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A QUEST TOWARDS QUANTUM INTERNET MODEL

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ABSTARCT

The quantum revolution– "Fifth Industrial Revolution"- is poised to emerge with prominent and eye-catching disruptive quantum technologies to fundamentally transform the economy from digital to quantum. Two of the protuberant and conspicuous technology concepts are emanating to form the "Quantum Internet" (QI) in the future to enable transmission more than quantum bits (qubits) between any two points on earth in order to solve problems that are intractable classically. The concept binding symbiotic integration of quantum computing (QC) and 6G wireless will facilitate QI with secured quantum communications disrupting every industry globally. The other concept embracing "Quantum Teleportation" derives the power from quantum satellites (QS) by teleportingqubits/qutrits/ququarts or even higher information between the satellites and multiple ground stations encoded in delicate photons of infrared light to form QI. Both technology concepts will disrupt markets to create quantum opportunities to attain quantum value co-creation (QVCC). The aim of this conceptual research is a quest towards developing QI holistic model that offers impetus to enhance far-reaching applications with greater capacity, reliability, security, and public safety. The research methodology utilizes an exhaustive literature review on 6G wireless, quantum computing, quantum internet, quantum teleportation, and QVCC. The contribution of this research provides new knowledge towards a holistic QI model, the essential constituents, and building blocks of QVCC to the literature. Future researchers can build on this QI model to examine the limitations by using empirical research.

Keywords: 6G Wireless, Quantum Computing, Quantum Teleportation, Quantum Internet, QVCC

INTRODUCTION

At present, a fourth industrial revolution is building the digital era with exponential phenomenon characterized by a combination of innovative technologies. Starting in 2030, the quantum revolution - "Fifth Industrial Revolution" – will emerge with quantum technological supremacy that will fundamentally alter the digital era to quantum, as shown in the figure 1, with the scale, scope, and complexity humankind has experienced before.

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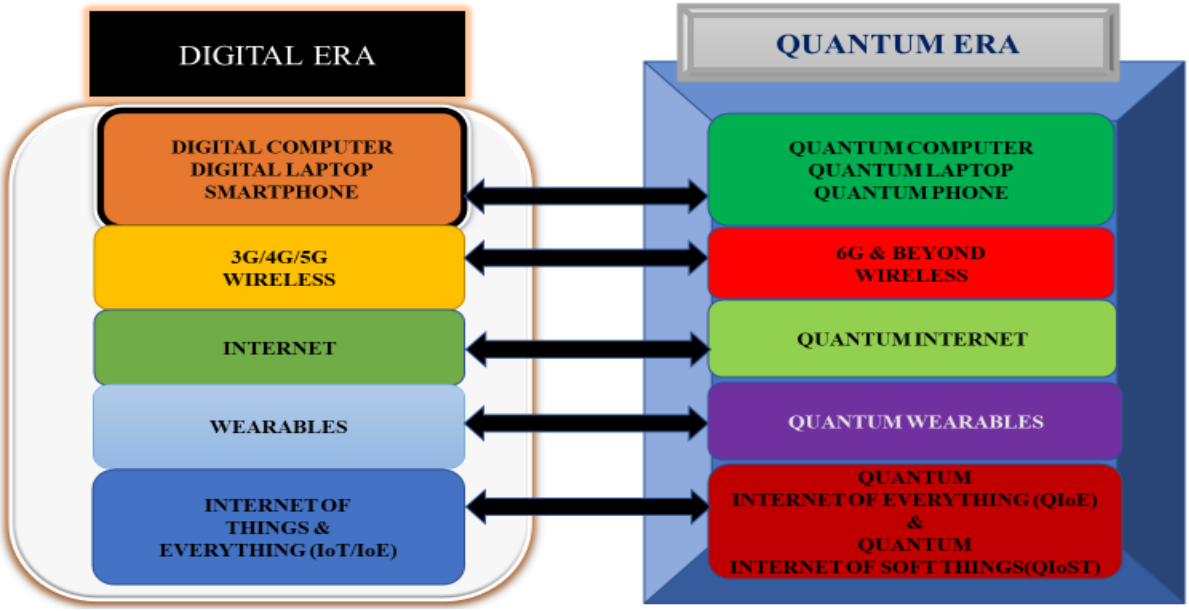

Fig. 1 Digital Era vs. Quantum Era

The quantum information age will disrupt every industry and present enormous possibilities by technology breakthroughs in the creation of quantum satellites, quantum computers, quantum internet (QI), quantum phones (Qphone™), quantum tablets, quantum laptops, quantum wearables (QW™), quantum internet of everything (QIoE™) and quantum internet of soft things (QIoST™) creating the quantum economy with the potential to open new markets raising income levels and improve the quality of life globally.

Around the world ventures are at the forefront of the quantum movement, therefore the author forecasts a radical technological change is now just beginning to take shape. The technology companies that dominate today are very unlikely to be on top a decade from now. Surviving the quantum revolution means connecting the dots early and trusting the instincts when things are about to change. The cycle of innovation doesn't stop. A decade ago, the four biggest Corporations in the world by net worth were Walmart, Exxon, China Petroleum, The Industrial Bank of China. A decade later, the top four corporations in the world are Apple, Amazon, Google, and Microsoft by net worth. Starting in 2030, the author predicts that there will be a similar turnover. In short, the "digital era" will come to an end and the world will witness the "quantum era".

Imagine 1,000 participants simultaneously experiencing an eXtended Reality (XR) – Augmented Reality (AR), 3D Virtual Reality (VR) and Mixed Reality (MR) demonstration in real-time. For such scenarios to be possible, 6G wireless communication is essential. The foundation for the 6G will allow for the extreme densification of communications systems enabling thousands of simultaneous wireless connections with 100 to 1,000 times higher capacity than the 5G network. https://arxiv.org/abs/1902.10265

6G is in the embryonic stage. At present, research efforts are aimed at the quantum realm to intersect with 6G. Currently, a United Nations body (the International Telecommunication Union - ITU) is studying what a 6G world might look like. Globally, research scholars at various universities are pursuing new technology research that could become the basis for "6G and Beyond". S. K Telecom (South Korea) partnering with Ericsson and Nokia pursuing 6G wireless research and development. Ting mobile is the first carrier to claim in North America offering 6G mobile network technology. Qualcomm and Samsung have started working on 6G and exact capabilities are still in the speculation phase. The objective of European QI alliance is to enable quantum communication applications between any two points on earth.

6G will drive the demands for machine-to-machine communications, including the Internet of Everything (IoE), robotics, autonomous drone delivery, and transport systems. Other future trends for 6G include ultra-dense cell

networks, reconfigurable hardware, millimeter (mm) Waves for user access, enhanced optical-wireless interface, and intelligent networking to enable a fully immersive experience for users. Users will demand greater global coverage, higher capacities with always-on connectivity for QI services and applications. The driver for the 6G is the increasing trend of Software Defined Networking (SDN), Software Defined Radio (SDR) and Inter-Vendor Operability (IVO) enabling the user's an easier way to upgrade to cloud-based resources endowing numerous applications. https://www.google.com/search?client=firefox-b-d&q=software+defined+network.

Starting in 2030, a new handful of technologies will mature along the same time of 6G and play a key role in the 6G standardization and research process. One such disruptive, prominent, eye-catching technology is quantum computing (QC) - still years away from becoming a conventional technology. The emerging quantum era is a tight arms race which will deliver the most stable and scalable quantum computer accessing quantum-inspired cloud services to provide quantum networking and end-to-end quantum programming.

Digital computers are defined by bits and Quantum Computers by qubits. Quantum technology (QT) can harness the laws of quantum mechanics to build powerful tools for information processing to develop new kinds of communications networks, and sensors in novel ways. A quantum computer harnesses mystical phenomena of quantum mechanics to deliver huge leaps of processing power to outstrip tomorrow' supercomputers. Availability of commercial quantum computer is on the horizon and fast advancing with governments investing billions and blue-chip technology heavyweights prioritizing the technology. In quantum computing, the power grows exponentially with the number of logical qubits. Research shows a fully functioning QC has the potential to be transformative and is still a decade away to coax many qubits operating together efficiently because qubits are finicky and have the propensity to create error at the slightest disturbance. The immense calculation QC power could help identify new chemical compounds to treat intractable diseases and eliminate traffic snarls by predicting and managing the flow of vehicles. The QC machines may also crack all existing forms of encryption that handle sensitive data. At present, security systems are protected with RSA, an asymmetric cryptographic algorithm used by computers to encrypt and decrypt messages. Quantum computers could one day effectively provide a key to confidential information and password databases. One of the biggest challenges will be the transition from today's computing systems to a "post-quantum" world. https://www.washingtonpost.com/business/2019/08/18/seven-basic-questions-about-quantum-technology-answered/

Quantum computer developers can access them through the cloud. However, current quantum computers have some limitations, including the instability of quantum computing environments, which makes their practical use more difficult. Researchers are currently working to mitigate these inhibitions. Large-scale application production and rollout of QC has not occurred yet. Five ways quantum computing has the potential to transform cybersecurity forever:

(i) Speed – QC is a game-changing technology for cybersecurity due to the inherent speed boost it offers to solve complex problems.

(ii) Security - the most compelling impact of QC is the role of security "distribution functions" providing a powerful mechanism for sharing cryptographic keys between remote parties with a high degree of implicit security.

(iii) Responsibility - for safe use is by no means guaranteed because QCs can effectively run what is known as Shor's algorithm, the most complex quantum algorithm known, posing risks to cryptography. https://qudev.phys.ethz.ch/content/QSIT15/Shors%20Algorithm.pdf

(iv) Safety - could efficiently run Shor's algorithm to enable factorize large prime numbers and do things one cannot even imagine today.

(v) Resistance - QC can build an unbreakable computer truly resistant to hacking?

