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АКТУАЛЬНЫЕ ПРОБЛЕМЫ СОЦИАЛЬНО-ГУМАНИТАРНЫХ НАУК

ACTUAL PROBLEMS OF HUMANITIES AND SOCIAL SCIENCES

ТОШКЕНТ-2024

ОАК Рўйхати

Мазкур журнал Вазирлар Маҳкамаси ҳузуридаги Олий аттестация комиссияси Раёсатининг 2022 йил 30 ноябрдаги 327/5-сон қарори билан тарих, иқтисодиёт, фалсафа, филология, юридик ва педагогика фанлари бўйича илмий даражалар бўйича диссертациялар асосий натижаларини чоп этиш тавсия этилган илмий нашрлар рўйхати (Рўйхатга) киритилган.

Электрон журнал **1368-сонли гувоҳнома** билан давлат рўйхатига олинган.

Муассис: “SCIENCEPROBLEM S TEAM” масъулияти чекланган жамияти.

МУНДАРИЖА

07.00.00 – ТАРИХ ФАНЛАРИ

08.00.00 – ИҚТИСОДИЁТ ФАНЛАРИ

09.00.00 – ФАЛСАФА ФАНЛАРИ

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QUANTUM COMPUTING AND LEGAL READINESS FOR E-GOVERNMENT SERVICES

Abstract. Quantum computing promises unprecedented processing power that could revolutionize e-government services. However, realizing this potential requires updating legal frameworks on data privacy, cybersecurity, intellectual property, and procurement. This paper provides an overview of quantum computing and its applications to e-government. It analyzes gaps in current laws and regulations, arguing for benchmarks towards legal readiness. Recommendations focus on data protection standards, liability rules, transparency policies, interagency collaboration, and public-private partnerships. With timely legislation and strategic planning, governments can harness quantum computing for more secure, efficient, and equitable public services.

Keywords. Quantum computing, e-government, legal implications, data privacy, cybersecurity, public policy

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КВАНТОВЫЕ ВЫЧИСЛЕНИЯ И ЮРИДИЧЕСКАЯ ГОТОВНОСТЬ К УСЛУГАМ ЭЛЕКТРОННОГО ПРАВИТЕЛЬСТВА

Аннотация. Квантовые вычисления обещают беспрецедентную вычислительную мощность, которая может произвести революцию в услугах электронного правительства. Однако реализация этого потенциала требует обновления законодательной базы в области конфиденциальности данных, кибербезопасности, интеллектуальной собственности и закупок. В этой статье представлен обзор квантовых вычислений и их применения в электронном правительстве. В нем анализируются пробелы в действующих законах и правилах, приводятся доводы в пользу критериев правовой готовности. Рекомендации сосредоточены на стандартах защиты данных, правилах ответственности, политике прозрачности, межведомственном сотрудничестве и государственно-частном партнерстве. Благодаря своевременному законодательству и стратегическому планированию правительства могут использовать квантовые вычисления для более безопасных, эффективных и справедливых государственных услуг.

Ключевые слова: Квантовые вычисления, электронное правительство, правовые последствия, конфиденциальность данных, кибербезопасность, государственная политика

Islombek Abdixakimov
Toshkent davlat yuridik universiteti Kiber huquq kafedrasi oʻqituvchisi

