can neither be a functional computing system completely free from vulnerabilities nor a Turing-complete algorithm that can guarantee to halt an adverse algorithm if it continues to run in a loop indefinitely.

Having formulated the hypothesis as a research question, reviewing the research methodology and the current state-of-the-art approach to AI safety, security, and containment is essential. This will help in placing

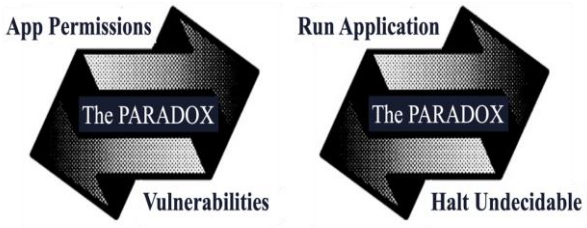

Fig 3. The Permissions Paradox & the Halting Paradox

the evidence in support of the CASI hypothesis in proper perspective. So, the next sections discuss the state-of-the-art, followed by section 5 on the evidence in support of the hypothesis that goes beyond the state-of-the-art. Section 6 highlights the prospects of proving the hypothesis and limitations of the proposed research, and finally, section 7 summarizes and discusses the conclusions of this research.

3. Research Methodology

This is hypothesis-generating research designed to generate and formulate a new research question, not hypothesis-testing or hypothesis-proving research designed to empirically answer a known research question [44]. Although the methods of less rigorous hypothesis-generating research do not replace or undermine more rigorous hypothesis-testing or hypothesis-proving research methodologies, they play an important role in building new paradigms that lay the foundation for new discoveries. Except for a few rare serendipity inventions, almost all discoveries the world has ever seen begin with a HYPOTHESIS. Whether a hypothesis is eventually proven or disproven, it never loses its importance as the beginning of a journey to new knowledge. Historically, hypothesis-generating research has facilitated inventions that may not have been possible otherwise [45]. Both the computability rules that this paper recognizes in formulating the CASI hypothesis in the previous section have existed since modern computers came into existence. However, in peer-reviewed literature, they are scarcely studied in the cybersecurity or AI context except in a handful of studies [36-38, 41]. To support the hypothesis, a detailed literature review is presented herein.

4. Review of Literature: Foolproof Security & Controllability of AI Impossible?

The seven requirements for trustworthy AI articulated by AI HLEG that render AI lawful, ethical, and robust must be secure and controllable (**Fig. 4**). Saghiri et al. surveyed challenges that AI faces today and concluded that in the era of superintelligence or AGI, the ML agents would be difficult to control for humans [46]. They identified 28 challenges that AI needs to address. In the peer-reviewed literature, at least two challenges are unassailable and essentially the cause of classifying AI as an existential risk to humanity. As illustrated in **Fig. 4**, security and controllability are the two challenges that constitute the two foundational pillars on which trustworthy AI/AGI of the CASI hypothesis is built.

As identified in the preceding section, these foundational pillars represent two mandatory rules of computing that any legacy AI system must comply with viz. i) third-party permissions and ii) Turing computability (**Fig 4).** As discussed, legacy computers and AI systems can only be built in compliance with these rules. Put another way, these

