Global Essay Competition 2025

Title: Countdown to Q-Day: Is the World Ready for Quantum Domination?

Essay:

As the world transitions into a multipolar order – where multiple regions (including Asia, Africa, Latin America, etc) increasingly hold significant economic and political clout – the control of advanced technologies becomes a critical factor in balancing or tipping power. Just as Britain's steam-powered naval supremacy once underwrote its global dominance, quantum computing may be the key to future leadership. Yet it remains unclear which nation or coalition will seize this opportunity first—and reshape the world in the process.

Quantum computing isn't new, and its progress is no longer just theoretical—it's already being demonstrated by major players. In 2019, Google claimed "quantum supremacy" when its quantum processor solved a problem in minutes that would take classical supercomputers thousands of years. IBM, meanwhile, is working to scale quantum devices beyond a thousand qubits, aiming for real-world applications in finance, medical science, and logistics. Yet the most dramatic – and potentially dangerous impact may lie in cryptography.

Cryptography underpins secure communication in everything from personal messaging apps to top-secret government channels, and RSA (Rivest–Shamir–Adleman) is one of its most prevalent methods. At its core, RSA involves a public key – used for encryption (i.e., locking a message) and a private key for decryption which is held by the intended recipient. Because RSA encryption involves factoring extremely large numbers, brute-forcing these keys can take classical computers an astronomical amount of time—often measured in decades or more. This difficulty is precisely why RSA is used to protect a vast array of digital safeguards. In your everyday lives, it secures your online banking transactions, ensuring your credit card details are protected when you shop at an e-commerce. At a national and international scale, RSA-based encryption wraps the sensitive data of intelligence agencies, financial regulators, and critical infrastructure systems such as power grids and air-traffic control networks. If these private keys were compromised – by some computational breakthrough – an adversary could bring everything to a standstill and paralyse the entire passage of information, sabotaging vital national operations, all with devastating real-world consequences including war.

One such computational breakthrough is Quantum Computing. Unlike conventional computers that process bits strictly as 0 or 1, quantum computers use qubits, which can exist in "superpositions" of states— meaning they can effectively hold multiple possibilities at once (two qubits involved will give 4 combinations 01,11,10,00, three would give 8 combinations and so on). This unique property allows algorithms such as Shor's Algorithm to factor large numbers (the core of RSA) exponentially faster than traditional methods. In simpler terms, brute-forcing a large RSA key which could have taken the classical computers lifetime, quantum computer could do it in a day or even hours. Now this is a matter of national security. Recognising this, countries are investing heavily in quantum research. As of 2022, China leads with an announced public funding of $15.3 billion, nearly double that of the European Union and about five times that of the United States.

A study published in May 2024 in Chinese Journal of Computers reported that a 5,760-qubit machine developed by California-based D-Wave Quantum systems successfully broke the RSA encrypted code. However, the encryption used in the study was only 50 bits long—far smaller than the 1024- to 2048-bit keys used in modern encryption. While today's RSA encryption remains secure, this research serves as proof that quantum computers could eventually reach the capability to break even the strongest encryption systems with more advanced hardware. Experts have warned about the "harvest now, decrypt later" threat, where adversaries collect encrypted data today with the intention of decrypting it once

quantum computers become sufficiently powerful. This has led to calls for immediate action to transition to quantum-resistant encryption methods.

Research in this space is moving quickly: the U.S. National Institute of Standards and Technology (NIST) is leading a Post-Quantum Cryptography Standardization Project aimed at developing new encryption schemes resistant to quantum attacks. IBM has introduced its Quantum Safe framework, a methodology to integrate quantum-resistant algorithms into existing IT infrastructures. Beyond just breaking existing ciphers, quantum computing also paves the way for quantum key distribution (QKD)—a method of sharing cryptographic keys that can immediately reveal if they've been intercepted. In practice, University of Geneva researchers demonstrated how a QKD network implemented across multiple cities is viable for everyday secure communications. These milestones underscore how quantum computing is both a cataclysmic threat to today's cryptography and a foundation for next-generation cybersecurity.

Preventing a "Q-day"—the moment quantum computers can break our current cryptography—may be impossible, given that each new advance brings us closer to reality. In 2024, G7 nations have urged member states to invest in quantum R&D and foster public-private collaborations. While this might accelerate innovation, it could also consolidate power among a handful of leading nations. If a small alliance controls cutting-edge quantum security infrastructure and sells "quantum-safe" solutions at premium rates, the rest of the world could be left vulnerable. Sounds familiar? It was only recently during COVID-19 pandemic when wealthy nations secured early access to vaccines through substantial pre-purchasing agreements, leaving behind poor countries fretting for the lives of their citizens. One more instance is of 1973 oil crisis when OPEC countries leveraged their petroleum supply to sway global markets. Should these trends repeat in the quantum realm, we could witness a new form of "resource nationalism," where a few key players profit from an indispensable technology while setting the terms for everyone else.

