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Computing and networking are rapidly evolving from classical to quantum expressions. Quantum computing is the natural outcome of an oceanic scale of inexorable trends pervading hardware/software components and present throughout the Global Internetwork. In order to sufficiently enhance computer and network throughput and availability to continue to meet worldwide information requirements, the following conditions must be addressed:

- Computing and networking components and systems must be driven at increasingly higher clock frequencies within shrinking chip geometries and diminishing memory latencies
- Computing and networking components and systems must be increasingly integrated due to the speed of light limitation while remaining within classical space-time symmetries
- Increasingly miniaturized components and systems need to be continually more energy efficient, while avoiding serial architecture (Von Neumann) bottlenecks and resistance-capacitance delays; these issues are only temporarily delayed within classical parallel processing platforms

During the past four decades, we have witnessed a dramatic acceleration of computer technology miniaturization. The advent of a one-billion transistor chip within the near future, able to execute over 100 billion instructions per second, is quite likely. When we extrapolate the exponential trend of miniaturization, which has held since 1950 under Moore's Law, we attain a limit of one atom per bit and Single Electron Transistor (SET) by 2010–2020. Prior to these levels, it becomes necessary to use quantum effects to address worldwide computing and networking requirements. Exponential improvements in computer component physical size reduction and logic speed increase cannot continue while remaining within the realm of classical space-time physics, due to quantum effects which pervade the molecular, atomic and sub-atomic scales.

Of all the candidate technologies that continue to scale well beyond the current classical era, quantum logic has one unique feature—it is not contained by classical space-time physics. Moore's Law is exponential; any classical approach demands exponential increases in space or time. Even the Avogadro's number of elements in a molecular computer is quickly limited by the size of the exponential problem. Quantum computing and networking access Hilbert space, the one exponential resource that has been untapped for computation. In so doing, quantum computers will increasingly drive the advancement of Information Technology (IT), the world's leading economic sector.

Quantum computing is based on the principles of quantum physics. Quantum computers, still in various stages of development, operate according to the rules of quantum mechanics governing the world of the very small—the waves and particles that begin to show their presence at the molecular/nano-scale (10^{-9} meter), and pervade the atomic/angstrom-scale (10^{-10} meter) and pico-scale (10^{-12} meter, the domain of electrons and photons). Perhaps the most striking characteristic of quantum computers is that elementary particles can persist in two or more states at once, making possible processing units (quantum bits, or qubits) that are far more efficient than any conventional, "classical" computer could ever be.

Quantum computers operate in truly parallel fashion, with sequential and simultaneous processing co-structured into their very nature. Quantum computing simultaneity ensures that all computational pathways are pursued at once, as compared to serial processing of discrete tasks as found in conventional computers. In other words, each quantum operation acts on all of the system states simultaneously. Therefore, one machine cycle, one tick of the quantum computer clock, computes not just on one machine state (as is true of classical computers), but on all possible machine states at once.

Quantum Computing Implications For Everyday Systems and Applications

Quantum computers will, within a few years, be able to solve problems that conventional computers could never manage, in a fraction of the time. Major quantum computing applications include: Quantum Searching; Quantum Database and Modeling; Quantum Simulation; Quantum Factoring; Quantum Cryptography; Quantum Order-Finding, Period-Finding, Fast-Fourier Transform; Quantum Counting; Quantum Teleportation; and Quantum Error Correction.

- **Quantum Searching**—Searching the World Wide Web has been likened to tracing connections among friends and acquaintances within social networks. Connections between any two people within the world population of 6.5 billion people have been shown to be linked by a chain of five or six acquaintances, giving rise to a feature of social networks known as “six degrees of separation” after John Guare’s Broadway play and movie based on studies published in 1967 by Stanley Migram, a Harvard sociologist. Social networks are grouped in small clusters, representing circles of friends and acquaintances in which each node (person) is connected to all other nodes through no greater than six links.

The World Wide Web, social networks, power grid networks, and the human brain alike exhibit small node separation and display high degrees of clustering. Initial models of the World Wide Web based on finite size scaling by Albert-Laszlo Barabasi and others at Notre Dame during 1998 predicted the shortest path between two pages selected at random among an estimated 800 million nodes (documents) to be 19.