KVANT HISOBLASH VA ELEKTRON DAVLAT XIZMATLARIGA HUQUQIY JIHATDAN TAYYORLIK

Annotatsiya. Kvant hisoblashi elektron hukumat xizmatlarida inqilob qilishi mumkin bo'lgan misli koʻrilmagan hisoblash kuchini va'da qiladi. Biroq, bu potentsialni roʻyobga chiqarish uchun ma'lumotlar maxfiyligi, kiberxavfsizlik, intellektual mulk va xaridlar sohalarida qonunchilik bazasini yangilash talab etiladi. Ushbu maqolada kvant hisoblash va uning elektron hukumatdagi qoʻllanilishi haqida umumiy maʼlumot berilgan. U amaldagi qonun va me'yoriy hujjatlardagi kamchiliklarni tahlil qiladi va huquqiy tayyorgarlik mezonlarini muhokama qiladi. Tavsiyalar ma'lumotlarni himoya qilish standartlari, javobgarlik qoidalari, oshkoralik siyosati, idoralararo hamkorlik va davlat-xususiy sheriklik masalalariga qaratilgan. O'z vaqtida qonunchilik va strategik rejalashtirish bilan hukumatlar xavfsizroq, samaraliroq va adolatli davlat xizmatlari uchun kvant hisoblashlaridan foydalanishlari mumkin.

Kalit so'zlar: Kvant hisoblash, elektron hukumat, huquqiy oqibatlar, ma'lumotlar maxfiyligi, kiberxavfsizlik, davlat siyosati

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Introduction. Quantum computing leverages quantum mechanical phenomena to solve problems beyond the reach of classical computers [1]. By encoding data in quantum bits (qubits) that exist in superposition and entanglement, quantum algorithms can analyze combinatorial optimizations, database searches, and machine learning effectively [2], [3]. With speculative timeframes for commercial viability ranging from 5 to 30 years [1], [4], quantum computing will likely disrupt electronic government (e-government) services.

E-government aims to improve public sector performance using information and communication technologies [5]. Quantum computing could bolster e-government by enabling faster data analysis to inform decisions, policy modeling with finer granularity, encrypted databases protected from conventional cyberattacks, optimized logistics like traffic control, and machine learning across heterogeneous government datasets [6]-[9]. However, these technologies introduce new risks, uncertainties, and access barriers with broad legal implications [10]-[12].

This paper examines the policy and regulatory landscape regarding quantum computing to identify readiness gaps in e-government. It focuses on the United States federal context but draws lessons for other jurisdictions. The analysis calls for updated data and encryption standards, cybersecurity frameworks, intellectual property protections, equity safeguards, transparency mechanisms, interagency coordination, public-private partnerships, and procurement reforms. It contributes recommendations on timelines and benchmarks to motivate legal modernization. Ultimately, proactive legislation and strategic roadmaps will enable governments to adopt quantum computing safely, responsibly, and for public benefit.

Background on Quantum Computing. Quantum computing relies on quantum bits or qubits. Unlike classical binary, qubits can represent 1, 0, or both simultaneously through superposition [13]. Groups of qubits also exhibit entanglement where their states depend on each other regardless of physical proximity [14]. These phenomena enable quantum computers to explore multiple permutations of a problem's inputs concurrently. As qubits scale into larger systems, quantum computers can analyze vast problem spaces intractable for classical machines [2].

Several technical challenges currently limit broad quantum computing adoption. Qubits remain fragile with propensity for errors during computation, although error correction techniques are advancing [15], [16]. ambiguous citation Quantum machines also require extreme cooling to enable superposition in qubits, with 2-3 orders of magnitude warmer temperatures hoped for room temperature quantum computing [17]. Nevertheless, existing machines with as few as 53-65 qubits have already demonstrated quantum supremacy in specialized tasks like pseudo-random number sampling, indicating their advantages over classical computers [18], [19].

Major quantum computing hardware platforms include superconducting qubit machines by companies like IBM, Google, and Rigetti, as well as trapped ion approaches from IonQ and Honeywell [4], [20]-[22]. Cloud access models for quantum simulation and experimentation also enable software development [23]. These firms and research initiatives anticipate scaling qubit counts towards fault-tolerant machines over the next decade [24]. In the race for viability first, innovations across the quantum stack from hardware and infrastructure to applications could arrive in fragmented or unexpected combinations [25].