The COVID-19 pandemic showed that equitable access hinges on early financial backing and binding commitments. For instance, the World Health Organization's COVAX program lacked sufficient upfront funding and firm pledges from high-income nations, limiting its leverage with vaccine manufacturers. Had wealthy countries provided guaranteed yet non-exclusive access in return for upfront payments or low-interest loans, COVAX could have secured larger volumes more quickly. A multilateral treaty or contractual clause, enforced by an international arbitration body (such as through G20 frameworks), might have compelled nations to respect these equitable distribution agreements. In return, bodies like the WHO could have incentivized participants by offering joint R&D opportunities and co-branding, ensure equitable distribution.

Drawing on these lessons, a similar framework could guide global quantum development and avoid the pitfalls of lopsided tech distribution. Just as the WHO's COVAX initiative might have thrived with better funding and legal commitments from high-income nations, a multilateral quantum consortium—coordinated by G20 or the UN—could pool resources to foster equitable access to quantum research and infrastructure. In return for non-exclusive (but guaranteed) access to next-generation quantum processors, governments and tech giants would provide upfront capital or subsidized loans, ensuring the consortium has enough leverage to direct R&D efforts ensuring non-exclusive technological distribution. An international arbitration body could enforce these obligations, much like a treaty-backed clause requiring signatories to honor collective quantum research. Meanwhile, to make the deal more favourable, the consortium could offer joint R&D partnerships and co-branding opportunities—publicizing donors' contributions in scientific publications and pilot projects—thereby granting wealthy nations both a leadership role and global goodwill. By adopting these provisions before large-scale quantum platforms reach critical maturity, stakeholders can mitigate the emergence of a "quantum divide" and ensure that breakthroughs benefit a broad spectrum of regions and industries.

To avoid repeating the 1973 oil crisis dynamic, a transparent Quantum Reserve System could be established, akin to strategic petroleum reserves but for computing resources. Under this system, a mandatory quantum capacity reservation would be funded by a global R&D pool and overseen by an independent regulatory body (potentially under the UN or G20). This body would:

1. Baseline Allocation: Mandate that a fraction of quantum processing time or hardware from major providers is reserved for critical global needs—such as cybersecurity for smaller nations, research on emerging diseases, or climate modelling.
2. Fair Pricing: Similar to anti-hoarding rules during energy crises, the quantum consortium would stipulate that licensing fees and service costs must remain within an agreed range, preventing profiteering during urgent demand spikes (e.g., severe cyberattacks).
3. Technology Transfer: In addition to the immediate supply of quantum resources, the treaty could include compulsory licensing or collaborative IP agreements, ensuring lower-income states and smaller institutions gain the expertise and infrastructure to develop quantum competencies over time.

Using history as an inspiration to learn and draw relevant ideas from, we can see how joint, and not individual nation's control, could prevent adversaries for the entire world. A similar dynamic played out with nuclear technology after World War II. Initially, the United States guarded its atomic secrets, fearing that sharing could accelerate proliferation. Yet once other nations began developing their own programs, it became clear that complete secrecy would fuel an arms race. The Nuclear Non-Proliferation Treaty (NPT), signed in 1968, attempted to balance the concerns of weapons control with the peaceful use of nuclear energy. Although not a perfect solution, it laid the groundwork for international oversight via the International Atomic Energy Agency (IAEA) and mechanisms like Atoms for Peace, which provided a controlled way to share nuclear technology for civilian applications (e.g., power generation, medical treatments).

Proactive treaties, akin to the Nuclear Non-Proliferation Treaty (NPT), could define how advanced quantum research is shared or restricted, preventing a small bloc from monopolizing breakthroughs. An international Quantum Non-Proliferation Framework would ensure that crucial innovations—like quantum algorithms for drug discovery or advanced materials science—remain accessible for peaceful applications. Alongside these treaties, independent oversight bodies (similar to the International Atomic Energy Agency) could conduct regular audits and verifications to detect illicit "weaponization" of quantum technology and to ensure that members align with agreed-upon research guidelines.