Six or even 19 degrees of separation within social or Web networks respectively, suggests that items are easy to locate in a small world. However, search problems become quickly intractable when constrained to classical computing and networking technologies. For example, the average number of links on any given Web document is seven, meaning that seven links can be followed from the first page, 49 documents are two clicks away, 343 documents are three clicks away, and so forth. On this basis, nodes located 19 degrees away from the search request origin require searching through

10^{16} documents, 10 million (10^7) times greater than the estimated number of pages on the Web. While several links encountered in this search point back to previously viewed pages, even one second used to check single documents would require greater than 300 million (300×10^8) years to view all documents within 19 clicks.

Social and Web separation of 6/19 degrees respectively are diminishing in scale, primarily due to the evolution of the Web itself. Web searching techniques do not require “brute force” analysis of all possible links due to use of contextual link interpretation, creating an increasing number of logical pathways with widely different limits between any two people or objects of interest. Web search evolution may have already effectively reduced separation between any two people in the world to three degrees, leading to highly interrelated and clustered “small worlds.” However, weak link connections outside of clustered small worlds, coupled with rapid increases in requirements for multi-contextual searches, will quickly exceed the reach of even massively parallel classical computing search engines and algorithms.

Quantum search engines™ will likely emerge within the next few years which exploit quantum logic and pursue all possible search pathways at once. This approach will propel Web searches in a fraction of the time and with far greater contextual precision than is imaginable today even using massively parallel (non-quantum) systems, with quantum search engines that examine and update every possible worldwide location and context within a matter of several seconds.

- **Quantum Database and Modeling**—Modeling national and global economies based on continuously refreshed worldwide searches of hundreds of thousands of worldwide, networked databases, leading to rapid weather and climate pattern forecasting.
- **Quantum Simulation**—Simulating the intricacies of complex systems at scales unattainable by conventional computing technologies, leading to dramatic breakthroughs in cost-efficient and environment-friendly ageless materials based on optimum strength-to-weight ratios, atomic- and subatomic-scale mending of material dislocations, electronic- and photonic-scale chip design (pico-electronics™), one-step design-to-build Quantum Memory, and optimized design-to-reconstruction of entire communities.

- **Quantum Factoring**—Factoring multi-million-digit-long numbers at least one billion times more quickly than is currently possible with the best non-quantum methods, enabling rapid access by authorized individuals to secure private information such as financial transactions and records. Classical (non-quantum) factoring of primes for example, quickly becomes an intractable problem with increasing values of the factored number (n). Quantum computing enables evaluation of all possible powers of n simultaneously. One quantum computational technique is to transform the cyclic behavior of periodic functions into enhanced probability amplitudes of certain quantum states.
- **Quantum Cryptography**—Ensuring protection of sensitive information and data using quantum cryptographic methods which prevent unauthorized access through both classical and quantum means, regardless of the scale, breadth and depth of brute-force or contextual attempts.
- **Quantum Order-Finding, Period-Finding, Fast-Fourier Transform**—Performing global-scale calculations and worldwide database updates with contextual precision across a wide range of systems within a matter of minutes, regardless of the scale or order of distributed combinations or permutations involved.
- **Quantum Counting**—Calculating all required solutions to any scale of presented problem within a reasonable period of time, regardless of the dimensions involved.
- **Quantum Teleportation**—Transcending speed-of-light and temporal computing boundaries at great distances using quantum properties associated with non-local connections.
- **Quantum Error Correction**—Automatically fixing system errors while revealing nothing about ongoing quantum computations, thereby preserving the quantum system in a state of quantum superposition.
- Suitable state space; quantum computational circuits operate on some number, n , of qubits, therefore, the quantum computational state space is a 2^n -dimensional Hilbert space, with product state of the form $|X_1, \dots, X_n\rangle$, where ($X_i = 0,1$) are computational basis states.
- Any computational basis state $|X_1, \dots, X_n\rangle$ can be prepared in $\leq n$ steps.
- Quantum gates that can be applied to any subset of qubits and a universal family of gates that can be implemented. Quantum logic gates are the basic units of quantum computational algorithms just as classical logic gates are the basic units of classical computational algorithms. The major distinction is that quantum gates must be implemented unitarily and, in particular, must incorporate reversible operations.
- Ability to perform measurements in the computational basis of ≥ 1 qubit(s).
- Inherent ability to perform classical computations if quantum computations are not required.

