



The World as Web

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Editorial Note: Networks play a central role in the biology of organisms and their physiological functioning, social organizations and relationships, domestic and international political processes, business, finance, development of new ideas and discoveries in science and technology. The World Academy's project on 'The Science of Networks' focuses on the various dimensions of networks and the principles governing their operation. This is the first in a series of articles applying concepts of Network Science to explore untapped potentials for accelerating the development of global society.

Abstract

Society is a highly complex, interconnected, living network of relationships. The entire process of social development and civilization from early times can best be understood as the progressive growth of the number, type and complexity of interactions and relationships between people, places, activities, and ideas. Moore's law for the micro-processor is a subset and technological expression of a principle that has been operative in society since before the invention of agriculture. Networks govern the operation of society at multiple levels and scales in Space and Time. They determine the movement and exchange of material things, interactions between individuals and groups, interrelationships between activities, systematic linkages between organizations, collection and dissemination of information, accumulation and organization of knowledge, and exchange and development of ideas. The exponential growth in the power and productivity of modern society is an expression of the laws of network science. This article examines the development of the physical dimension of social networks that begins with the linking together of small isolated communities into clusters and their organization around larger urban commercial and political centers. It explores the role of language as a networking tool, the transformative power of roads and railroads, the rise of cities as multi-functional centers, and the role of printing, media and the Internet as catalysts for human interaction and social development. The concept of integration, which is so critical to the power of networks, is also the key to unlimited expansion of social productivity and human welfare.

The development of Knowledge and Language are interdependent. It is sometimes difficult to comprehend a phenomenon until after we have formulated a special word or concept to express it. This may be the case with the word *complexity*. It is only after the word has come into common usage as a scientific term that researchers have uncovered patterns of non-linear relationship among a wide range of phenomena, such as weather, the edges of leaves, fluid dynamics and oscillating chemical reactions, which were previously believed to be random variations.

The formulation of a new metaphor can have a similar result. Over the past two decades, the World Wide Web has become a powerful metaphor for understanding society as a whole. The idea of society as a complex interconnected network of relationships is not new. Since the 1930s, a number of early theorists in social complexity have studied the exponential growth arising from increasing social encounters and exchanges. But until recently this perspective has been largely overshadowed by a predilection to view society in static terms of structure and function, rather than as a living system in terms of the flow and exchange between innumerable interdependent nodes. The very sudden and rapid development of the World Wide Web as an entirely new global system of electronic inter-relationships has made far more tangible and evident the relevance of the web metaphor to society as a whole. Insights into the nature and functioning of society as a web reveal immense potential for enhancing its capacity to promote the welfare and well-being of all its members. This article focuses on the physical aspects of the social network. Subsequent articles will examine the growth of its economic, political, intellectual and cultural dimensions.

1. Interconnectivity

What does the web metaphor tell us about society? The most fundamental characteristic of a web is its connectivity. Web connectivity is a function of the number and distribution of nodes, the distance between nodes, the patterns and degree of their interconnectedness. The greater the number of nodes and the greater the intensity of their interconnections, the greater the power of the system. A larger market is obviously more lucrative than a smaller one, a larger research network more productive than a smaller one. But the capacity of a web is not merely a function of the number of nodes. It depends far more on the degree of functional interrelationship between them. Webs are not merely masses of haphazard interconnections. They may and do have structure – hierarchical levels of authority, multiple pathways, clusters, hubs, centralized or distributed centers of concentrated activity, etc. The primary function of that structure is to ensure optimal connectivity between all nodes and specialized centers of activity. Thus, American prosperity after World War II made evident to the countries of Europe that sheer numbers of people were not sufficient. They recognized the need to remove the barriers to improve interconnectivity and fashion their vast, fragmented economies into a single, integrated market. Since the end of the Cold War, the same process has been repeating at the global level.

Webs are not just complex networks of interconnection. They are living systems. The structures of a living system are intended for maximum interaction and exchange between myriad nodes and centers; for rapid feedback and dynamic regulation; for growth, development and evolution of the structure itself. Families and tribal communities constitute the first human networks. Cooperation within families and communities makes possible the first steps toward the division and specialization of function that have so powerfully contributed to the development of civilization. The family is a simple network in which the roles of each member are physically and culturally defined and the knowledge and skills needed by each unit are passed on from person to person, generation to generation, forming the basis for the conscious accumulation and dissemination of knowledge unique to the human species.