In Nov 2017, IBM announced a 50-qubit quantum chip prototype. Google also announced its ambitions to achieve a 49-qubit superconducting quantum chip. In the marathon race to build quantum computing systems, Intel has passed a key milestone in quantum computing while running alongside Google and IBM. Intel's 49-Qubit superconducting quantum chip, called Tangle Lake, is shooting for quantum preeminence. Intel has already figured out how to fabricate spin qubits based on the processes used to manufacture its 300-mm silicon wafers. The primary quantum computer companies are Google, IBM, Intel, Ion Q, Microsoft, and Rigetti. Other

ventures such as QC Ware is helping many industries harness quantum computing technology for a wide range of potential applications. QC Ware has announced the integration of Google-developed Cirq as the backend for QC Ware's quantum computing cloud service platform. The following companies have gate-based quantum processors but use different qubit technologies as shown below:

Company	Qubit Type	Number of Qubits
Google	Superconducting	72
IBM	Superconducting	50
Intel	Spin Qubit	49
Ion Q	Trapped Ion	72
Regetti	Fixed & Tunable Transmon	20

China has launched the world's first quantum satellite (QS). This 1,400-pound QS doesn't beam radio waves. It is designed to send and receive bits of information encoded in delicate photons of infrared light providing quantum communications which could offer far secure than any existing information relay system spanning multiple countries expecting quantum internet by 2030. China currently has experimentally demonstrated 18-qubit entanglement that is the basis of quantum computation and quantum communication.Quantum Internet (QI) supports many applications deriving the power by creating quantum entangled qubits information transmitted between the remote quantum processors. Most applications of QI require very modest quantum processors.

As per most literature on service dominant logic (SDL) perspective [1], all Internet providers are service providers, and service is the fundamental basis of exchange. Even though SDL paradigm has contributed to the conceptualization of "value co-creation", so far, no academic research study has investigated the role played by the stakeholders in quantum internet (QI) service sustainability. Hence, the author has coined quantum value co-creation (QVCC) - a business strategy focused on inscribing economic, socio-cultural and environmental issues by recognizing sustainable competitive advantage that bring about community benefit by QI service providers.

The aim of this paper is to develop a holistic QI model. This study also takes a strategic view to discuss QI paradigm including goals, markets, potential deployment, and consequences for global competitiveness offering several recommendations.https://www.wired.com/story/quantum-internet-is-13-years-away-wait-whats-quantum-internet/

RESEARCH MOTIVATION & STUDY JUSTIFICATION

So far, no academic research work has investigated to fill the void in the literature with regards to the following emerging technology concepts that formthe "Quantum Internet" holistic model:

(i) Integration and symbiotic relationship between quantum computing and 6G wireless networks that creates "Quantum Internet (QI)".

(ii) (ii) Quantum Teleportation - derives the power from quantum satellites (QS) by creating quantum entangled qubits information transmitted between the satellites and multiple ground stations encoded in delicate photons of infrared light supporting many applications known as quantum communications to span across multiple countries offering "Quantum Internet".

Both technology concepts mentioned above disrupt market opportunities to attain quantum value co-creation (QVCC). Value co-creation requires a multidimensional approach and performance by the firms those who aspire to develop, manufacture and market disruptive technologies. Value co-creation is multi-faceted with the integration of the economic, environmental and socio-cultural dimensions of sustainability concerns and the challenges have consequences for every aspect of a company's business strategy. Yet, the most top leadership team of technology firms consider sustainable development as a one-dimensional opportunity. Hence, this conceptual research justifies filling the void in the literature by proposing a holistic QI model to provide new knowledge important for all stakeholders as a multidimensional opportunity for the QI market contributing to the discourse on quantum value co-creation (QVCC) domain. Considering the

above scenario, it is worthy of attention to fill the knowledge vacuum by conceptualizing the QI model enriching the literature.

This conceptual study is important and directed towards the stakeholders of QI market and shall have the benefit to the wider audience to understand the changes and challenges contributing to the discourse of QVCC for an enterprise and principally relevant to two main groups:

(i) Governments and its agencies, entrepreneurs, investors, industry leaders, management practitioners, and policymakers will be able to make decisions about the implementation of sustainable value co-creation (QVCC) capabilities.
(ii) Researchers, academic faculty members, and students will learn a methodology that explores principally the literature review focusing on QI holistic model in creating quantum value co-creation (QVCC).

RESEARCH BACKGROUND

The evolution of "Gs" - history & context

A new generation of wireless technology has transpired almost every decade since 1G was introduced in 1982. Globally various wireless (2G, 3G, 4G) technologies are available today to users for mobile communication. These wireless technologies differ from one to another based on coverage, range, availability, and performance. Currently, 3G and 4G are the most popular globally.

5G wireless technologies and networks are being in the deployment stages. The development of 5G a ubiquitous mobile network integrates data collection and computation with billions of devices offering unprecedented insights and abilities that will change the society with dramatic economic prosperity. 5G Competition is already being fierce. The cost, coverage and rollout implications of 5G networks across many countries in the world are explored by extrapolating 4G LTE and LTE-technology/network characteristics. For the business-as-usual scenario, 70% of the global population may be covered with 5G by the end of this decade. Furthermore, varying the annual capital intensity or deploying a shared small cell network can greatly influence the time taken to reach the 70% threshold mostly benefiting rural areas. Moreover, the deployment of 5G wireless technologies won't provide adequate security, lack of significant reliability gains over existing wireless networks, and going to pose impediments enabling the far-reaching applications, particularly in the Internet of Everything (IoE) domain. Such shortcomings are encouraging activities to focus on the "beyond 5G" wireless aiding terabit per second speeds needed for true microsecond latency with unlimited bandwidth to provide pervasive IoE applications and adequate security as well as dependability benefits.

5G is being developed and commercially deployed in some parts of the world is emerging to offer a wide range of features that are mentioned below in comparison to the previous technologies:

- Speed - 1 to 10 Gbps.
- Latency will be 1 millisecond (end-to-end round trip).
- 1,000x bandwidth per unit area.
- Feasibility to connect to 100 number of devices.
- Global coverage.
- 90% reduction in network energy usage.
- Battery life will be much longer.
- The whole world will be in the Wi-Fi zone.

However, 5G wireless technology has the following limitations: (i) most of the old devices would not be competent to 5G, hence, to be replaced with new one — expensive proposition, (ii) high cost for infrastructure development, (iii) security and privacy issues are inadequate, and (iv)coverage distance of up to 2 meters (in indoor) and 300 meters (in outdoor) can be achieved due to higher losses at high frequencies (millimeter waves suffers from penetration loss, attenuation due to rain, foliage loss, etc.). It will take some time for the common person to make use of 5G technology.

5G wireless principal benefits over current wireless platforms are proclaimed as latency reduction, therefore, 6G will emerge to satisfy the expectation not met with 5G. Assuming the mobile technology trend continues, 6G wireless will emanate several years after 5G is embraced and will offer terabits per second along with microsecond latency.
Concepts and functions of 6G technology are at the nascent stage of research. 6G wireless is upcoming in the field of mobile communication technologies and is based on a set of standards that enable devices for the Internet of Everything (IoE) applications with broadband wireless access. 6G wireless technology promises to be at least twice the speed of 3G standard for cellular data and 2.7 times more legit than the 5G iteration of 4G wireless technology moving beyond the Software-Defined Network (SDN) to the Market Defined Network (MDN).

Most devices connected nowadays are machines (Internet of Things - IoT) rather than people. Given the rise of smart homes, smart buildings and smart cities, 5G and 6G will involve exponential demands for machine-to-machine communications such as autonomous drone, robotic and transport systems. Some other trends projected for 6G involves ultra-dense cell networks, millimeter waves (mmWaves) for user access, enhanced optical-wireless interface, intelligent networking to empower full immersive experience. Users will demand higher capacities, greater global coverage, and always-on connectivity for future Internet services and applications. Hence, the Internet-of-Everything (IoE) is a relevant development. and 6G will be expected to deliver all the above.

The author predicts that some carriers are going to innovate in the Iterative Network Naming Technology (INNT) field and decide to take that challenge head-on. While most carriers can claim to offer the speeds of 6G wireless technology, Ting is the first company in North America to market with the 6G wireless technology rebranding of today's LTE standard offering faster and more reliable in the field of wireless technology. TING 6G Mobile Network Technology is set to take over as the new mobile marketing buzzword and Ting is the first carrier to bring this brand-new mobile buzzword to market. https://ting.com/blog/ting-first-market-6g-mobile-network-technology/

As per Google search, 6G is among the top 17 most searched keywords today. 6G is promised to provide increased data speed up to 1000 Megabits per second and 6G devices are expected to move up to 1GB or even more than that improving data and voice quality with video calling rich media as well as better security for wireless data transmission standards.

6G technology will require vast new base stations - these are the masts that transmit and receive mobile phone signals which means that the level of radiation exposure from 6G antennas will be lower. 6G spectrum will fall within the microwave band. Microwaves create heat in objects through which they pass. At the levels utilized for 6G, the heating effects may be harmful.

To integrate the three kinds of satellite networks (navigation satellite networks for the global position, the telecommunication satellite networks, earth imaging satellite networks) to provide position identifier, multimedia and internet connectivity, as well as weather information services for mobile users are key objectives for 6G.

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	6G
Generation	Sixth
World Wide Web (WWW) Support	Wireless WWW (WWWW)
Architecture	Open Wireless Architecture (OWA)
Data Rates	10 to 11Giga bits per second (Gbps)
Transmission Speed	Terabit Range
Useable Format	Mobile Internet Packet (IP)
Multiple Mobile and Network Access	Yes
Integration of Satellite Communication Networks	Yes (Satellite to Satellite Communications)
Applications	Futuristic – Autonomous System, Network Mix Reality, 3D Internet concept, Space technology and defense applications, home based ATM systems and Natural Calamities will be controlled by 6G. Mind to Mind communication is possible.
Remote Management & Diagnostics	Yes
Encryption	Yes (Flexible and Anti-Virus)
Memory Capacity	Large
Clarity/Quality (Audio & Video)	Yes

6G [2] wireless network should be planned for global coverage with space roaming. In a satellite network system, the satellite will be for voice and multimedia communication; navigational satellite for the global positional system (GPS) and earth image satellite for additional information such as weather update. The 6G will be the most advanced generation in wireless communication but there will be some challenging issues specifically during the roaming usage of mobile phone from country to country since satellite moves constantly in a specific orbit. Most of the 6G applications require higher bit rates than 5G catering to IoE applications such as eXtended Reality (XR) encompassing virtual reality (VR), augmented reality (AR) and mixed reality (MR) and wireless brain-computer interactions (WBCI). 6G should deliver around one (1) Terabit/second and will motivate exploration of frequencies beyond sub6 GHz requiring higher reliability providing pervasiveness across most 6G applications. 6G must deliver multiple services for applications such as XR, BCI, CRAS, and DLT where tracking, control, localization, and computing are an inherent feature. While live multimedia streaming applications will remain central to 6G, the key determinants of the system performance will be four new application domains:

1) Multisensory XR Applications: XR will yield many killer applications for 6G across the AR/MR/VR spectrum. Upcoming5Gsystemsstillfallshortofprovidingafullimmersive XR experience capturing all sensory inputs due to their inability to deliver very low latencies for data-rate intensive XR applications. A truly immersive AR/MR/VR experience requires a joint design integrating not only engineering (wireless, computing, storage) requirements but also perceptual requirements stemming from human senses, cognition, and physiology. Minimal and maximal perceptual requirements
2) Connected Robotics and Autonomous Systems (CRAS):
3) Wireless Brain-Computer Interactions (BCI):
4) Blockchain and Distributed Ledger Technologies (DLT)

The following are five mobile industry goals in the 6G era, as shown in figure 2:
• Boundless secured (encrypted) connectivity for IoE
• Innovation networks with optimal economics including satellite networks
• The digital transformation of industry verticals
• Transform the mobile broadband experience& integration of satellite networks.