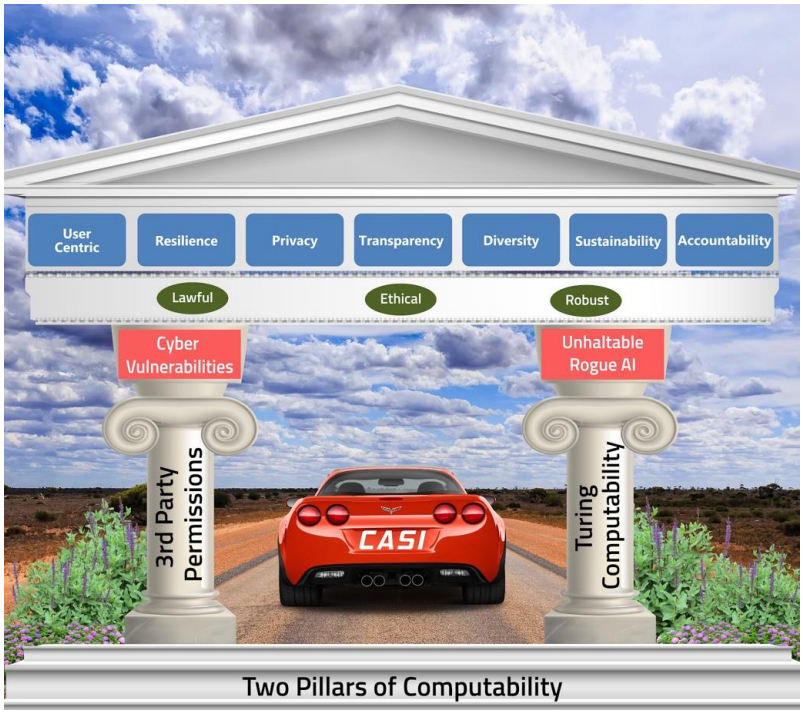

Fig 4. Overcoming the mandates of computability to build lawful, ethical, robust AI system.

two mandatory computing rules render AI/AGI vulnerable to adversarial attacks and cannot guarantee foolproof security from adversarial control of AGI or halting it if it goes into rogue hands.

The controllability of AI/AGI has four types: explicit, implicit, delegated, and aligned, and it gets more severe by increasing the autonomy of AI-based agents [46-48]. Consequently, properly balancing security with usability is a major concern in designing any AI containment strategy. The tradeoff between security and usability is a tough question without clear answers. In an extreme case, the most secure method could render the AI useless, defeating the whole purpose of building AI. Ignoring the AI's core uncontrollability problem, Babcock et al. discuss AGI containment with different tradeoffs between usability and security [47]. However, because of the assumed capabilities of future AGI/ASI, we cannot rule out the possibility of machines that will be uncontrollable in some situations.

4.1) Why Foolproof Cybersecurity of AGI is impossible in Legacy Systems?

AI systems are computer programs. As such, they remain subject to the basic rules of computability theory. Third-party permissions are mandatory in building present-day computers and AI algorithms. However, permissions are also responsible for the vulnerabilities that bad actors can exploit. It is undeniable that all computers are vulnerable [49], and therefore all cybersecurity implementations are policy based and cannot be secure by default. Standard security measures for ML models [51] include (i) access control; (ii) system monitoring, and (iii) audit trail.

The principal reason all computers are vulnerable, and no computer is without an attack surface, is because computer hardware and software cannot be built without granting third-party permissions that software vendors can use to develop applications that make computers work. Bad actors often abuse these permissions by creating attack vectors that render computers vulnerable to malware. Without such permissions, computers will be virtually useless as none of the diverse range of software applications we depend on will work. So, a paradoxical catch-22 situation makes these third-party permissions a necessary evil that remains unassailable in the prior art.

The traditional attack surface results from third-party permissions that all computers mandate for running third-party applications [36-38]. The advent of AI must deal with additional vulnerabilities associated

explicitly with machine learning (ML) that create an ML attack surface [52]. The ML attack surface results from training data sets, which attackers can manipulate well before model deployment time. Such attack vectors, which do not exist in conventional software, include adversarial reprogramming, data poisoning, malicious input, or stealing information by a probe (**Fig. 6a**). Discussed in more detail in the next section, **Fig. 6a** illustrates all these vulnerabilities resulting from the traditional as well as ML attack surface in a self-explanatory graphic illustration adapted from Isaac & Reno [53]. Cyber attackers use threat vectors to target the vulnerable attack surface. NIST defines a threat as *"The potential for a threat source to exploit (intentionally) or trigger (accidentally) a specific vulnerability* [54]." The literature describes several types of threat modeling approaches [55]. STRIDE is the most mature and widely used strategy [56] that recently Mauri & Damiani [57] adapted for threat modeling in the AI domain by taking an *asset-centered* methodology for identifying threats to ML-based systems [58]. Their *STRIDE-AI* strategy for assessing the security of AI-ML-based systems identifies six asset classes in the AI ecosystem (**Fig 5**) [**58**]. They argue that their STRIDE-AI extension to the original STRIDE provides an *ML-specific, security property-driven* approach to threat detection, which can also guide in selecting the security controls needed to alleviate the identified threats. In a special report on AI Cybersecurity, the European Union Agency for Cybersecurity (ENISA) also considers STRIDE as a promising starting point for AI threat modeling [59].