By an imperceptibly slow process of repetitive contact, small clusters of individuals and families evolved into tightly knit local communities. Initially, these communities may have

little connection or interaction with other groups in the outside world, which are often perceived as threats. The process of connectivity gradually extends beyond local boundaries as previously isolated communities discover a commonality of interest for collective defense, commercial exchange or acquisition of knowledge. The development of networks of roads linking local clusters in spoke-like fashion to regional hubs led to the rise of trading centers as an efficient way to coordinate exchanges among many small outlying communities. Roads constitute the primary physical network needed for the development of society. Historian Eugene Weber described the transformative effect of roads on the evolution of France into a modern nation in the decades around 1900. He referred to roads as “the first fertilizer” for their catalytic impact on production, trade, technology adoption, flow of information, literacy, education, health, democracy, law and human rights.¹ One isolated French village where surplus grapes were fed to the pigs for want of a market began exporting wine within a year after a road was laid connecting it to the national economy. The hub and spoke, one of the simplest of all web structures, evolved as an ingenious method for connecting many outlying rural centers of agricultural production through a centralized marketplace where all could converge to exchange their produce. These centers also became a means of pooling resources for collective self-defense and governance. The lure of conquest and trade provided strong incentives for clusters of such communities to reach out to other clusters as components of a wider network, thus giving rise to market towns and trading centers and eventually to great commercial empires. All roads lead to Rome.

2. Univer-cities

The development of road networks provided the essential infrastructure for the development of another network that transformed the social existence of the human species – the rise of towns and cities. The urban center is a highly complex and sophisticated social organization designed to centralize a wide range of activities within a small geographic area with linkages to the surrounding world to provide all that is needed for the existence of its inhabitants that is not generated locally. Cities became the first universities – places where all forms of knowledge, expertise and experience were available in a single concentrated area. Urban centers may have begun as centers for trade and security from invaders. But they quickly diversified to become centers for the development of manufacturing, distribution, transport, communication, education, health care, governance, sanitation and other public utilities, entertainment, the arts, culture and religious worship.

Urban centers consist of densely concentrated and highly integrated networks of systems covering all of these and many other social functions. The ‘structure’ of these complex social webs is so thickly woven, overlapping and intricate in design that it is almost impossible to disentangle, but the functional power of their connectivity is self-evident. Historically, cities have been the birthplace of great revolutions – Athens (508 BC), Boston (1773), Paris (1789, etc.), St. Petersburg (1917), Budapest (1956), Berlin, Prague and Beijing (1989), Cairo (2011). Today, cities are epicenters for the birth, growth and development of civilization and culture.

Silicon Valley became the birthplace of another kind of revolution in the 1970s when it developed into a global hub for the micro-electronics industry due to an extraordinary nexus of innovative research and educational facilities, entrepreneurial corporations and dynamic

venture capitalists immersed in the revolutionary, anti-establishment culture born in the late 1960s and surrounded by one of the most prosperous, fast growing markets of its day. All the ingredients necessary for a catalytic reaction were present in one place and interconnected. Today our systems for interconnectivity extend globally and proximity is far less dependent on physical location. The Internet supports the spontaneous creation of virtual groups in a manner unthinkable in the past, as witnessed by the Occupy Wall Street and the Arab Spring movements. Direct connectivity appears to exist between all nodes on the network; in fact, the nodes are grouped into clusters and the clusters linked to more centralized centers, as rural towns are linked to cities and cities to metropolitan centers. Even when direct connectivity is possible, in practice it proves far more efficient to utilize major pathways for linkage, as the bulk of internet traffic is directed in and through major hubs such as Facebook, Twitter, Google, YouTube, Wordpress, LinkedIn, Amazon, Apple, Wikipedia and so forth.

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3. Movement Creates Relationship

Human beings are social creatures. We depend on one another for our physical survival and security, acquisition of skills and knowledge, social companionship and affection, ideas and values. Human relationships are the catalyst for our remarkable inventiveness, innovation, curiosity, creativity, and soaring aspirations. The growth, development and evolution of the human community is founded on relationships between people. Human relationships are the real source of our wealth, knowledge and psychological fulfillment. Human resourcefulness is the ultimate resource.