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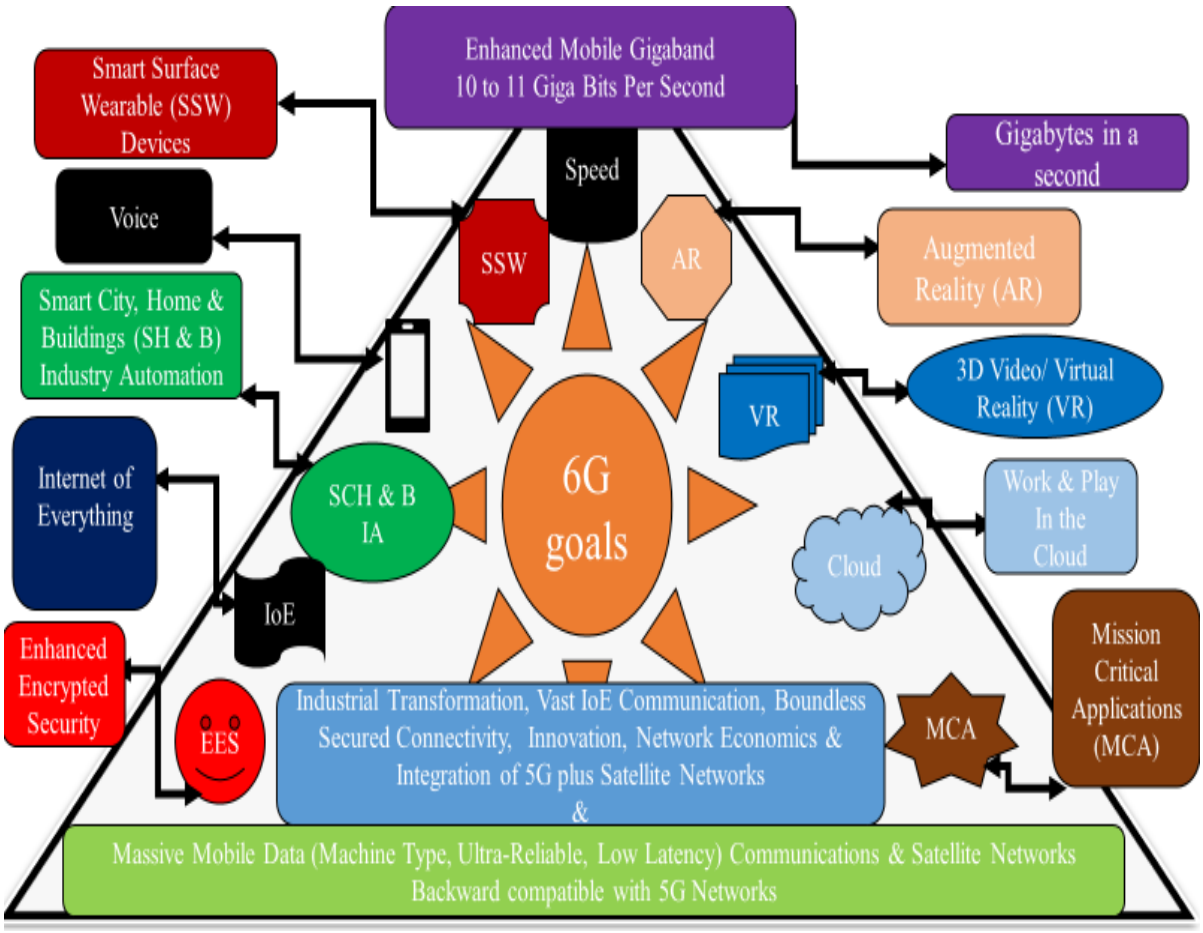

Fig.2 6G Wireless Goals & Applications

6G Recommendations

- 6G ought to deal with ground and aerial users, encompassing smart surface wearables and XR devices.
- 6G systems should motivate new machine learning and data analytics techniques harnessing both big and small datasets across their infrastructure to enhance network functions and provide new services.
- Blockchain (distributed ledger technologies) motivate an urgent need for intelligent Self-Organizing Networks (SON) to manage network operations, resources, and optimization. Therefore, 6G requires a paradigm shift from classical SON into a self-sustaining network (SSN) that can maintain its key performance indicators in perpetuity and rich 6G application domains.

Quantum Computing

Classical computers are developed upon the concept of digital logic and bits. Quantum computers. Quantum systems exist in a superposition of states and developed upon the concept of qubit. The following table compares Classical (Digital) Computing Vs. Quantum Computing Terms:https://quantum1net.com/classical-computing-vs-quantum-computing/

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	Classical	Quantum
Basic Unit	Binary Bit (1 or 0)	Qubit or Qutrit or Ququart or higher
Description	Truth Table	Unitary Matrix
Computing	Logical Operation	Unitary Operation
Direction	Most gates run forward	Gates are Reversible
Copying	Easy	Impossible
Noise	Minimal with Error Correction	Quantum Error Correction very difficult, but recently researchers found the compound uranium ditelluride (UTe_2) could be used to build logic circuits with qubits that can be in two states at once without errors. Topological quantum computing has challenges of its own, but uranium ditelluride as a superconductor is a step in the right direction for error correction. This superconductor (UTe_2) potentially the silicon for the quantum information.
Storage	n-qbits storage holds 1 value from 0 to 2 ** n-1	n-qbits storage holds 2 ** n values
Computation	n – bit processor = 1 operation	n-qbit processor = 2** n operations

Quantum mechanics is not a new kid on the technology block. It is a concept almost 120 years old.The quantum theory was introduced in 1900, an innovation that won the Nobel Prize in physics in 1918. In 1959, the concept Quantum Computing was introduced and suggested using quantum mechanics to build a new type of computer called Quantum Computer.

For more than 50 years, the road towards ever more performant computing has been guided by Moore's Law. The need for increased performance and reduced power consumption are becoming the main drivers for innovation.One can imagine what these high-performance commercial quantum computers might look like as early as 2030.For both cloud computing and supercomputing, we will need solutions that bring computing to a higher level of performance at the lowest possible power consumption.

Quantum computing (QC) is now emerging as the next generation of computing and undeniably having the power to complete operations that took days within seconds. In 2019, two major technologies have been making headlines – artificial intelligence (AI) and quantum computing (QC). These two technologies would transform the nature of cyber-attacks. Artificial intelligence can be used to probe and to tailor attacks against organizations. With QC, the scaling of computations goes up dramatically to the point where the time needed for breaking traditional encryption would shrink to minutes and has the potential to completely transform the cyber threat landscape.

Quantum computing is an exciting new computing paradigm and is the ultimate in parallel computing with the potential to tackle problems that conventional digital computers can't handle. A quantum computer, completely different from a binary digital computer that performs computing using quantum-mechanical phenomena and would theoretically be able to solve certain problems much more quickly than any digital computer. Where current digital computers would require tens of billions of years to solve some of the world's most challenging problems, a quantum computer would be able to find a solution in only minutes, hours, or days enabling researchers to develop new catalysts, state of the art materials, new smart fashion surface wearables, improve medicines, accelerate advances in artificial intelligence, and even answering questions about the origins of the universe.

National Institute of Standards and Technology (NIST) scientists have found a superconductor that could sidestep one of the primary hurdles standing in the way of effective quantum logic circuits. Newly discovered properties in the compound uranium ditelluride, or UTe_2, could prove highly resistant to one of the nemeses of

quantum computer development — the difficulty with making such a computer's memory storage switches, called qubits, function long enough to finish a computation before losing the delicate physical relationship that allows them to operate as a group. This relationship, called quantum coherence, is hard to maintain because of disturbances from the surrounding world.The interaction of qubits or qutrits or quqarts or even higher causes their quantum behavior to decline and ultimately disappear. This is called decoherence. Little change in temperature creates disturbances are known as "noise" tumble out of superposition. Quantum supremacy - Quantum computer can calculate a mathematical calculation compared to the most powerful digital supercomputer.https://www.nist.gov/

The basic principle behind quantum computing is that quantum properties can be used to represent data to perform operations on it. Quantum computers will disrupt industries, businesses, markets globally by solving problems that are impossible today. MIT's quantum learning initiative has created in collaboration with IBM Q, and MIT – IBM Watson Artificial Intelligence (AI) Lab. https://quantumcurriculum.mit.edu/

Since 2016, IBM has introduced and released the following related to quantum computing:

May 2016 - Q Experience, with a five-qubit quantum processor.
July 2016 - Q Experience community forum.
January 2017 - several additions to the IBM Q Experience.
March 2017 - Qiskit enable users writing code easily and run experiments on the quantum processor.
May 2017 - made an additional 16 qubit processor available on the IBM Q Experience.
January 2018 - IBM launched a quantum awards program.
January 2019 - world's first commercial quantum computer called IBM Q "System One
https://www.technologyreview.com/s/613596/how-a-quantum-computer-could-break-2048-bit-rsa-encryption-in-8-hours/

Quantum computing building blocks, as shown in figure 3.
Constructing a quantum computer is a formidable task. Scientists are inventing to create innovative patterns of nitrogen-vacancy (NV) centers in diamond, an approach to computing and storing quantum data. Quantum computers could hypothetically perform specific calculations far quicker and better than digital computers. Diamond nanophotonic technology (DNT) is a key contender for future optical computers. This facilitates an appropriate roadmap for the mass production of quantum logic gates (QLG) that are an important element for quantum computing architectures. However, properly positioning these NV centers is a fundamental challenge.