Foundation of Quantum Computing

Quantum computing generally requires the following key elements based on the quantum circuit model of computation:

The Cosmic Computer and Cosmic Switchboard

Profound insights into the ancient Veda and Vedic Literature, brought to light by His Holiness Maharishi Mahesh Yogi over the past fifty years, have ushered in the discovery that the laws of nature that shape the structure and function of quantum computing and quantum networking are identical to those that give rise to the syllables (*Akshara*), words (*Shabd*), phrases (*Pādas*), verses (*Richās*), hymns (*Sūktas*), and chapters (*Maṇḍals*) of the Vedic Literature and to the administering intelligence of Natural Law described in the Vedic Literature as *Vedic Devata*. Maharishi, in his *Apaurusheya Bhāshya*, locates the fundamental significance of Veda and the Vedic Literature as emerging from the dynamics of the Gaps (*Sandhi*) found between Vedic *Akshara*, *Shabd*, *Pādas*, *Richās*, *Sūktas* and *Maṇḍals*.

Quantum computing—including the quantum gates and algorithms at its core—has the same structure and function as the non-changing, eternal basis of Natural Law identified by quantum physicists as the Unified Field. The Cosmic Computer and Cosmic Switchboard operate at the level of the Unified Field and provide the basis to the highly predictive, infinity-point fabric pervading the domain of quantum computation.

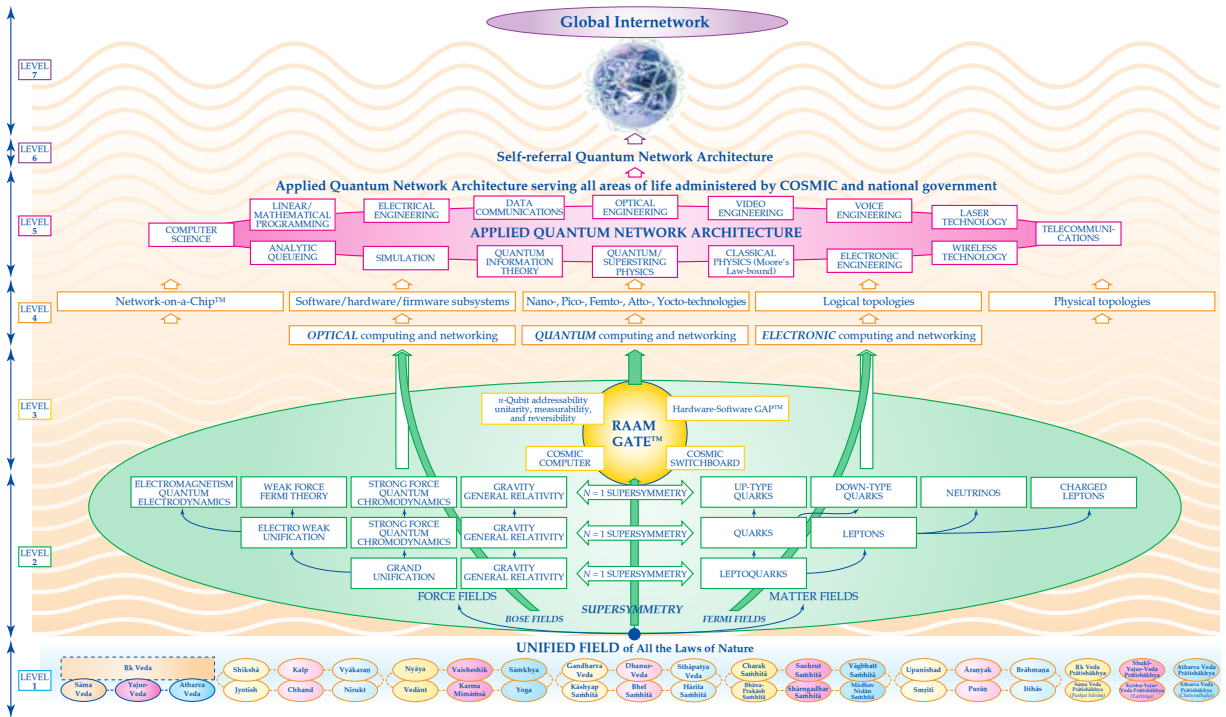


Figure 1: Quantum Computing Foundation in Unified Field Physics, Veda, and the Vedic Literature

Figure 1 presents the relationships among quantum computing, the Unified Field in physics, and the forty branches of Veda and the Vedic Literature. The Unified Field gives rise to the fundamental force fields (Bose Fields) and matter fields (Fermi Fields), which are expressed as optical and electronic computing and networking, respectively. The Unified Field also impels the supersymmetric basis of the Routt Addressable Absolute Memory Gate™ (RAAM Gate™)* shown in Figure 1. The RAAM Gate provides the quantum window and computational superfabric through which the source, course, and goal of the Cosmic Computer and Cosmic Switchboard are harnessed.