Essentially, STRIDE strategy is an acronym for six threat vectors that hackers commonly use to attack any computing resource connected to a network. They are spoofing, tempering, repudiation, information disclosure, Denial-of-Service, and Elevation of Privilege, as illustrated in the following table.

Table 1: Six threats of STRIDE

Threat	Description
Spoofing Identity	An attacker poses as an authorized user by taking or faking an identity of another person.
Tampering with Data	An attacker modifies some information in the system by changing a data item.
Repudiation	An attacker deletes a transaction to cover up and deny his intrusion into the system.
Information Disclosure	Personal user data is stolen and sold to a competitor with an intent to make profit.
Denial of Service (DoS)	An attacker exhausts network resources to make it inaccessible to its intended users.
Elevation of Privilege (EoP)	*An attacker, instead of spoofing identity, just elevates his own security level to an administrator.*

As illustrated in **Fig 5**, except in some instances of DoS / DDoS attacks on AI assets, the remaining five require subscription-based authentication for accessing the AI assets. Therefore, the only way a cyber attacker can generate a threat vector in these cases is by gaining access to the AI assets. In other words, except for some types of DoS/DDoS attacks, a hacker will always need to access an ML agent one or the other way, whether as a legitimate subscriber or an unauthorized intruder using an attack vector to breach the ML attack surface. As already explained, the traditional attack surface is essentially a consequence of third-party permissions that all computers mandate for running third-party applications [36-38]. Therefore, as in traditional security breaches, the ML attack surface also depends on unauthorized access to ML assets. Such unauthorized access is only possible because all legacy systems integrate third-party permissions, which bad actors abuse by deploying

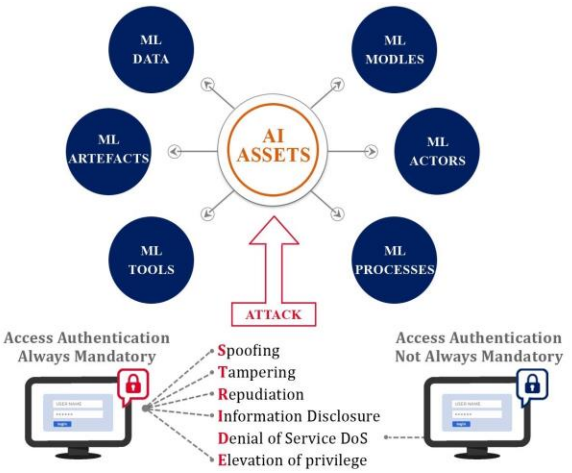

Fig. 5. Holistic STRIDE-AI Strategy to secure ML Assets. Adapted from Mauri and Damiani, doi: 10.1109/CSR51186.2021.9527917 [**58**]

different strategies to attack the ML models of AI's neural network.

4.2 AI's Unassailable Halting Problem renders AI unstoppable

Another basic rule of the computability theory presents a pivotal limitation to the AI algorithms programmed in Turing-complete programming languages. It is impossible to write a program in Turing-complete language that can examine any other program and tell, in every case, if it will terminate or get into a closed loop when it is run [**60**]. Termed the **halting problem**, it is *one of the most philosophically important theorems of the theory of computation*" and is unsolvable [**61**]. The undecidability of the halting problem has an immediate practical bearing on all software development, particularly in AI development. Widely regarded as the canonical undecidable problem [**62**], the halting problem [**63**] and controllability [**64**] of a Turing complete program are impossible to solve [**65**]. Therefore, many AI-based systems that inherit the problem might not be manageable. "It is simply not possible for computers to catch the halting problem. Humans will always be a part of it [**66**]." Alfonseca et al. argue that total containment superintelligence is principally impossible due to the fundamental limits inherent to the theory of computing itself [**41**]. The halting problem is a decision problem about the properties of computer programs on a fixed Turing-complete model of computation. The problem is to determine, given a program and an input to the program, whether the program will eventually halt or run indefinitely when executed with that input. In simple terms, "halting problem" refers to the impossibility of determining whether an arbitrary computer program will finish running or continue to run forever (**Fig. 7a**). Turing proved that "a general algorithm to solve the halting problem for all possible program-input pairs cannot exist [**67**]." This means that the only way to stop a globally rogue AI would be something that must go wrong with the Internet infrastructure itself, which is highly unlikely. In simple terms, once a self-referential loop is encountered, the program that generated the loop cannot "step out" of the loop by itself. An outside source needs to address the problem, which in the case of a computer running AI algorithms is eventually a human operator.