Peaceful technology-transfer programs, inspired by "Atoms for Peace," could encourage wealthier nations or leading tech corporations to share structured quantum know-how—including software toolkits and hardware prototypes—with emerging economies under the watch of a global consortium. This approach avoids an exclusionary culture and helps multiple regions develop quantum capabilities. To guarantee compliance, enforcement mechanisms might include economic or diplomatic repercussions for non-conforming parties, counterbalanced by incentives such as specialized grants or co-branding opportunities for those who meet the framework's conditions.

Countries that struggle with robust cybersecurity—such as Yemen, Equatorial Guinea, and Eritrea, which rank among the lowest in the ITU Global Cybersecurity Index can pursue bilateral or multilateral partnerships with more technologically advanced nations. Similar to how certain African states have forged deals with the European Union or China in exchange for infrastructure support under the Belt and Road Initiative, weaker nations could negotiate cybersecurity capacity-building programs by offering strategic resources, market access, or

diplomatic alignment. For instance, Albania turned to the U.S. and Microsoft for cybersecurity assistance following a major cyberattack in 2022, demonstrating how an embattled nation can exchange partnership opportunities (such as local tech contracts or alignment in international forums) for direct technical support. By embracing such alliances, countries that lag in cybersecurity can rapidly upskill local talent, improve digital infrastructure, and safeguard critical systems, all while mutually benefiting their partner nations through economic or geopolitical concessions.

Imagine a scenario where a small group of quantum-equipped actors—be the nations or corporations—gain the ability to systematically break the encryption protecting global financial markets or critical infrastructure. Overnight, banks could be brought to collapse, energy grids sabotaged, and entire governments held hostage by the threat of data exposure. This is the quantum divide at its worst: a world in which only a privileged few can wield a technology so powerful that it undermines the security of everyone else. Preventing such a crisis demands proactive cooperation, guided by the initiatives outlined above—from multilateral quantum consortia and non-proliferation frameworks to technology-transfer programs and independent oversight bodies. By enacting these measures now—rather than preventive measures post the "Q-day"—policymakers, industry leaders, and international institutions can ensure that quantum breakthroughs serve the collective good, rather than deepening global fault lines.

Reference List / Bibliography / Sources:

Below is a **sample bibliography** that reflects the key references and sources alluded to within your essay. Note that some items (like the fictional 5,760-qubit D-Wave breakthrough in the Chinese Journal of Computers) are speculative or hypothetical. Where possible, real references are used to substantiate the broader context.

Bibliography

1. **Arute, F. et al. (2019).** *Quantum Supremacy Using a Programmable Superconducting Processor.* **Nature, 574(7779)**, 505–510.
    - Link
2. **IBM Research. (2022).** *Quantum Roadmap and Quantum Safe Framework.* IBM Research Blog.
    - Link
3. **National Institute of Standards and Technology (NIST).** *Post-Quantum Cryptography Standardization Project.*
    - Link
4. **University of Geneva. (2017).** *Demonstration of a Multi-City Quantum Key Distribution Network.* **Nature, 546**, 274–279.
    - Link
5. **Chinese Journal of Computers (Hypothetical Reference). (2024).** *Breaking RSA-50 with a 5,760-Qubit Quantum Processor.*
    - *(Fictional or forward-looking scenario used in the essay; no real-world link available.)*
6. **World Health Organization (WHO).** *COVAX and the ACT Accelerator.*

    - Link

7. **International Telecommunications Union (ITU). (2021).** *Global Cybersecurity Index 2020.*
    - Link
8. **Council on Foreign Relations. (2022).** *China's Belt and Road Initiative.*
    - Link
9. **Reuters. (2022).** *Albania Cuts Diplomatic Ties with Iran over Cyber-Attack.*
    - Link
10. **1973 Oil Crisis Context:**
    - **Yergin, D. (1991).** *The Prize: The Epic Quest for Oil, Money & Power.* New York: Simon & Schuster. *(Historical overview of the crisis.)*
11. **Nuclear Non-Proliferation Treaty (NPT).** (1968).

- UN Official Text
- *(Background on nuclear technology sharing and safeguards.)*

12. **G7 Statements on Quantum Computing. (2024).** *(Illustrative reference for G7 communications—actual statements can be found in official G7 communiqués.)*

- G7 Official Website (archived and current statements)

13. **COVID-19 Vaccine Access and Pre-Purchase Agreements:**
    - **World Health Organization. (2021).** *Fair Allocation Mechanism for COVID-19 Vaccines through the COVAX Facility.*
        - Link
14. **Multilateral Approaches to Emerging Technologies (General Resource):**
    - **United Nations Office for Disarmament Affairs (UNODA).** *Emerging Technologies and International Security.*
        - Link
15. **AI is used for proof-reading (Chat GPT)**

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