Maharishi describes the Cosmic Computer in terms of the infinity-within-all-points and all-points-within-infinity cosmic computational foundation for perfection of evolution. We locate the Cosmic Computer and Cosmic Switchboard both within the self-luminous junction point of the Hardware-Software Gap™ and throughout every point of manifest creation. It is here that we discover that intelligence which is at the same time numeric and also with boundaries, where physical digits are connected to numeric digits, where the physical is expressed in terms of numbers.

Figure 2 illustrates the Hardware-Software Gap and its relation to the Vedic Gap (*Sandhi*) identified by Maharishi as the eternally silent and dynamic fountainhead of memory (*Smṛiti*), giving rise to the human physiology (*Sharira*) and entire universe (*Vishwa*).

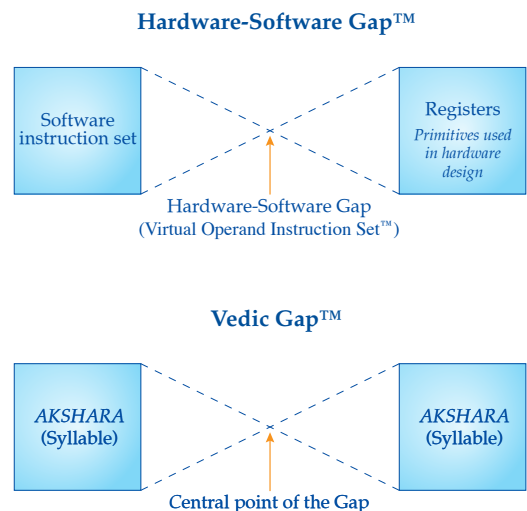


Figure 2: Hardware-Software Gap as an Expression of the Vedic Gap

* RAAM Gate derivations, spatial and functional scales, clocking mechanisms, and methods to achieve quantum memory, memory associations, quantum computation, and quantum networking are a partial reflection of United States Patent Application Number US2004/0078421, "Methods for Transmitting Data Across Quantum Interfaces and Quantum Gates Using Same," Thomas J. Routt.

The Hardware-Software Gap contains a lively virtual operand instruction set comprised of eight gap properties, and functions as the structural and functional interface between a given software instruction set and hardware registers. Bi-directional, sequential expression of software instructions occurs through a process of collapse (*Pradhvaniśa-Abhāva*) onto its point value in the center of the Gap (*Atyanta-Abhāva*), from where self-referral structuring dynamics (*Anyonya-Abhāva*) elaborate from the Gap point value, leading to the emergence (*Prāg-Abhāva*) of the next software instruction or hardware primitive. Hardware-Software Gap instances include:

- Compiler Gap between instances of a low- or high-level programming language and an assembly language program
- Assembler Gap between instances of an assembly language program and machine objects
- Linker Gap between instances of machine language module or library routine and an executable (machine language program)
- Loader Gap between instances of an executable and memory
- Analog/Digital Signaling Gap
- Optical Wavelength Gap
- Optical Waveband Gap

The Hardware-Software Gap behaves as a Quantum Gap™ in the RAAM Gate, providing the basis to quantum memory, quantum computing, and quantum networking within the totality of computational past, present and future.

When we consider a quantum computational system of n quantum bits (qubits), we find the computational basis states of this system to be of the form $|\chi_1\chi_2 \dots \chi_n\rangle$. Therefore, the system quantum state is specified by 2^n amplitudes. For n greater than 500, this number is larger than the estimated number of atoms in the known physical universe.

The Cosmic Computer and Cosmic Switchboard, revealed by Maharishi, are found to be perpetually processing far greater than 2^n amplitudes, even for systems that contain only a few hundred atoms, to say nothing of the massively parallel infinity-point calculations eternally proceeding behind the scenes to evolve and maintain all the Laws of Nature on every level of creation. We extrapolate that Nature maintains greater than 2^{300} calculations for every few hundred atoms throughout the entire universe.