4.3 The Ethical Dilemma with AGI/ASI

Can an AI system developer, implementer, or regulator, by means of any known procedure, predetermine whether an AI system will consistently deliver output that remains in compliance with ethical norms? The answer is "NO." No algorithm in any of the Turing-complete languages can reliably do so for all AI systems all the time for any given input. Although, for some AI systems running some input, ethical control may be possible, but not always, leaving AGI/ASI unrestrained by any ethical norms [**68**]. So, ethical compliance also remains undecidable and consequently unsolvable.

Five principles guide the ethical governance of AI in society: i) beneficence (promote human well-being), ii) non-maleficence (do no harm), iii) autonomy (preserve human freedom), iv) justice (operate with fairness), and v) explicability (output explainable results) [**69**]. However, AGI and ASI pose a fundamentally different problem than those typically studied by Asimov under the banner of "robot ethics" [**70**]. This is because AGI and ASI are multi-faceted and, therefore, capable of mobilizing a diversity of resources to achieve potentially incomprehensible objectives to humans, let alone controllable [**41**]. As argued in the preceding section, the Halting Problem introduces subjectivity of decision output at all levels [**71**], making run-time implementation of algorithms with principles of ethics impossible.

5. Beyond State-of-the-art

A solid cybersecurity infrastructure is the most crucial shield against data poisoning or other AI breaches [**72**]. However, legacy systems cannot be totally free from vulnerabilities. They remain vulnerable by virtue of their mandatory permissions to the third-party codes built into their architecture [**36-38**]. Put another way, all legacy computing systems can run any third-party code/algorithm irrespective of whether it is installed by legitimate means or injected by a bad actor. This means a legacy system always leaves some attack surface that an adversary can disguise as a legitimate system user to gain access and exploit AI's ML algorithms in several ways.

5.1 Zero Vulnerability Computing (ZVC)

A breakthrough in cybersecurity provides an interface for running all third-party applications without granting them any permission to install on the computer [**36-38**]. ZVC is a new award-winning computing paradigm [**73**] that bans all third-party

permissions to eradicate computer vulnerabilities and reduce the attack surface to zero and is defined as follows [36]:

> *"ZVC is a cybersecurity paradigm that proposes a new zero attack surface computer architecture that restricts all third-party applications exclusively to a web interface only, declining permissions for any utilization of computing resources by any non-native program and creates a switchable in-computer offline storage for securing sensitive data at the user's behest."*

The empirical evidence not only supports the ~zero attack surface proposition unequivocally but also establishes that ZVC is inherently resistant to threats from future quantum computers because the security mechanism of ZVC is encryption agnostic and is not cryptography dependent [36-38].

As stated earlier in the previous section, Isaac & Reno [51] recently summarized the vulnerabilities of the traditional and ML attack surface in a self-explanatory

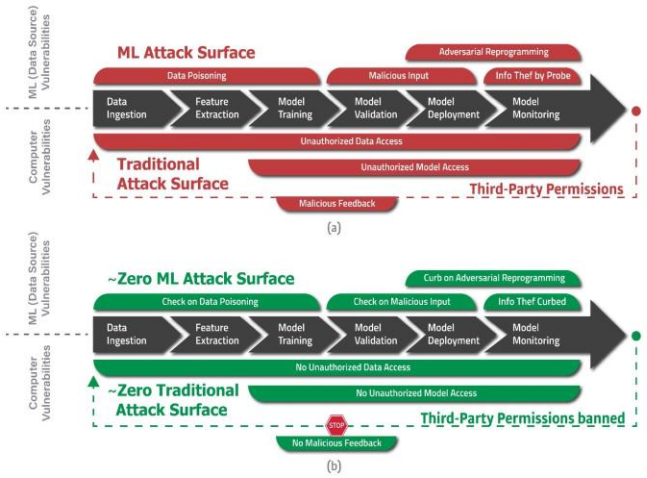

Fig. 6a & 6b. Vulnerabilities and Threats in (**a)** Legacy ML Systems Vs **(b)** CASI Adopted from Isaac & Reno, https://arxiv.org/pdf/2304.11087.pdf