IBM Q systems are designed to one-day solve problems that are currently seen as impossible. Future applications of quantum computing may include finding new ways to model financial data. IBM Q System One is comprised of several custom components that work together to serve as the most advanced cloud-based quantum computing program available that includes the following:

- Quantum hardware designed to be stable and auto-calibrated to give repeatable and predictable high-quality qubits;
- Cryogenic engineering that delivers a continuous cold and isolated quantum environment;
- High precision electronics in compact form factors to tightly control large numbers of qubits;
- Quantum firmware to manage the system health and enable system upgrades without downtime for users; and
- Classical computation to provide secure cloud access and hybrid execution of quantum algorithms.

IBM's indispensable history in computing goes back to the development of IBM's first line of business computers in the 1950s which revolutionized the world by changing the way businesses thought about computer hardware. The IBM Q System One is a major step forward in the commercialization of quantum computing critical in expanding quantum computing beyond the walls of the research lab to develop practical quantum applications for business and science.

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Classical computers store data in bits that can have a state of either 0 or 1. Quantum computers store data in quantum bits (qubits) that can have a superposition of both 0 and 1 states. A graphical representation of nitrogen vacancy (NV) qubits fabricated within the diamond. The NVs were made in precise, dense arrays (μm = micrometers) for future quantum computers.

The design of IBM Q System One includes a nine-foot-tall, nine-foot-wide case of half-inch thick borosilicate glass forming a sealed, airtight enclosure that opens effortlessly using "roto-translation," a motor-driven rotation around two displaced axes engineered to simplify the system's maintenance and upgrade process while minimizing downtime – another innovative trait that makes the IBM Q System One suited to reliable commercial use. A series of independent aluminum and steel frames unify, but also decouple the system's cryostat, control electronics, and exterior casing, helping to avoid potential vibration interference that leads to "phase jitter" and qubit decoherence. A new study indicates that scientists have already found quantum computers to perform the code-breaking calculations, reducing the resources they require by orders of magnitude and quantum technology will converge with encryption standards to store data securely for decades. https://www.technologyreview.com/s/613596/how-a-quantum-computer-could-break-2048-bit-rsa-encryption-in-8-hours/

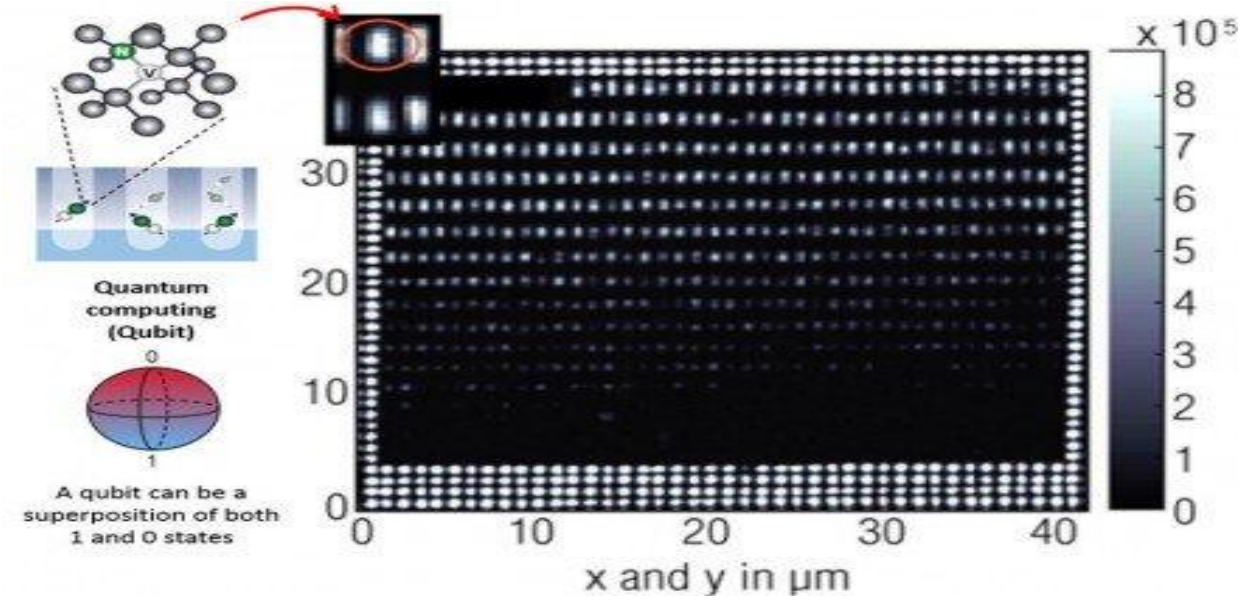

Fig.3 Quantum Computing Building Blocks
Source: Image courtesy of Dirk Englund, Massachusetts Institute of Technology (MIT), and Sara Jarret.

Google has hinted its gate-based 72 qubit quantum processor called Bristlecone and has done an outstanding work of keeping quantum errors in check with Bristlecone, as shown in figure 4. QC Ware's cloud service platform will be compatible with the Bristlecone quantum processors from Google.

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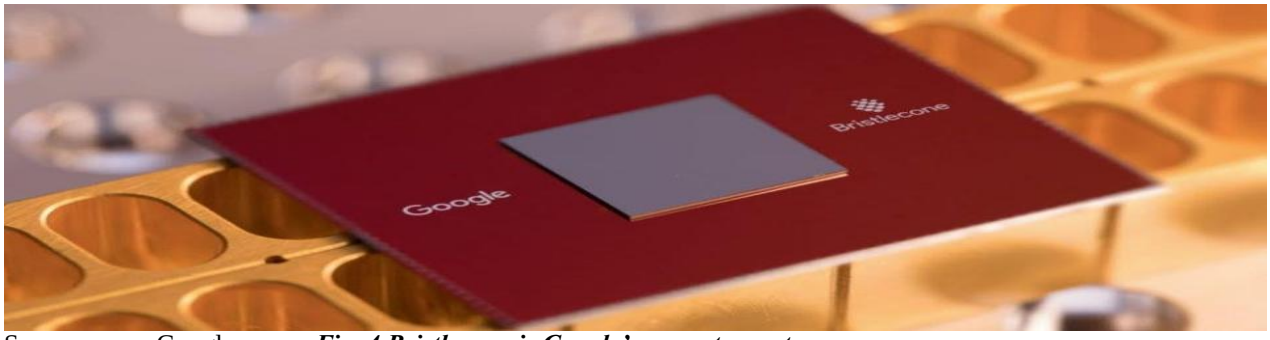

Source: www.Google.com ***Fig. 4 Bristlecone is Google's newest quantum processor***

It will take at least 10 years until the real benefits of quantum computing are realized. The following areas where QC will have a significant impact:

(i) New chemicals, drugs, and materials modeling.
(ii) Designing custom properties to develop new pharmaceutical.
(iii) Optimization problems solving with robust simulations to provide in-depth insight, better forecasting, and higher efficiency.
(iv) The combination of QC and AI become orders of magnitude smarter.
(v) Quantum computing, genetic engineering, and artificial intelligence (AI) will coalesce to enable forced speciation of the homo sapiens.

Besides materials discovery, there are many other useful applications, including weather and climate modeling, space exploration, fundamental science, the modeling of economic or societal phenomena (where complex differential equations need to be solved), machine learning, and the development of personalized medicine. Eventually, it is required to embed the growing power of quantum processing into existing computing paradigms to enable the required 'quantum leap' in performance. QC will also make previously uncrackable security codes obsolete, resulting in a need to establish QC-resistant cryptography methods. More generally, QC is expected to accelerate the progress of a wide range of disparate applications, such as artificial intelligence (AI), finance modeling, weather forecasting, and particle physics. Today, it takes pharmaceutical companies up to 10+ years and often billions of dollars to discover a new drug and bring it to market. Improving the front end of the process with quantum computing can dramatically cut costs and time to market, repurpose pre-approved drugs more easily for new applications, and empower computational chemists to make new discoveries faster that could lead to cures for a range of diseases. Revolutionizing the molecule comparison process Quantum computing has the potential to change the very definition of molecular comparison by enabling pharmaceutical and material science companies to develop methods to analyze larger-scale molecules.

Quantum computing is on a steady upward trajectory, but the field is in flux with new technologies starting to come online. Unlike binary bits, the qubits in quantum computing/computers (QC) exist as 1s and 0s simultaneously and act as a group. As a result, a 300-qubit set would be enough to calculate all the information in the universe, according to some calculations. In other words, more than anyone needs to know in a lifetime. Despite the multiple challenges in quantum computing, the field is steadily progressing towards a high-performance quantum computer that can solve difficult problems in cryptography, chemistry, and AI. According to Boston Consulting Group, the hardware and end-to-end providers are building the commercial foundations of QC, while specialized software service providers focus on solving problems.

D-Wave is the only company that is currently selling quantum computers. Google and NASA have been testing D-Wave's machines since 2013. Each D-Wave QC costs more than $10 million (the first unit was sold to cybersecurity firm Temporal Defense Systems Inc. for $15 million). While IBM has yet to start selling quantum computers, it raised the capacity of its prototype to 50 qubits in 2017 and — in early 2019 — IBM announced Q System One. Many see this 20-qubit machine, which measures nine cubic feet, as a significant step towards mass commercialization. Using a 49-qubit test chip from Intel, the Dutch company QuTech plans to offer access to its Quantum Inspire prototype platform as well as to a full-blown QC processor sometime in 2019.