The scale of Natural Law calculations of the Cosmic Computer and Cosmic Switchboard are further estimated to extend exponentially beyond the atomic level when we shift our attention to the scales of the fundamental force particles (Photons for the Electromagnetic Force; Weak Gauge Bosons for the Weak Force; Gluons for the Strong Force; Gravitons for the Gravitational Force; refer to Figure 1). The fundamental force computation density of the Cosmic Computer and Cosmic Switchboard is again extended hyper-exponentially at the superstring dimensions that pervade sub-Planck scales of less than 10^{-35} meter and less than 10^{-43} second.

The Cosmic Computer Expressed in Human Physiology and Computer Science

Maharishi Mahesh Yogi has explained in his *Apaurusheya Bhāshya* that Veda is uncreated (*Apaurusheya*) and eternal (*Nitya*). Veda is the infinite set of fluctuations of pure consciousness. In the Vedic Literature, pure consciousness is called *Ātmā*. *Ātmā* is a state of pure Being, an unmanifest reality of pure existence, unboundedness, and singularity. It is the totality of all possibilities, infinite silence and infinite dynamism, unboundedness and point values. Veda is a self-sufficient and self-referral state, and all manifestations in creation emerge from and submerge into it. This emergence and submergence, creation and dissolution, as well as all possible interactions in the physical universe, are conducted by the Laws of Nature, all of which are contained in pure consciousness, *Ātmā*.

Veda, the perfectly orderly, eternal structure of knowledge, has been preserved over thousands of years in the Vedic Tradition of India. Complete knowledge of Veda and its profound, practical significance for life has been revived and understood in a scientific framework by Maharishi in his Vedic Science and Technology, as presented in its forty aspects in Figure 3.

Maharishi describes the human mind and body as the embodiment of Veda, the living replica of Natural Law, emerging from the self-referral quality of pure consciousness. Professor Tony Nader, MD, PhD—His Majesty Maharaja Nader Rām, *Vishva Prashāsak*, the first sovereign ruler of the Global Country of World Peace—brought to light under Maharishi's guidance the discovery of Veda and the Vedic Literature in human physiol-