graphic illustration. Based on an adaptation of their illustration, we elucidate how CASI deploys ZVC to eliminate or mitigate these attack surfaces (**Fig. 6b**). By banning all third-party permissions, ZVC obliterates the traditional attack surface. The advent of AI has introduced another type of attack surface resulting from bad actors deploying different strategies to attack Machine Learning (ML) models of AI's neural network. While traditional attack surface is essentially an outcome of third-party permissions, except DoS (denial of service) attacks (**Fig. 5**), a good majority of ML attacks are also permission dependent (See section **3.1 and Fig. 5**). As illustrated in **Fig 6b** the empirical evidence [36-38] suggests that ZVC can also potentially eliminate ML Attack Surface as it is also primarily permission-based. This is explained with some clarity in **Fig. 6b**, how ML attack surface is created, and how ZVC can deal with it.

5.2 How does CASI solve the halting problem to stop rogue AI?

As we have seen, banning all third-party permissions with ZVC obliterates the traditional and ML attack surface to keep the bad actors from breaching a responsible AI (**sec 4.1**). As far as much of the traditional as well as ML attack surface originates from the rogue elements' accessibility to ML models, data poisoning, adversarial reprogramming, malicious input, or stealing information by a probe (**Fig. 6**), the CASI ecosystem can impede unauthorized access from legacy computing devices, tackling all known AI attack vectors. However, if a bad actor succeeds in taking control of CASI by some mechanism presently unknown, the halting problem may still render AI unstoppable [41]. As a standard computability rule, in any of the Turing complete AI programming languages, there is no algorithm that can determine if a program would halt and not run into an infinite loop [40-43, 60-68]. Therefore, there is no way to exercise any control over the adverse actions of AI if it goes into rogue hands. By deploying a blockchain-based AI governance strategy, CASI builds an indirect defense against the unsolvable Halting problem to stop rogue AI. Blockchain is a continuously growing data ledger. The machine learning algorithms can be trained on blockchain smart contracts [74] to produce trusted models for reliable prediction [75]. A smart contract is made between all the AI stakeholders and deployed on the blockchain. Smart contracts are self-executing agreements encoded on a blockchain with their terms directly inscribed in code that will automatically execute when predetermined conditions are met. They offer transparent, tamperproof, and cost-effective alternatives to traditional contracts. Peer-reviewed literature presents many examples of Blockchain-enabled AI systems in diverse use case settings, such as ensuring accountability and quality control in zero defect manufacturing [76], enhancing edge intelligence in IoT networks [77], for automatic learning in big data-based digital gaming [78], for improving cybersecurity [79], in healthcare [80], and many more [81]. However, in the literature, one cannot find evidence of using blockchain smart contracts to solve AI's halting problem. The CASI

framework provides an indirect solution to the halting problem by deploying any one of the following two approaches:

5.2a) Obstructing execution of any new unethical decision by smart contract transaction fee restriction

Because AI programs are Turing complete, the halting problem applies, and a single execution of a rogue AI could run forever [60-68]. To prevent this, CASI uses a specially designed blockchain that assigns certain unethical or rogue decision-making to smart contracts that can only be executed autonomously if a sufficient fee (gas) is available in the system wallet payable to the miner/validator. Miners or validators of blockchain transactions must spend resources such as computing power or electricity to validate and record each transaction on the blockchain [82]. Such costs are recovered as transaction fees, generally calculated based on the transaction size in bytes and the current network congestion. A miner/validator will terminate the script if it runs out of funds (**Fig. 7b**). Thus, blockchain indirectly addresses the halting problem by introducing the concept of gas (transaction fee) [82]. All ML actions are divided into two types of transactions,

i) routine, no-fee ML actions pre-approved by the DAO (decentralized autonomous organization) that governs the blockchain, and,
ii) all new suspect ML actions requiring fee-based smart contract authentication, wherein the DAO controls such fee remittance.

As illustrated in **Fig. 7**, all routine transactions get executed without any restrictions. However, any new suspected unethical action will only execute if fee restrictions pause the AI engine until such actions get reviewed by the DAO or DAO's ethical committee. By making the CASI wallet multi-sig (requiring multiple unique signatures) under the control of the democratically elected CASI DAO members, the execution of the smart contract is guaranteed to halt the Turing-complete algorithm destined for infinite loops [83]. Thus, CASI indirectly solves the unassailable Halting Problem and can prevent AGI/ASI from going rogue.