A few huge scientific leaps, including a superconductor that can act in the same way as silicon, required for quantum computing to become fully realized. A thorny issue known as quantum decoherence must be solved for qubits to be operational and stable for long enough to do actual computing. UTe2 as a superconductor is strong resistance to magnetic fields - resistance to the errors. Researchers found the compound uranium ditelluride (UTe2) could be used to build logic circuits with qubits that can be in two states at once without errors. Topological quantum computing has challenges of its own, but uranium ditelluride as a superconductor is a step in the right direction for error correction. This superconductor (UTe2) potentially the silicon for the quantum information era.https://www.sciencealert.com/this-superconductor-material-could-be-the-silicon-of-quantum

QC could enable some of the key numerical algorithms of the 21st century and is best suited to solve problems using three types of algorithms: optimization, sampling and machine learning. In collaboration with 1QBit, Accenture Labs has mapped more than 150 cases for quantum computing to be used for various applications such as portfolio risk optimization, protein folding, drug discovery, supply chain, purchasing, utility system distribution, advertising scheduling and revenue maximization in industries like financial services, healthcare, and manufacturing, etc. By leveraging quantum computing – a computing paradigm that has the potential to find the answer to complex business problems millions of times faster than classical computing by leveraging the properties of quantum physics – the new application such as at Biogen looking to harness cutting-edge technologies that push the boundaries of traditional pharmaceutical research to discover new treatments and cures for complex neuroinflammatory and neurodegenerative conditions. Biogen a distinct competitive advantage through time to market and cost savings by collaborating with researchers at Accenture Labs and 1QBit a quantum-enabled application has been deployed to enable to bring medicines to people quicker and transformation of the drug recovery process. https://www.accenture.com/us-en/insight-quantum-computing

The calculating units of QC are quite delicate, struggling to cope with environmental noise. Majorana fermions tend to be sturdier, so it's been suggested they could make for good qubits. Majorana fermions are thought to emerge in certain phase transitions of superconductors, and it's this transition that's believed to be the topological superconductivity observed by the researchers. Researchers have succeeded in revealing experimental evidence for a new state of matter – topological superconductivity that can be manipulated in ways that could both speed calculation in quantum computing and boost storage."
https://www.iflscience.com/physics/scientists-discover-a-brandnew-state-of-matter-that-could-improve-quantum-computers/

The new discovery of topological superconductivity in a two-dimensional platform paves the way for building scalable topological qubits not only to store quantum information but also to manipulate the quantum states that are free of error. This new state is called "topological superconductivity," could help to increase storage capabilities in electronic devices and enhance quantum computing.
https://interestingengineering.com/newly-discovered-state-of-matter-could-vastly-enhance-computing

Quantum Internet – a vision for the road ahead

Two prominent, eye-catching disruptive technology concepts are emerging to offer Quantum Internet (QI). The symbiotic integration of quantum computing (QC) and 6G wireless will facilitate “Quantum Internet” (QI) with secured quantum communications disrupting global markets. The other concept called “Quantum Teleportation” derives the power from quantum satellites (QS) by creating quantum entangled qubits information transmitted between the satellites and multiple ground stations encoded in delicate photons of infrared light supporting many applications known as quantum communications to span across multiple countries offering “Quantum Internet”.

Concept 1- Symbiotic Integration between Quantum Computing and 6G

Global demand for broadband connections from both households and business has been strong for many years. The broadband market can be divided into wired (fixed) and wireless (mobile). Globally, the wireless broadband market is much larger than the wired broadband market: Six (6) billion mobile broadband versus 1.1 billion fixed broadband subscriptions at the end of 2018. It is worth noting that the number of fixed broadband users is

at least three times the number of fixed broadband connections due to shared subscriptions in households, enterprises, and public access spots. Globally, the mobile broadband market has enjoyed higher growth; increasing on average by more than 20 percent annually over the past five years. The growing global popularity of the Internet and video streaming has led to increasing demand for high-performance broadband services. This demand cannot be met with legacy xDSL or cable. In addition, many operators are struggling to find revenue growth. Despite fixed and mobile broadband growth, there is a large underserved household market. This market can be served by 5G/6G cost-efficiently with fixed wireless access (FWA).

MNOs have already deployed 5G home broadband (fiber like speed). MNOs like THREE in UK has launched 5G home internet.The following are the reasons FWA is gaining momentum: (i) Enhanced network performance, (ii) increased demand, (iii) additional spectrum, (iv) lower network cost, (v) increased machine to machine connectivity, (vi) Governments (around the world) connectivity ambitions, (vii) additional revenue for the mobile network operators (MNOs).FWA is not a new phenomenon and the following are drivers for 6G market attractiveness: (i) market dynamics, (ii) MNOs strategy, (iii) competitive environment and substitutes, (iv) MNOs network and spectrum.6G fixed wireless access (FWA) unlocks a world of opportunity. 50% of the world's population is still waiting for reliable and robust broadband internet access. Many households and business globally represent a profitable FWA growth opportunity. A very real use case of 6G is to provide higher data bit rate to fixed subscribers. Mobile technology is considered a true murderer of a fixed (wired) network. It's the emerging 6G's turn to omit the need for FTTH (Fiber to the Home). The trend is obvious: 6G routers are among pioneering emerging products to hit the market which consume bandwidth supposed to be provided by the fiber.https://www.ericsson.com/en/networks/offerings/fixed-wireless-access

Imagine the phenomenon of symbiosis and the different types of symbiotic relationships exist in the eco-system. A "symbiotic" relationship is an interdependent relationship between two (or sometimes more) entities which is mutually beneficial for the stakeholders of the relationship. The relationship between the computing and communication industries began during the birth of the modern computing industry and has a stronger symbiotic relationship over the past decades. Hence, there is a positive sum gain from the relationship. Computing devices are becoming more communications driven. Communication networks are computing centric. Increasingly the success of computer-enabling services connecting millions of people and machines in useful ways depends on Gigaband wireless data.

The race to roll out "6G and Beyond" wireless paradigm will be the most tectonic fight for global technological preeminence. The 6G archetype can offer backward and forward compatibility with 5G and 7G respectively integrating terrestrial wireless with satellite communication systems as well as space roaming for global ubiquitous mobile network coverage creating strategic competitive advantage offering virtually Internet of Everything (IoE) for everybody. Smattering technologies will mature along the same time of 6G wireless to play a symbiotic role in the standardization process. One such prominent and eye-catching technology is quantum computing. Quantum computing communication (QCC) explores the integration of quantum computing and 6G wireless offering "Quantum Internet" - a disruptive symbiotic model (DSM) disrupting markets globally making the products, process, and services superior during the next decades.

Concept 2 - Quantum Teleportationis a method for teleporting data that relies on a phenomenon called entanglement. New experiment findings show, for the first time ever, researchers have teleported a qutrit, a unit of quantum information that exists as three orthogonal quantum states. Quantum teleportation has long been limited to qubits. With this achievement researchers have also made an important step towards practical applications towards future quantum internet.

Researchers start experimenting on teleporting ququarts, four-level units, or even higher. Scientists have tested with record breaking amount of data in quantum form, using quantum information called a qutrit proving Qutrit entanglement. https://interestingengineering.com/qutrit-experiments-show-progress-in-quantum-teleportation, https://phys.org/news/2019-08-complex-quantum-teleportation.html

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The internet has had a revolutionary impact globally with a massive network that enables simultaneous long-range communication. The vision of a quantum internet is to fundamentally enhance internet experience by enabling quantum communication between any two points on earth. So, a quantum internet operates in parallel to the present internet available connecting quantum processors and enables to solve problems that are fundamentally impossible for the classical internet.

In 1993, teleportation was indeed possible in principle. In subsequent years, research scholars have demonstrated teleportation experimentally in a variety of systems. Teleportation promises to be quite useful as an information processing primitive, facilitating long range quantum communication, perhaps ultimately leading to a "quantum internet".

A quantum internet has many applications ranging from secure access to remote quantum computers and the well-known application such as quantum key distribution (QKD), which enables two remote network nodes to establish an encryption key whose security only relies on the laws of quantum mechanics. One of the applications of a quantum internet is to enable secure access to remote quantum computers in the cloud. Specifically, a simple quantum terminal capable of preparing and measuring only single qubits can use a quantum internet to access a remote quantum computer. Almost all other applications of a quantum internet can be understood from two special features of quantum entanglement. QuTech, at the Delft University of Technology (Netherlands) in collaboration with the European Quantum Internet Alliance, is pursuing the research to achieve proof of concept vision and establish a quantum Internet between the cities of Amsterdam, Leiden, Delft, and The Hague. Quantum Internet involves quantum computers sending quantum data, quantum bits (qubits) and is not necessarily meant to replace the classical internet or classical communication, but rather to supplement and enforce it with quantum communication. https://techupdatess.com/a-super-secure-quantum-internet-just-took-another-step-closer-to-reality-mit-technology-review/

The quantum internet connects particles linked together by the principle of quantum entanglement. There are many more applications where the idea of entanglement could be helpful. Example: Increase of the baseline of telescopes by using quantum entanglement. One could envision using the quantum internet to create entanglement between atomic clocks in different locations around the world.

Internet is a huge global information highway. And I think some of the same things could happen with the quantum internet. The concept of quantum entanglement is so counterintuitive that it is not easy to use intuition to find applications for it.At present, sensitive data is encrypted and transmitted across fiber-optic cables and other channels together with the digital "keys" to decode the information. Quantum communication takes advantage of the laws of quantum physics to protect data. These laws allow particles—typically photons of light —to transmit the data using quantum bits, or qubits or qutrits or ququarts or higher.

World's first link-layer protocol brings quantum internet closer to reality by the Delft University of Technology Using the link-layer protocol, higher-layer software can request the creation of entanglement without needing to know which quantum hardware system is in the box.

Researchers from QuTech have developed a so-called link layer protocol which enables the phenomenon of quantum entanglement to a real-world quantum network. This brings one step closer to become quantum internet a reality. Two or three or four quantum bits can be entangled and make the connection for quantum networking. The phenomenon of entanglement provides the basis of a quantum internet. It is physically impossible to eavesdrop on an entangled network connection.

The quantum internet is emerging sooner than quantum computing itself and new rules will protect data against attacks from computers that don't even exist yet. Scientists and cryptographers hope it could provide protection against not only theoretical threats but also those we haven't dreamed up yet. The primary contribution of a quantum internet is to allow encrypted communication in a perfectly secure way. The quantum internet would hopefully protect us from planned new computers, along with every theoretical computer for the foreseeable future.

Post-quantum cryptography could be the most important and relevant change that quantum computing will bring to your life. Entanglement, a quantum phenomenon, in a quantum-internet can bring a communications revolution. A quantum repeater works by first creating entanglement between the repeater and each of the end nodes individually. Subsequently, the repeater teleports one of the qubits entangled with node one onto node two. This procedure is called entanglement swapping and allows the creation of entanglement over distances where direct transmission is infeasible. After establishing long-distance entanglement, a data qubit may now be sent using quantum teleportation

A quantum internet composed of three essential quantum hardware components. First, a physical connection (quantum channel) that supports the transmission of qubits. Second, a means to extend the short distances. Quantum channels are inherently lossy. To reach longer distances, quantum repeaters are necessary. The final component is the quantum processors connected to the quantum internet. Quantum internet is not meant to replace the classical internet, but rather to supplement it with quantum communication. A specific implementation of a quantum internet may be optimized for distance, functionality, or both.