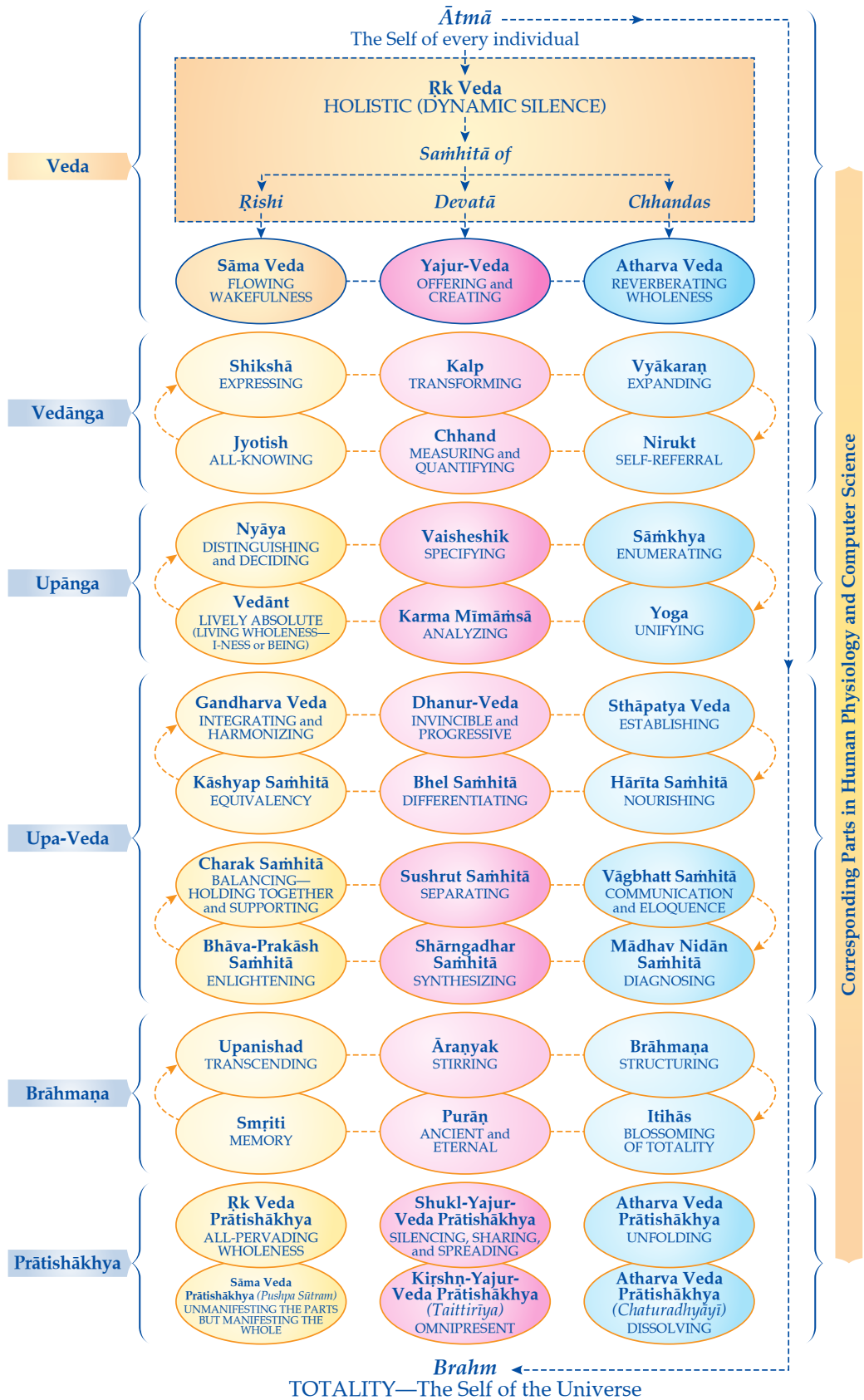


Figure 3: Veda and the Vedic Literature

	Veda & Vedic Literature	Human Physiology (Sharira)	Computer Science Quantum Computing (Vishva)
Veda	Rk Veda HOLISTIC (DYNAMIC SILENCE)	Holistic Physiology	Cosmic Network of Consciousness
	Sāma Veda FLOWING WAKEFULNESS	Information & Flow Systems: Sensory Systems	Network Self-Referral and Feedback Systems
	Yajur-Veda OFFERING and CREATING	Processing Systems	Network Processing Systems
	Atharva Veda REVERBERATING WHOLENESS	Motor Systems	Nodal Input/Output Systems
Vedāṅga	Shikshā EXPRESSING	Autonomic Ganglia	Dynamic Computer Network Architecture
	Kalp TRANSFORMING	Limbic System	Network Architecture, Design, and Implementation Process
	Vyākaraṇ EXPANDING	Hypothalamus	Redundant Network Systems
	Nirukt SELF-REFERRAL	Pituitary Gland	Feedback Loops
	Chhand MEASURING and QUANTIFYING	Neurotransmitters, Neurohormones	Dynamic Bandwidth, Load Balancing & Content Management
	Jyotish ALL-KNOWING	Basal Ganglia, Cerebral Cortex, Cranial Nerves, Brainstem	Self-Aware, Massively Parallel Network Architecture
	Upāṅga	Nyāya DISTINGUISHING and DECIDING	Thalamus
Vaisheshik SPECIFYING		Cerebellum	System Configuration and Connection
Sāmkhya ENUMERATING		Cells, Tissues, Organs—Types and Categories	Arithmetic Logic Unit (ALU)
Yoga UNIFYING		Association Fibers of the Cerebral Cortex	Logical Network Topology and Associations
Karma Mimāṃsā ANALYZING		Central Nervous System	Backbone Network System
Vedānt LIVELY ABSOLUTE		Integrated Functioning of the Central Nervous System	Integrated Functioning of the Backbone Network System
Upa-Veda	Gandharva Veda INTEGRATING and HARMONIZING	Cycles and Rhythms, Pacemaker Cells	Network/Computer Clocking and Synchronization
	Dhanur-Veda INVINCIBLE and PROGRESSIVE	Immune System, Biochemistry	Security Architecture
	Sthāpatya Veda ESTABLISHING	Anatomy	Physical Topology
	Hārīta Samhītā NOURISHING	Venous and Biliary Systems	Bandwidth Management, Quality of Service
	Bhel Samhītā DIFFERENTIATING	Lymphatic System and Glial Cells	Prioritized Queueing Systems
	Kāshyap Samhītā EQUIVALENCY	Arterial System	Availability Logic
	Charak Samhītā BALANCING	Cell Nucleus	Network-on-a-Chip™
	Sushrut Samhītā SEPARATING	Cytoplasm and Cell Organelles	Field and Gate Logic
	Vāgbhatt Samhītā COMMUNICATION and ELOQUENCE	Cytoskeleton and Cell Membrane	Dynamic Network Modeling
	Mādhav Nidān Samhītā DIAGNOSING	Mesodermal Tissues	Network/Systems Management
	Shārngadhār Samhītā SYNTHESIZING	Endodermal Tissues	Database and Transaction Processing
	Bhāva-Prakāsh Samhītā ENLIGHTENING	Ectodermal Tissues	Optical Networks
	Brāhmaṇa	Upanishad TRANSCENDING	Ascending Tracts of the Central Nervous System
Āraṇyak STIRRING		Fasciculi Proprii	Application Programming Interface
Brāhmaṇa STRUCTURING		Descending Tracts of the Central Nervous System	Network/System Standards and Protocols