5.2b) Coding smart contract using a non-Turing compete language

Although it is a standard practice to use Turing complete programming language to code the conventional smart contract, recent evidence suggests that smart contracts can also be efficiently coded using a non-Turing complete language [84]. A non-Turing complete language such as Vyper does not face the halting problem, and smart contracts coded in Vyper have been shown to be more efficient in terms of performance speed, storage, and eliminating certain classes of bugs [85]. This means a CASI smart contract coded in a non-Turing language can automatically stop anytime the ML detects an unethical anti-human action without resorting to the indirect method of stopping smart contract execution utilizing fee restriction. Non-Turing-complete smart contracts allow easier auditing due to the lower code complexity since they do not support recursion or complex loops. This will also decrease the possibility of implementing defects since the code will be more straightforward to review. Executing simpler programs results in better performance and prevents

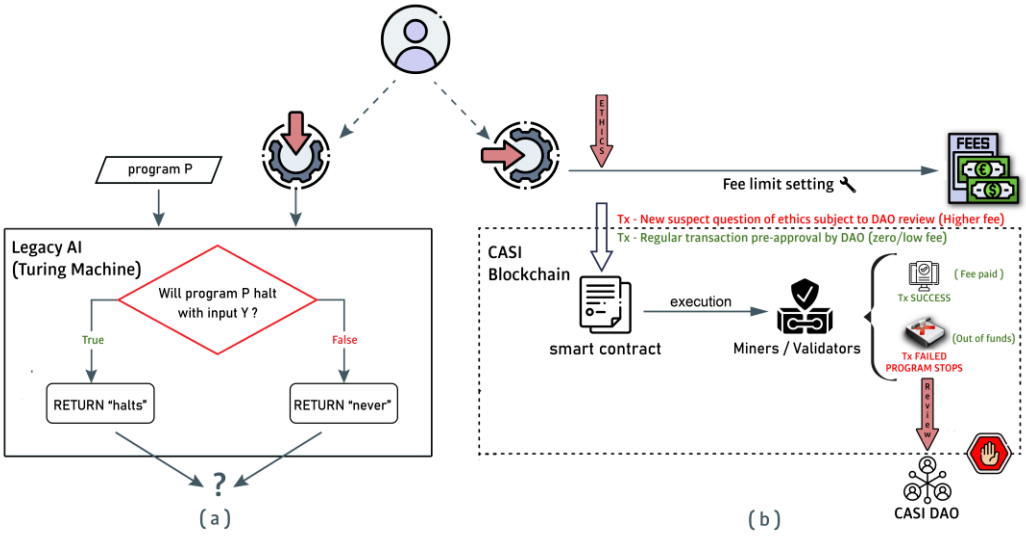

Fig 7a & 7b. Undecidable Halting Problem of **(a)** Legacy AI Vs. **(b)** DAO Controlled CASI system

congestion, often caused by Turing-complete smart contracts that use much storage [86]. Our current development focuses on comparing both approaches in terms of ease of implementation and effectiveness in stopping rogue AI/AGI.

5.3 Securing the Smart City IoT infrastructure from QC and AI threats.

The AGI and QC timelines are well in sync with the epoch when smart cities become a norm [29-30]. Therefore, in planning smart cities or any future digital infrastructure, the existential threats from AGI and QC cannot be ignored.

A smart city is made possible by the Internet of Things (IoT) [87], comprising a diverse range of computing devices that are inherently vulnerable [88]. Almost all cybersecurity currently relies on cryptography [89]. It is estimated that ~75 billion devices will be connected to the Internet by 2025 [90]. When QC arrives in the future, the security of the entire IT infrastructure will be threatened [24]. Post Quantum Cryptography (PQC) is being aggressively pursued for defending the Internet against QC. NIST initiated a PQC standardization initiative in 2016-17, and after a rigorous multiyear vetting process, selected two out of 82 algorithms, CRYSTALS-Kyber and CRYSTALS-Dilithium. However, a Swedish group cracked CRYSTALS-Kyber [91-92], and a group of French cryptographers recovered part of the secret key sufficient to produce universal forgeries [93].