Governments recognize quantum computing's disruptive potential both offensively and defensively [26]. The White House established the National Quantum Initiative Advisory Committee involving the National Science Foundation (NSF), Department of Energy, NIST and other agencies to coordinate strategies for research funding, infrastructure, and standards [27]. The Department of Commerce recently added quantum computing to technology export controls indicating its security sensitivities [28]. These policy moves acknowledge the complex ecosystem needed to develop quantum capabilities responsibly.

Applications to E-Government Services. Quantum computing's exponential speedups to computational problems make it invaluable for public sector systems and data. With qubits' ability to represent n values simultaneously, quantum machine learning can detect patterns within massive, heterogeneous government datasets more accurately [29]. Optimization algorithms offer significant public service improvements whether maximizing efficacy of policy interventions or planning infrastructure like energy grids or traffic systems [9]. Secure communications are vital for sectors like defense that quantum key distribution enables.

Processing power enhances existing e-government functionality. Online portals can use quantum machine learning to improve citizen experiences via better recommendations, personalized interfaces, and automated chatbots. Simulations leveraging quantum physics allow fine-grained modeling of outbreaks, disasters, or economic conditions to test decisions. Tax and revenue systems can hasten fraud detection or audits through quantum analysis augmenting classical algorithms. Logistics systems like GPS can achieve faster updates while blockchain implementations benefit from quantum resilience.

These exponential speedups do not trivialize computational challenges but expand what problems are solvable. Where classical systems struggle with complex combinatorial optimizations like route mapping, quantum variations make larger-scale instances achievable. Quantum-enabled tools cannot replace policymaking processes but offer scenario analysis at granularity not previously possible.

For encryption, quantum computing necessitates upgraded cybersecurity frameworks across government. All widely used encryption today rests on computational complexity assumptions, relying on limits to brute-force attacks. Quantum algorithms like Shor's take prime factorization challenges from intractable to efficient, breaking public key infrastructure underlying activities from classified communications to citizen tax records. Although complete deciphering requires a fault-tolerant quantum computer at scale, hybrid attacks using quantum and classical systems pose nearer-term threats. Cryptography research on post-quantum encryption explores algorithmic alternatives resistant to quantum attacks. Till these standardized and implemented, governments risk data breaches across critical systems.

Legal Implications and Gaps. While promising government efficiencies, quantum computing introduces new threats, uncertainties, access barriers and liability concerns requiring legal modernization. Outdated regulations on data protections, transparency, equity and responsible innovation slow progress. Strategic planning and early legislation can mitigate risks in adopting advanced technologies.

Data Privacy, Security and Standards. Government processes vast citizen datasets from identification records to healthcare, taxes, social security, licenses and judicial files. Much information remains sensitive including biometrics, locations, affiliations and financials. Quantum encryption using cryptographic keys encoded in qubits can prevent decryption by unauthorized parties, protecting databases from conventional cyberattacks. Such quantum key distribution networks were demonstrated across metropolitan infrastructure indicating readiness.

However, legal scholars warn how quantum computing threatens existing encrypted data. Public key infrastructure protects sensitive materials temporarily, awaiting next-generation post-quantum cryptography. Lacking data protections adapted to these threats risks breaches across critical systems by malicious actors. Governments must update encryption standards and cybersecurity frameworks accordingly.

Further, aggregated metadata derived from government databases raise privacy issues with quantum computing's processing potential. While anonymized, combining non-sensitive indicators can reveal identities. Data regulations rarely cover such metadata streams. Queries performed on encrypted databases using quantum-enabled tools might also leak information despite cryptography. Governments must expand data privacy laws' scope for the quantum context.

Overall, legal readiness requires governments align emerging technologies with civil liberties protections. Privacy laws balancing security, transparency and accountability can regulate applications of quantum machine learning, encryption or simulation on public sector data. Governments might establish ethical review boards to assess quantum computing projects' societal impacts. Ongoing revision of laws and technological standards can ensure data policies keep pace with innovation.