Quantum teleportation is a process by which quantum information can be transmitted from one location to another. Researchers announced another feat in quantum teleportation when entangled photons were sent from the Micius satellite to two ground stations over distances between 994 miles and 1,490 miles (1,600 and 2,400 km), depending on the location of the satellite in its orbit. This experiment showed that entanglement can happen over long distances.

China launched the world's first quantum satellite and is designed to send and receive bits of information encoded in delicate photons of infrared light. It's a test of a budding technology known as quantum communications, which experts say could be far more secure than any existing info relay system. This satellite has been kept busy sending so-called entangled photons between the satellite (nicknamed Micius) and multiple ground stations. The metaphor used - quantum communications are like mailing a letter, entangled photons are like the envelope and carry the message to keep it secure. China will launch more quantum satellites in the next five years. By 2030, quantum communications will span over multiple countries, thereby expecting quantum internet. The technology is still in its infancy and research scholars still can't control and manipulate quantum signals very well. The quantum satellite was able to send and receive signals, but it can't really store quantum information. The researchers aren't sure how they'd transmit signals efficiently between the nodes of the future quantum web. Blanketing Earth with quantum satellites is expensive and ground-based transmission via optical fiber isn't perfect either.

QUANTUM VALUE CO-CREATION (QVCC)

Internet and mobile industry marketing have sparked interest in co-creation of value defined as the collaboration of service providers, producers, and consumers through the production, delivery, and use of products, process, and services. Quantum value co-creation (QVCC) - a business strategy focused on inscribing economic, socio-cultural and environmental issues by recognizing sustainable competitive advantage that brings about community benefit by QI service providers.Co-creation of value in marketing is a business strategy promotes and encourages active involvement from the customer to create on-demand products. In this study, the author has coined the term QVCC and the definition is as follows:
(i)Quantum term refers to scale and scope where effects become important.

(ii)Value is described in two ways. In the ethical sense, value denotes something of significance and contribution to society to make a positive difference in humanity. From an economic point of view, value is defined as the utility of goods and services as well as the benefits arising from ownership.

(iii)Co-creation is a management initiative, or form of economic strategy, that brings different parties together (for instance, a company and a group of customers), in order to jointly produce a mutually valued outcome. Co-creation is getting other people to do the work and love the brand for it. Nowadays, most businesses are learning to listen, consult, co-operate to work with stakeholders. Furthermore, co-creation is a management dynamism, contemporary business thinking and a new frame of reference that brings the stakeholders together to jointly

produce a mutually value-added result. While most people think of co-creation to innovate to transform the competitiveness, it is also a way of cutting cost. Value co-creation brings the unique blend of ideas to innovative ideas for the brand to provide unique experiences for the stakeholders with continual learning and enhanced market performance drivers. With co-creation, consumers get exactly what they want and have a hand in making it happen.

(iv)Co-creation of value is not new, but new disruptive technologies create new possibilities and opportunities. The following are the two-best-known value chain processes for co-creation of value: (a) Stakeholder´s revetment process - the brand like Apple, able to cut promotional costs. Why is Apple so profitable? Among many other reasons, it draws its stakeholders to market to each other. Apple does not spend marketing dollars to promote products and services (https://www.Apple.com). (b) Product or service development process - the company like IBM, engage third-party resources in product and service development processes. Why is IBM able to reduce its R&D cost? By setting up ―Collaboratory ‘s where its co-partners, as key stakeholders, not only bring their expertise in specific domains but also underwrite some of the cost of that research and development (https://www.IBM.com). Sustainable value denotes the approach to sustainable management, calibration of environmental and socio-cultural resource-based impact assessments on the enterprise valuable contribution to the society.

RESEARCH METHODOLOGY

The choice of research methodology is dependent on the nature of the problem. Morgan and Smircich (1980) argue, “the actual suitability of a research method, derives from the nature of the phenomena to be explored” [3]. In this conceptual study, the research methodology uses exhaustive literature review that facilitates broad search, identify high-quality peer-reviewed papers and analysis to obtain quantum value co-creation (QVCC) perspective related to disruptive technologies such as 6G wireless, quantum computing, quantum teleportation, and quantum internet.

Literature Review

The literature review [4] includes the following three segments:
Segment1. Explores various terms broadly and the search keywords include explanation on the following sections mentioned above: (a)introduction, (b) research background on 6G wireless, quantum computing, quantum teleportation, and quantum internet.

Segment2. Quantum value co-creation (QVCC) building block approach, as shown in figure 5, is as follows: Quantum value co-creation (QVCC)- a business strategy focused on inscribing issues by recognizing competitive advantage sources that bring about community benefit. It's also about diverting business exertions in a way that makes the enterprise profit and empowers communities by unlocking the following:

- Transforming the quantum core.
- Focusing on quantum experience and outcomes.
- Innovating quantum business models.
- Building a quantum-ready workforce.
- Creating a quantum enterprise and quantum ecosystem.

Based on the author’s extensive global marketing practice, as shown in figure 5, the following systematic building block approach is essential for emerging co-creation of opportunities is to collaborate with relevant stakeholders to attain QVCC.

Collaboration with Customers

The following key elements of the market mix is essential while discussing the value co-creation through the collaboration of consumers:
Product: Customers provide feedback to product design, features, and performance through user groups, prototyping, alpha/beta testing, innovation, methodology, open architecture hardware, and software development, etc.
Place: IBM, Microsoft, Intel, MIT, Amazon, Facebook, Apple, Walmart, Fed X, and many other customer locations are involved in the entire process including the supply chain.

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Promotion: The Super Bowl ad is a classic example. As marketing communications evolve from marketer to consumer into multi-directional conversations and brand identity is increasingly co-created.
Price: The consumer is deeply involved in pricing and decides on the price of the product or service.

Collaboration with Suppliers
Supply chain collaboration is the key to value creation. Collaboration can provide a competitive edge. Supply chain management optimizes which companies perform each production, function, inventory, financing, and delivery. As global markets grow, competition takes place between entire supply chains. Research shows that suppliers and customers have little or virtually no role in inventory management.

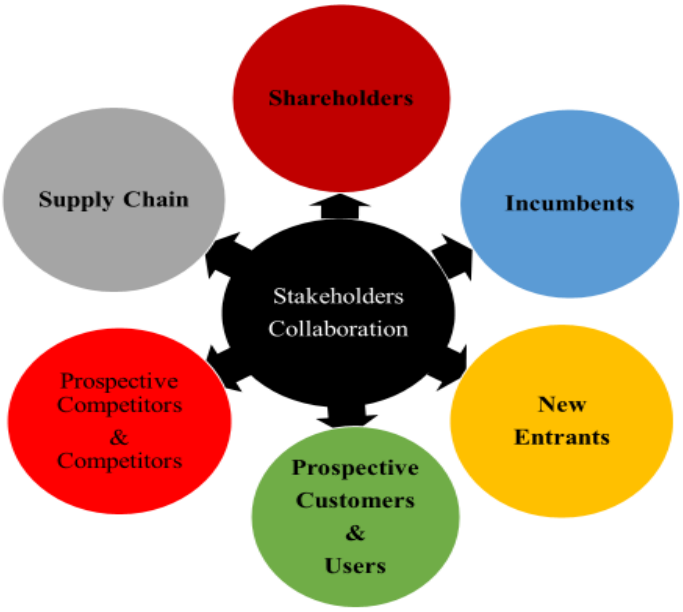

Fig. 5 QVCC building block approach

Collaboration with Competitors
As industry structures evolve and technologies advance, one increasingly sees situations where two firms will be competitors for one part of their businesses and partners in others. Mobile Network Operators (MNO's) are fierce competitors, yet they often share the costs of building and maintaining cell base stations and towers for the Internet. In addition, small mobile network providers lease networks from bigger MNOs to provide Internet services to their customers.

Collaboration with Incumbents
Collaboration with the products and services offered by Digital Computers, Laptops, Tablets, Smartphones, IoT/IoE providers, Internet service providers, and VLSI chip makers makes a more effective and efficient contribution to the creation and sustainability of QI.

Collaboration with New Entrants
A collaboration of large corporations with new entrants (ventures) can produce win-win in the following way: resources and access to markets that new entrants just don't have, therefore, the new entrant can provide technology and skills that complement the large corporations' core strengths. If the collaboration is successful, it may lead to a merger and acquisition.

Collaboration with shareholders

Investors perform a key role in the capital markets. An entrepreneur with a vision can creates a new business, but it takes a collaboration of various stakeholders to make it a success. The author contends that collaboration with investors is imperative for businesses to grow. Based on their collaboration and decision, funding fuels value creation for businesses. This means shareholders have the power to influence the behavior of the companies.

The Value Creation of Quantum Computer

If quantum computing's transformative value is at least ten years away. It is a disruptive technology, therefore, presents early adopters stand to gain expertise, visibility into knowledge and intellectual property that will enable investors and entrepreneurs at a structural advantage as quantum computing gains commercial traction. Quantum computing is considered for a precipitous breakthrough. Companies that have invested to integrate quantum computing into the workflow will capitalize on the immense opportunity. The assessment of value begins depends on what kinds of problems quantum computers can solve more efficiently than digital computers. Example - Drug discovery researchers trying to design a compound targeting disease pathway. The critical element is to determine the electronic structure of the molecule. Modeling the structure of a molecule of penicillin is impossible through a digital computer. But the quantum computer can simulate this type of modeling well within the realm of possibility requiring a processor with 286 qubits. The quantum advantage one day can demonstrate superiority in solving various types of the extreme complexity of computational problems.

The Value Creation of Quantum Internet

The Mobile industry works on a ten-year cycle. 4G-LTE is a great success and a fifth generation (5G) of mobile network technology is due around 2020. With 5G there is a great opportunity to rewrite the industry playbook. 5G has the potential to affect every industry, every company and every person on the planet. 5G fixed wireless access (FWA) unlocks a world of opportunity. 50% of the world's population is still waiting for reliable and robust broadband internet access. Many households and business globally represent a profitable FWA growth opportunity. A very real use case of 5G is to provide higher data bit rate to fixed subscribers. Mobile technology is considered a true murderer of a fixed (wired) network. 5G's turn to omit the need for FTTH (Fiber to the Home). The trend is obvious: 5G routers are among pioneering emerging products to hit the market which consume bandwidth supposed to be provided by the fiber. If the industry follows this pattern, 6G will be launched around 2030. The idea is to insert 6G into diverse industrial value chains and provide entirely new categories of service – the quantum internet, autonomous vehicles/drones, smart cities, quantum wearables to pick just a few examples -- so that MNOs can earn value generated by these services to add an entirely new market segment.