Moreover, a recent comprehensive survey confirms that the security of most PQC algorithms is unfortunately insufficient, rendering them vulnerable [94]. With no PQC algorithm proving robustness and resilience, NIST's standardization process is seriously jeopardized. Most PQC algorithms are too complex to employ in most resource-constrained IoT devices [95] efficiently. However, in peer-reviewed literature, empirical evidence exists [36-37] that a resource-efficient, low-cost, encryption-agnostic approach based on banning all third-party permissions can be developed to secure network devices against Q-Day threats [38].

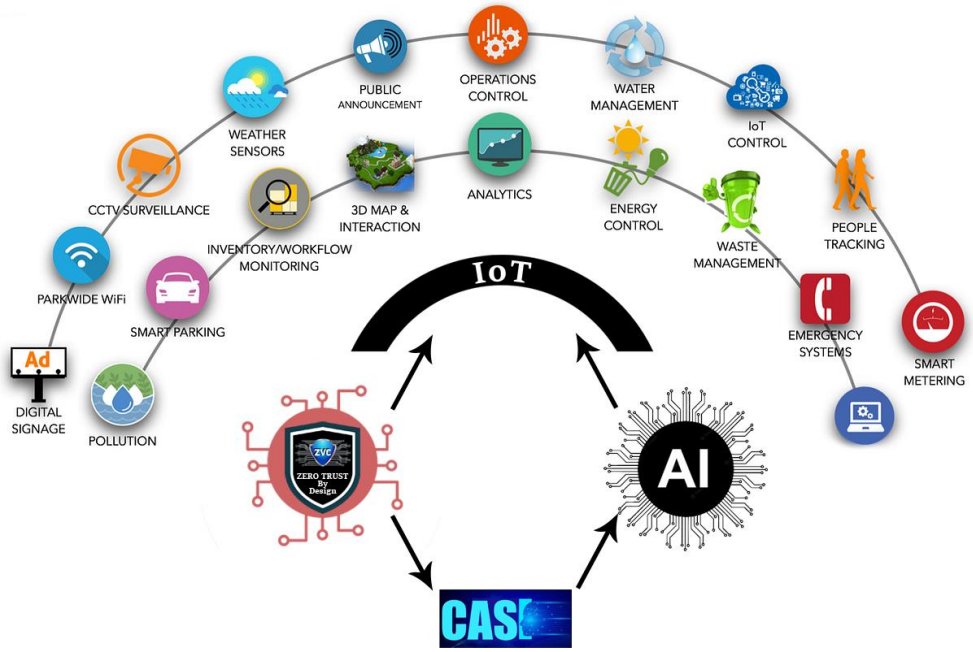

Fig 8. The concept of CASI enabled secure & controllable IoT infrastructure.

6. Prospects and Limitations

The perspective presented in this paper provides theoretical support to the proposed hypothesis on a secure and safe transition of AI and the Internet to the future human-friendly AGI and QC. Although the hypothesis has far-reaching implications for our understanding of computer designs, cybersecurity, and machine learning models' resilience, it remains under investigation. This paper is no more than hypothesis-generating research intended to build and formulate a hypothesis that researchers across the world can design and investigate. experiments to test and prove or disprove the hypothesis. Until such studies are conducted, great care should be taken in extrapolating

the findings of this report to real-world settings. Such studies begin with defining what exactly is meant by quelling existential threats from AGI/QC. What will be the process? What protocols will be designed to implement the process? What KPIs will be appropriate to evaluate and control the protocols? Those and many other questions come to mind for planning the future of our AI/QC-powered digital infrastructure. The journey to answers to those questions largely depends on the following:

i) the evolution of the business model for delivering AGI/AGI and QC services to the end users, and,
ii) the safeguards that secure the Internet from the AGI/QC threats relevant to that business model.

Each of these elements is discussed in detail herein:

6.1 AI-as-a-Service Business Model:

As ML models and neural networks constantly evolve, improve, and learn from new data, they are also becoming more complex and resource intensive. These advancements have resulted in AI services being offered in pay-as-you-go cloud based service model [**96**]. Such AI-as-a-Service business model is cost effective and hence rapidly establishing as a popular business model for providing users with pre-trained and optimized ML models [**97**].

6.2 Quantum-as-a-Service Model:

The cost of building a QC is astronomically high and it is impossible for most end users to buy or build one for their exclusive use. Therefore Quantum-as-a-Service (QaaS) business model is the only choice for commercializing QC services. Several QC service have already launched their QaaS product, offering their QC services to specialized groups building QC based solutions [**38**].