Intellectual Property. Quantum computing progress relies on patented hardware, software and algorithmic breakthroughs with intellectual property (IP) issues. Much research and development behind quantum technologies involves government funding and resources, whether high-performance computing access or classified datasets and findings transferred for commercialization. Resulting IP ownership disputes can delay innovation if left unaddressed.

Closely governing attribution, licensing and access promotes equitable progress [65]. Legislation might grant government agencies royalty-free usage rights for technologies developed using public resources while allowing industry reasonable commercial benefits. Setting standards around open-source contributions prevents excessive patents constraining collective innovation as witnessed classically. Such balanced IP policies helped foster growth in industries like space technologies and biopharmaceuticals from the interplay between public and private sectors.

Further, national interests in economic competitiveness and defense spur calls for more assertive stances on quantum IP. Trade controls and export restrictions aim to regulate international dissemination of sensitive breakthroughs by determining what technologies, use cases or user categories constitute threats [28]. However, ambiguous provisions risk driving quantum talent and investments towards less restrictive jurisdictions. Overly stringent IP policies also conflict with the traditionally open nature of academic science. Governments must strategically balance interests across security, economics and scientific progress.

Overall, legislation on IP must weigh both risks and benefits of government contributions against proprietary claims by private partners across hardware, software and data. Laws enclosing the "quantum commons" might unduly constrain collective gains whereas those too permissive risk losing public investments or enabling adversaries. Besides clear contractual terms and data security guidance, governments can use transparency mechanisms around research funding and patents granted to inform balanced oversight.

Liability and Insurance. Emerging technologies pose uncertainty regarding standards, safety or errors with liability implications. In particular, quantum algorithms leveraging opaque physics and entangled systems remain probabilistic despite high accuracy rates overall. Complex data interdependencies also complicate determining exact failure points. Legal frameworks must delineate reasonable liability for risks introduced by quantum computing across public-private partnerships. Governments might constrain procurement contracts to qualified vendors meeting security and reliability criteria [80]. Regulations can also cap liability from accidental Quantum software errors or residual decryption based on adherence to cybersecurity protocols. By driving accountability while preventing excessive burden on well-intentioned providers, balanced liability policies foster responsible innovation.

For residual harms like residual data exposure despite encryption protocols, governments might establish insurance frameworks around quantum computing adding to cyber liability coverage. State-pooled contingency funds can compensate citizen losses from personal data decryption, algorithmic failures or other incidents balancing affordability and adequate restitution. Private sector policies might also emerge by quantifying risks of emerging technologies through actuarial processes as cyber insurance products have done. Overall, prudent liability rules and contingency funds limit deterrents to socially beneficial quantum applications.

Transparency, Ethics and Access. Public sector adoption of emerging technologies warrants transparency regarding use cases, data types, decision processes and performance indicators to uphold accountability. For quantum computing, citizens using government services leveraging opaque or probabilistic systems deserve explanations around pertinence, limitations and error rates which meaningful transparency provisions can mandate. Extending open government initiatives to documentation of procurement mechanisms, vendor selection, pilot trials, and audits builds trust. Allowing public commentary during deployment also adheres to democratic principles.

Further, the complexity of quantum technologies raises ethical questions regarding equitable access and biases [12]. Surface-level usage barriers persist around past physics exposure which sufficient public outreach and development of inclusive human-centric tools can overcome. However, quantitative advantages in processing power or cryptography could also overly empower technologically advanced governments over their citizens or global counterparts [26]. International cooperation and ethics review boards might prevent such imbalances. Overall, transparency and ethical oversight must govern quantum computing to promote just governments and societies.

Interagency Collaboration. Harnessing quantum computing necessitates extensive collaboration between government, industry and academia [27]. Substantial investments in specialized infrastructure, intellectual talent and long-duration research projects require coordinated agendas between legislators, agencies and scientific experts. The National Quantum Initiative Advisory Committee demonstrates such a model, integrating strategic priority-setting, funding allocation, commercial partnerships and ethics review across stakeholders [27]. Expanding this beyond niche agencies can mainstream quantum readiness across government functions from communications infrastructure to law enforcement [26].