Segment3. Principal constituents driving QVCC

As shown in the figure 6 , the literature review also focuses on the following nine principal constituents that are co-related to each other to drive QVCC attainment: (i)quantum culture, (ii) creativity, (iii) leadership, (iv) quantum innovative thinking, , (v) quantum business model (vi) quantum value proposition, (vii) strategy for quantum ready workforce, (viii) quantum ecosystem, (ix) quantum competitive advantage (QCA):

Quantum Culture

Culture is symbolic communication. A culture is a way of life - the values, symbols, behaviors, beliefs a team accept. Founding and endowing a culture of innovation is one thing but sustaining that culture is another. Technology companies can sustain a creative culture is by recognizing and rewarding the stakeholders, specifically employees. To create a quantum culture of innovation in a company, the following steps are essential:

- Define the mission around quantum innovation.
- Create a flexible structure allowing employees to experiment with new ideas in unstructured time.
- Recognize stakeholder's, specifically employees, contribution to the innovation process
- Be intentional with concise innovation intent.
- Measure what's meaningful.
- Provide freedom and free time to think and innovate
- Give your employees the freedom and "free time" to think and innovate.
- Lead with the right example.
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Quantum culture is a non-judgmental, practical method which helps companies to create dynamic, inclusive, respectful, flexible to build uniqueness by connecting around the innovative ideas and practices focusing on achieving formidable goals to create quantum value. Quantum Culture applies to private and public institutions including ventures, associations, community initiatives, and larger businesses, and non-profit organizations. Diversity among people and the differences attain opportunities is at the core of quantum culture.

Creativity

Creativity is the thinking and innovation is the execution. Creativity is not innovation, but one needs both. Business leaders frequently interchange innovation and creativity. Innovation is not a mysterious black box. Leaders need to understand the difference between innovation and creativity to pursue inspiring work to build a culture of innovation. While business leaders can promote innovation, firms need to support innovation through the design and development process and cultural makeup. Take the example of Starbuck's Frappuccino which is one of the most popular and profitable drinks. It happened because someone was allowed and encouraged to experiment with a new product that deviated from the company's core product line.

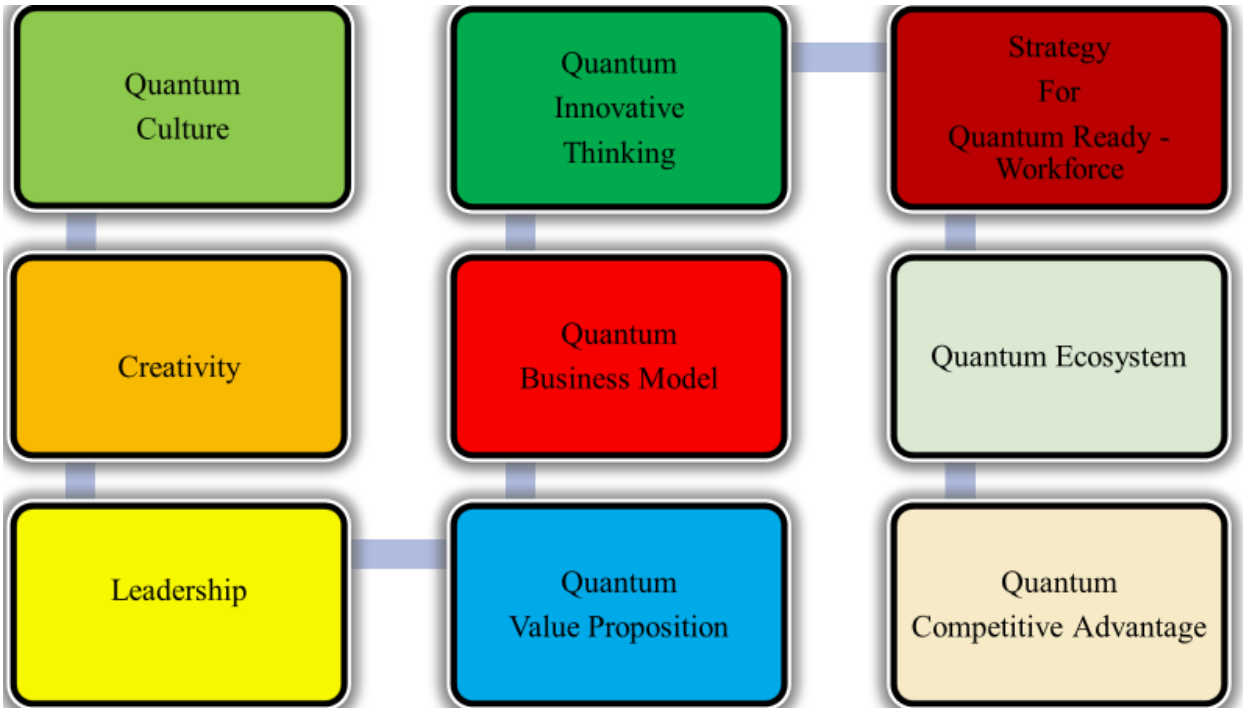

Fig. 6 Nine Constituents of QVCC

Leadership

Shape adaptable leaders who succeed through disruption. An enterprise with an innovation culture doesn't just happen. Developing an innovation strategy that aligns with organization's goals allows creating various aspects of success including identifying a leader and developing a vision. The following distinctive behaviors are essential from an innovation leader: (i) excellent strategic vision, (ii) a compelling customer focus, (iii) creating an environment of reciprocal trust, (iv) loyalty to do what's right for the organization and customer, (v) belief in a culture that amplifies upward communication, (vi) persuasive nature, (vii) excel at setting realistic goals, (viii) emphasizing speed with candid communication (ix) inspire through action.

Quantum Innovative Thinking

The old mantra, "differentiate or die," is not enough and no longer relevant. The author argues, nowadays, there's too much emphasis on differentiation. So, instead of "differentiate or die," the real mantra ought to focus on who to create an innovative solution to disrupt the market that surprises the market with excitement. An unconventional strategy leaves competitor scrambling to catch up to compete and takes an industry into its next

generation. It's what the author calls quantum innovative thinking. The integration of technologies (quantum computing and 6G wireless) share a unique symbiotic relationship. Information technology (quantum computing) and communication (6G wireless) integration are about connecting quantum systems and applications in order to increase availability both on-premises and in the cloud. Integration should be viewed as a key data management system component and helps cross-pollinate across systems to broaden and scale-up organizational outreach. In addition to offering system and application connectivity, the integration (symbiotic) relationship is about merging corporate data—or providing data integration to deliver mission-critical information enabling disruptive value proposition.

No 'one thing' is responsible for making a brand become more innovative. Most of the time a combination of vital ingredients delivers innovative thinking and behavior. The following ingredients are essential for continuous innovation:

(i)Learn to celebrate- What one celebrates plays a vital part in defining a company's culture by encouraging stakeholders to explore their passions, specifically give employees the opportunity to showcase their innovative work and celebrate their accomplishments.

(ii)Reframe problems – People need to reflect on problems to open the opportunity space to spring to mind a solution.

(iii)Co-develop with market dynamics - Think about the balance between technical and market development making sure growth should always be at a similar stage for both.

(iv)Flexibility - Can the technology be executed in other ways to produce the product for other useful applications.

Quantum Business Model (QBM)

The culture and methodologies of enterprise structures undergoing a fundamental shift and entering an unprecedented time in human history. All systems will evolve and elevate to new levels. QBM is a new paradigm of unified field operating with transparency, integrity, responsibility, and coherence incorporating a platform for growth drivers. In the future, companies ultimately thrive must have a coherence to recreate their business model to adapt to a new elevated value system to capitalize new understanding of how the world works. In the QC world, this includes providing the quantum computer, access to the quantum computer over the cloud, programming software, documentation, training classes, a partner program to enable third parties to support end-users and other tools. Examples: Amazon: The World's first QBM is driven by more than cost savings from market efficiencies of scale and the company's reaction time to changes in consumer demand and preference. At present, D-Wave and IBM are using the QBM with Rigetti, Google, Microsoft, IonQ, and others.

https://medium.com/embracing-mastery/the-quantum-business-model-a-new-paradigm-6795bc248d56

Quantum Value Proposition (QVP)

Offering value propositions in the age of disruption with new approaches and solutions is key to driving clients' business forward. To be disruptive is not about being critical; it's all about helping to take customers businesses to a higher level. Smart businesspersons welcome "quantum disruptions" that ensures business to become productive, creating a barrier to competition, efficient, and prosperous. Customers want to do business with people who are forward-looking. Every problem presents with the opportunity to come up with a "quantum disruptive" solution. Even though it maybe one's idea, offering customers' ownership of the endeavor simply speeds up the journey to success. "Quantum Innovation" drives to attain "quantum value proposition" and creates new markets with enormous opportunity.

Strategy for a quantum ready workforce

Companies regularly define their overall business strategy specific to supporting various functions, namely marketing, operations, finance, and R&D. Based on the author's 4 decades of experience in technology companies, firms rarely articulate strategies to align innovation efforts with business strategies. A strategy is a commitment to a set of coherent, mutually reinforcing policies or behaviors aimed at attaining relevant competitive goals. Quantum computing is showing signs of early benefits today. Companies need to train and develop the next generation of talent, expertise, and skills in the quantum workforce. Also, quantum computer developers need to continually innovate breaking down barriers to achieve affordability, flexibility to cloud access and user-friendly software and tools.

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Quantum Ecosystem

Technology is viewed as one of the major dimensions of ecosystems. For the integrant market ecosystems, human emotion factors become an integral part of the creation and design approach in products and a pivotal determinant for communication with the stakeholders. Encircling QC ecosystems design thinking with design tools are a path to generate systems value creation. The introduction of ecosystems originates from the social sphere in the analysis of the system's organization dynamics and to introduce a system view on value creation. An ecosystem can be explored from a macro-standpoint to generate value creation and new knowledge that continuously implement enhanced points of view. The ecosystem is created by a collaboration between brand ecosystem owners and other stakeholders. If one wants to build real ecosystems, then one needs to focus on: generation of the context where intercommunication and consanguinity can quirk. Combining intercommunications with the products and servicesone provides, in specific moments. Companies that have invested to integrate quantum computing into the workflow will capitalize on the immense opportunity.