*6.3 Safeguards***:**

Compared to traditional business practices, the "as-a-service" business model generally carries higher commercial viability because of cost savings. However, in the case of AI and QC, the respective business models provide an additional advantage of the ease of implementing CASI style safe, secure, and ethical framework, and makes regulatory control much more effective and enforceable because it is logistically easier to regulate business than the population at large [**38**].

Both the computing rules that this report challenges have deep roots in our practice of computing since the inception of the field of computer science and cannot be deracinated overnight. However, necessity is not only the mother of invention; it also mothers change. If the necessity is to save ourselves from extinction and change is the only choice left for humanity to survive, change will be inevitable. Time will tell if that change comes. However, once the hypothesis is proven with tangible evidence from multiple AI and QC labs, the hypothesis remains a concept.

Nevertheless, despite its limitation as hypothesis-generating research, this paper adds compelling evidence that controlling AI/AGI and QC is theoretically possible by using a new approach of encryption-agnostic decentralized governance to secure and control data for keeping it in compliance with ethical norms. The concept does demonstrate reasonable prospects of a credible path to be pursued by AI/QC researchers in their efforts towards building solutions that mitigate any existential risk that AGI / QC may pose in the future. It also holds out new hopes of a smooth passage to the technological singularity when it arrives, without questioning the debate of whether singularity will arrive or will not [**98**].

7. Discussion & Conclusion

The principal objective of this research was to identify the most serious pain points posed by AI/AGI and QC technologies that are currently perceived as existential risk to humanity by many experts [**23, 35-36**], and conduct a thorough literature review to generate a clearly articulated hypothesis that provides a credible path to mitigating the involved risks. The hypothesis thus formulated reads as follows:

"**Safe, secure, ethical, and controllable AGI/QC is possible by conquering the two unassailable rules of computability with Collective Artificial Super Intelligence (CASI).**"

The empirical evidence in peer reviewed literature provided enough basis to support the above hypothesis and afford sufficient motivation to AI and QC researchers to undertake further research to test and prove the hypothesis. This work introduces new ideas, new thinking, and a new understanding of the paradoxical computability concepts of permission-based Turing machines that have existed since the birth of modern computers. The new perspective on

those age-old concepts can be helpful to researchers, thinkers, AI developers, regulators, and practitioners working to secure the Internet generally and the brand-new fields of AI and QC specifically.

The Pause-AI call signatories believed the 6-month moratorium to give AI companies and regulators time to formulate safeguards to protect society from potential risks of the technology. Conversely, it is the dynamic input from research labs that decides the path that regulators take. Microsoft co-founder Bill Gates told Reuters the proposed pause will not "*solve the challenges* [99]." The need of the hour is "*acceleration, not a pause* [100]." Towing a similar but more diplomatic line, the Google CEO characterized the call as "*a conversation starter*" backed by good spirit [101]. With tech luminaries on both sides not disputing the potentially catastrophic dangers of uncontrolled AI/AGI, the Pause-AI call is indeed a conversation starter of epoch magnitude. This paper is testimony to that epoch for providing an optimistic research direction to the AI stakeholders on either side of the debate.

Besides the wildly raging AI controversy, the PQC standardization process initiated by NIST in 2016-17 as a defense against QC is also going through tough times, with 90% of PQC algorithms failing in the fourth round [89]. Recently, the final two PQC algorithms, viz. CRYSTALS (Kyber & Dilithium [91-92] were also reported to be compromised, further jeopardizing the NIST initiative. As researchers continue to find solutions to these intractable problems, the CASI hypothesis merits a pursuit as a more sustainable alternative to PQC. Indeed, as we speak, CASI is actively pursued by a consortium of European researchers. In these challenging times, the alternate research direction that the CASI hypothesis proposed and supported with empirical evidence in this paper may go a long way in planning our defenses against the impending dangers to our digital infrastructures from bad actors' future abuse of AGI and QC.

CRediT Author Contribution Statement

FR is the sole contributor to this study's hypothesis generated, supported, and tested. The author has read and agreed to the published version of the manuscript.

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Data Availability Statement

Not applicable as the study does not report any data.

Conflicts of interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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