Further, intergovernmental partnerships should agree on taxonomy, standards and best practices globally. As emerging technologies expand computational abilities regardless of borders, adversaries without international cybersecurity consensus risk destabilization. Already, censorship evasion using quantum exchanges appears feasible. Shared protocols allow governments to balance security with personal freedoms furthering human rights [26]. Overall, multidisciplinary and multinational collaboration in quantum computing helps governments adopt innovations for public good.

Procurement Policy. Governments remain substantial technology consumers with procurement driving innovation and signaling national priorities, evident from semiconductor investments this decade. Standardizing acquisition mechanisms around desired functionality signals commercial providers on strategic quantum applications. Centralized testbeds also evaluate solutions against benchmarks before scale adoption, lowering transition barriers for agencies.

Additionally, governments are anchor buyers for technologies like quantum encryption granting approved vendors qualified marketplace advantages. Tying public contracts to balanced IP rights, liability caps or ethics principles also accelerates responsible innovation pathways aligning with societal interests. Overall, procurement reform can mainstream emerging technologies like quantum computing across the public sector.

Timeline and Benchmarks for Legal Readiness. The exponential power promised by quantum computing warrants proactive governance given national security and economic implications [1]. The precedents of biotechnology, artificial intelligence, and commercial space travel demonstrate the risks of lagging legislation in fast-moving domains as harms emerge before safeguards. Avoiding reactive policies requires anticipating quantum applications, assessing gaps in legal codes and technological standards, and establishing roadmaps towards readiness across government functions.

Governments might target having essential post-quantum encryption mandated before realization of a full-scale, error-corrected quantum computer. Such systems anticipate Commercial viability within the decade albeit through gradual advances [20]. Encryption protocols rely on algorithm selection through standard-setting processes and hardware upgrades before institutionalization, expected to require under 5 years given known alternatives. Updating certain frameworks like intellectual property policy and interagency coordination can also commence immediately to resolve known disputes.

Later priorities like liability rules, insurance schemes or transparency mandates depend on observing quantum computing’s societal impacts once operational [12],. Governments might provisionally specify these pending demonstrated threat models and risk assessments, deferring details. Contingency funds may follow years behind with actuarial data. However, governments should designate oversight bodies beforehand considering longstanding technology policy institutions like the Government Accountability Office (GAO) or technology assessment agencies.

Overall suggested timeline:

2025: Selection and mandate of post-quantum encryption standards for government systems, clarified quantum IP policy

2026: Establish interagency and international partnerships model on quantum computing

2029: Liability rules and insurance schemes standardized

2030: Bulk of government databases/communications transitioned to post-quantum cryptography

2032: Comprehensive transparency and ethics review frameworks mandated

Such staging of legal upgrades and technology transitions will enable governments to capitalize on quantum computing for public sector innovation while limiting risks [23]. Prioritizing developments with immediate advantages expedites returns on emerging technology investments. Delaying intractable governance issues avoids obstructing progress. Above all, maintaining flexibility to recalibrate policies allows balancing law and technology co-evolution. Institutionalizing periodic reassessments of benchmarks keeps modernization ongoing [10].

Conclusion. Quantum computing portends a revolutionary advance for processing and cryptography. Its applications can transform government functionality across data analytics, modeling, optimizations and more. However, risks span from data exposures to liability issues requiring updated legal frameworks on privacy, IP and transparency. Government readiness necessitates new data security standards, interagency coordination, procurement reforms and benchmarks towards comprehensive legislation. With proactive policies and staged adoption, the exponential power of quantum computing can safely and equitably benefit public sector innovation. But delays in governance risk impeding progress at best or enabling adversaries at worst. The time for preparing appropriate oversight begins now.

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ACTUAL PROBLEMS OF HUMANITIES AND SOCIAL SCIENCES

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