Itihās BLOSSOMING OF TOTALITY		Voluntary Motor and Sensory Projections	End-User and Application Interactions
Purāṇ ANCIENT and ETERNAL		Great Intermediate Net	End-User and Application Interfaces
Smṛiti MEMORY		Memory Systems and Reflexes	RAM / RAAM / SAN / NAS / Hologram
Prātishākhya	Rk Veda Prātishākhya ALL-PERVADING WHOLENESS	Plexiform Layer, Cerebral Cortex Layer I	Quantum Computer
	Shukl-Yajur-Veda Prātishākhya SILENCING, SHARING, and SPREADING	Corticocortical Fibers, Cerebral Cortex Layer II	Quantum Algorithms, Circuits, Gates and Cryptography
	Atharva Veda Prātishākhya UNFOLDING	Corticostriate/Corticocortical/Corticospinal Fibers, Cerebral Cortex Layer V	Quantum Network
	Atharva Veda Prātishākhya DISSOLVING	Corticothalamic and Corticoclaustral Fibers, Cerebral Cortex Layer VI	Superstring Computer
	Kṛishṇ-Yajur-Veda Prātishākhya OMNIPRESENT	Commissural and Corticocortical Fibers, Cerebral Cortex Layer III	Quantum Tunneling, Quantum Teleportation
Sāma Veda Prātishākhya UNMANIFESTING the PARTS but MANIFESTING the WHOLE	Thalamocortical Fibers, Cerebral Cortex Layer IV	Quantum Network Architecture™	

Figure 4: The Cosmic Computer—Expression of Veda and the Vedic Literature in Human Physiology and Computer Science

ogy, in his book entitled *Human Physiology—Expression of Veda and the Vedic Literature*. The human neurophysiology, in both structure and function, is the perfect replica of Veda and the Vedic Literature, and structures the individual expression of the Cosmic Computer and Cosmic Switchboard.

Computer Science, in its Quantum Computing evolutionary expression, has also been shown under Maharishi's guidance to express Veda and the Vedic Literature, in the author's book entitled *Quantum Computing—The Vedic Fabric of the Digital Universe*, upon which this article is based.

Figure 4 depicts the Cosmic Computer and Cosmic Switchboard as intrinsic to the forty branches of Veda and the Vedic Literature. The figure illustrates the expression of Veda into Human Physiology (*Sharira*) and the Quantum Computing fabric of the universe (*Vishwa*), in terms of one-to-one elaboration of each of the forty branches of Veda and the Vedic Literature.

About the Author

Thomas J. Routt, PhD, directs a multinational hardware-software firm and provides Fortune 500 companies with computer network architecture solutions (www.vedacom.com). He holds two pending patents in quantum computation and has published 80 papers in computer and network technology journals. As a keynote speaker and chair at conferences worldwide, Dr. Routt has addressed over one million computing and networking professionals in 60 countries. Dr. Routt authored the book *Quantum Computing—The Vedic Fabric of the Digital Universe*, 1st World Publishing, 2005 (www.vediccomputing.com).