The salient features of ecosystems are (i) institutions; (ii) value propositions; (iii) resource integration. The two perspectives emphasize the need to interpret ecosystems as (i) systems composed of people and organization actively engaged in resource integration, and (ii) sharing information through digital technologies producing new social rules to enhance value creation and innovation.

Classical (Digital) computers are designed, manufactured and marketed to end-users today because of many different stakeholders collaborate. Such an ecosystem has evolved over time. Quantum computing market is emerging. Companies such as Intel, IBM, Rigetti, D-Wave, Google, Microsoft, and others have chosen to go down the vertical integration direction due to the constant change in research, lack of standards, incompatible hardware, and uncertain roadmaps in this new quantum industry. Some ventures are focusing on the software side including QxBranch, 1Qbit, QC Ware, and Cambridge Quantum Computing. Starting in 2030, the quantum computing market opportunity will be much bigger than classical computers. The QC industry will drive towards standardization process and cost improvements to capitalize on the market opportunity and expand the user base. To continue moving forward implementing the IoT/IoE/QIoE ecosystem, the continual technological innovation evolution and promotion of quantum computing, Internet of Things (IoT), and Internet of Everything (IoE) in industrial processes are essential. To accelerate and scale quantum computing, IBM is partnering with industries, ventures to foster QC ecosystem. IBM has brought online a 5 and 16 qubit system for public access through the IBM Q experience and developed the world's most advanced public quantum computing ecosystem.

Quantum Competitive Advantage

Customer care and trendsetting is at the core of the quantum competitive advantage. Maintaining quality is also one of the fundamental differentiations to attain quantum competitive advantage (QCA) in the QI creation and design. So, in line with the QVCC framework described in this study, ecosystems can be the creation of technology promoted experiences for improving competitiveness to acquire a quantum competitive advantage. To place companies in the vanguard of transformation, one should consider joining a quantum computing ecosystem that is already taking shape. Joining the appropriate quantum ecosystem today could give organizations a quantum competitive advantage tomorrow. Quantum Advantage refers to quantum applications delivering significant advantages and quantum volume is determined by the number of qubits, connectivity, and coherence time, errors, cross talk, and compiler efficiency.

TOWARDS A QUANTUM INTERNET MODEL

Still, to date, the most top leadership team of a firm consider sustainable development as a one-dimensional opportunity. Such a one-dimensional approach provides firms shortcomings to deal with the challenges in a strategic way. Hence, value co-creation requires a multi-dimensional approach by QI firms to achieve optimum performance.Since global security and economic prosperity are inextricably linked, the need for a bold QI framework is essential.

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The concept of QVCC is examined in the following manner: Co-creation of value comprises a two-phase process: first, firms like IBM co-create value with designers and developers for their customers or end-users through sustainability awareness. Second, other QI stakeholders co-create through a sustainable hybrid offering (a service bundled with a product). Such a proposition enables quantum technology firm to increase performance or to integrate sustainability into their supply chain. For each of the stakeholder, there is a different focus. For example, QC integrators together with suppliersfocus on the system integration, synchronization, and convergence of their products and services. QI customers add their inputs to receive the functional, emotional and social satisfaction through dialogue with QI providers. All these activities will inevitably be linked to the surrounding society that empowers communities and promotes joint efforts to achieve both economic growth and sustainability.Since co-creation of value is an important topic, manufacturers and service providers of various industries try to integrate it into their innovation practices.Based on the discussion above, QVCC is constructed for the QI firm in which it operates. Hence, QVCC framework is presented that connects the global sustainability challenges to the creation of stakeholder value by the QI firm. This framework can be used as an education model and guide for all stakeholders including suppliers, providers, customers, decision-makers and other industries who are seeking value co-creation for sustainable development.

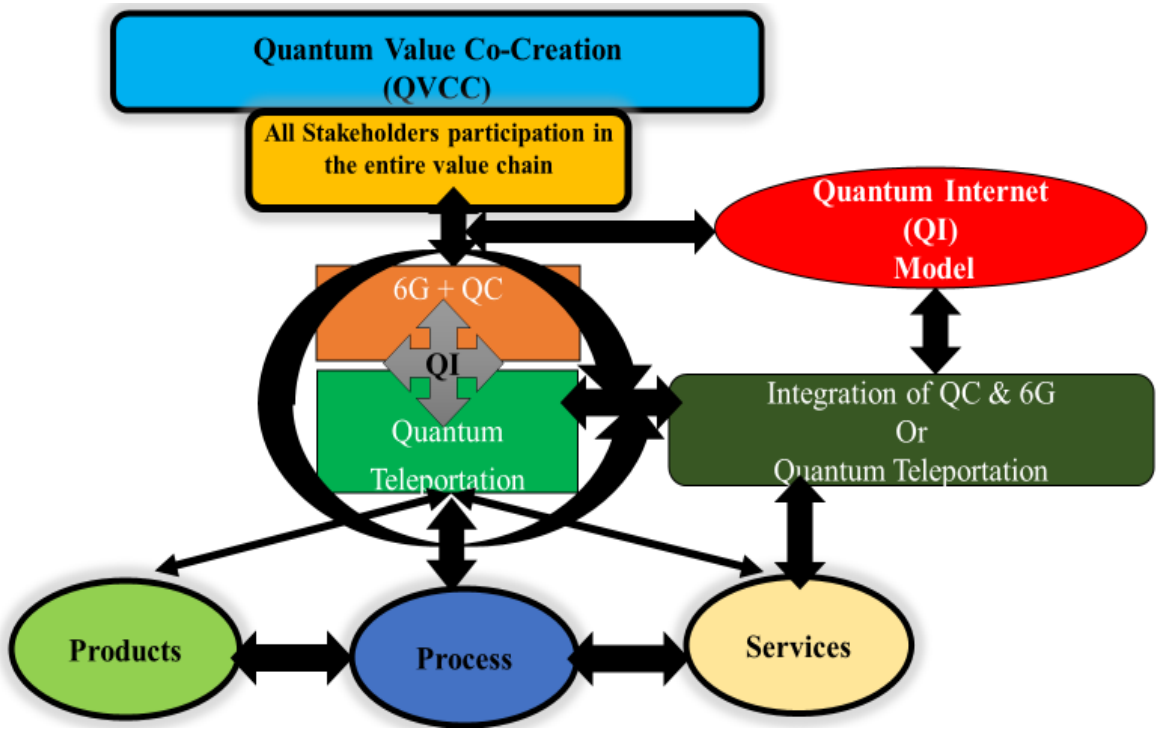

Fig. 7 Towards aholistic QI Model

CONTRIBUTION

This paper contributes the following new knowledge to the literature:

(i) Development of a holistic quantum internet (QI) model using two new disruptive technology concepts: (a) symbiotic integration of quantum computing into 6G to satisfy the need for a highly reliable QI to support critical wireless communications infrastructure providing terabit per second attaining QVCC, (b) Quantum Teleportation to form the "Quantum Internet" (QI) to enable transmission of qubits/qutrits/ququarts or even higher information between the satellites and multiple ground stations encoded in delicate photons of infrared light to create quantum opportunities to attain quantum value co-creation (QVCC).

(ii) Quantum value co-creation (QVCC) - a business strategy focused on the quantum competitive advantage that brings benefit to stakeholders by providing QI services.

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(iii) Identifies building blocks and nine principal constituents that are co-related to each other to drive QVCC attainment: (a)quantum culture, (b) creativity, (c) leadership, (d) innovative quantum thinking (e) quantum value proposition, (f) quantum business model , (g) strategy for quantum ready workforce, (h) quantum ecosystem, (i) quantum competitive advantage (QCA).

CONCLUSION

The technological development has been more rapid than ever. Firms who don't innovate continuously will be eliminated from the market. In a battle of unceasing innovation, particularly in the disruptive technology innovation domain, the new entrants win. New disruptive technology companies don't compete for head-on with the incumbent firms.

Everything revolves around people therefore; it is essential to shape a future that focuses on people first with moral consciousness based on a shared sense of destiny. In the quantum era, human capital, particularly talent, will represent the critical factor of productivity. The largest beneficiaries of continual disruptive innovation in the quantum information age is going to be the providers of intellectual and physical capital. Overall, the inexorable paradigm shift from the fourth industrial revolution to fifth will force industries to fundamentally reexamine the way to do business and profoundly impact the nature of global security posed by quantum technologies. Hence, it is imperative to grasp the opportunity to shape the quantum revolution directing towards a future that reflects common objectives and values.

Value is co-created as stakeholders integrate resources in practices to make practices a fundamental unit of value creation. Greater resource density relevant to a specific practice and mission of the stakeholder corresponds to greater value. The realization of the fact that value creation occurs in networks of interdependent stakeholders pinpoints the need for increased transparency both between functional silos and between stakeholders. The quantum internet (QI) stakeholders need to understand the importance of the nine constituents (mentioned above) to attain the QVCC.

6G wireless and quantum computing are emerging as disruptive technologies and have the potential to transform the way people live and work. Quantum computing and communication is the emerging new market disruption. The author has proposed a holistic QI model for firms to make a new growth business so that the processes can be designed to the disruption. QI is envisaged to create a new value network and market-disrupting the existing market and value network by dislocating products, processes, and services creating tremendous opportunities globally. Thus, this study demonstrates technology concepts such as quantum computing interacting with 6G wireless and quantum teleportation can inexorably facilitate the quantum value co-creation in the quantum communication era.The author predicts within 10 years, for specific limited applicationssuch as drug discovery and chemistry, quantum computers will play a significant role to offer solutions.

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BIOGRAPHY

Prafulla Kumar Padhi, a serial entrepreneur and techno-market futurist, has over 43 years of global business experience and held the Founder, CEO and Chairman of the Board positions for more than 25years and managed up to US$1.2 Billion revenue operations. His education qualification includes a Master of Science degree from the prestigious Massachusetts Institute of Technology (MIT), Cambridge, USA and a graduate of the Ivy League Wharton School of Business, University of Pennsylvania (USA) and holds seven diploma

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