Relationships are fostered by movement – movement of people, materials, information, knowledge, technology, skills, ideas and values. This movement is characterized by an energy or momentum which determines its velocity. The capacity for transportation and communication is the most essential infrastructure for the development of a dynamic social network. Speed and throughput are crucial measures of a network’s capacity and power for accomplishment. The greater the bandwidth, the greater the power. Anything that facilitates and enhances movement magnifies the effective power of a network.

As the development of rural road networks led to the growth of market towns, technological advances in transportation created the physical pathways for connectivity over long distances. The mercantile age of commercial empires was launched in Europe after the invention of the mariner’s compass and the chronometer enabled ships to safely navigate the open seas to establish links with distant trading centers. The invention of the steam engine made possible connectivity and rapid movement by railway over the vast expanse of the North American frontier, more effectively linking and uniting the American states and spurring the westward expansion to the Pacific. But it would be a gross over-simplification to reduce the major advances of civilization to technological changes. Advances in each field depend on corresponding advances in allied, connected and even distantly related fields of activity. The

development of technology is one among many strands of the social network that develop in tandem. The railway may have made possible the closer integration of states within a federated union, but it took an extremely violent and prolonged Civil War to create the required political will and legal structure, the lure of economic gain to integrate their markets, and many decades of intense and often bitter interaction to forge a common social and cultural identity between them.

4. Reaching Out

Movement creates physical contact but that is not sufficient for forging effective relationships. Means of transport must be complemented by effective means for communication. Language was the first great networking tool. It radically multiplied the variety, frequency, speed and effectiveness of communications between people, dramatically enhancing the capacity of individuals and groups to collaborate for their collective survival and defense, to gather and produce food, exchange the fruits of their labor for mutual benefit, work together to build communities, discover and transmit knowledge to present and future generations, fashion lasting social relationships and social structures, exchange affections, define rules and laws, develop shared values and beliefs, and extend all forms of communication in Space and Time.

Throughout the ages, humanity has devised innumerable mechanisms for extending the reach of language and the speed with which communications spread socially. Rome developed sophisticated methods for disseminating handwritten news on political happenings, trials, scandals, military campaigns and executions well before the birth of Christ. By that time China already utilized printed news sheets. Newspapers played an important role in the commercial and political success of Venice during the 16th century. Gutenberg's invention of the letterpress and movable type dramatically accelerated the spread of what was already an essential system for social networking. This led to the rapid spread of newspapers in England, Amsterdam, Germany and the English colonies, where they helped foment the American Revolution. Newspapers and printing made rapid mass communications from one to many possible for the first time. The first edition of *Origin of Species* published in 1859 sold out immediately and the book went through five editions in England and four in America within two years.

The most dramatic improvement in the speed, breadth and reliability of news coverage came in the 19th century with the invention of the telegraph and Morse code, which combined to create what has been aptly described as the "Victorian Internet".² Newspapers became the major customers of the telegraph companies. Newspapers combined to form wire services such as Associated Press to share the cost of telegraph transmissions. The telegraph enabled newspapers to report on current events occurring thousands of miles away. With the completion of the first cable in 1866, news of the latest political events, economic trends, and social developments travelled instantly across the Atlantic.³ More rapid communications acted as a powerful catalyst for revolutionary political changes, such as the rise of nationalism and the spread of communism, the dissemination of new scientific ideas and technological innovations. Most of all, they spurred the growth of trade and manufacturing.

The mindboggling speed and volume of global communications today are accelerating the evolution of every sector and aspect of global society in ways difficult to conceive let

alone measure. The launching of i-Tunes by Apple a decade ago has transformed the global music industry. Today e-books and newspapers are transforming publishing in a similar manner. In the past one year, the landscape for global education so firmly entrenched in brick and mortar has suddenly given rise to a new global delivery system that is likely to soon multiply access and transform the content of education worldwide.

5. Organizing Chaos

Social networks are not merely intricate patterns of connectivity. These patterns are organized in ways that are not easily perceived. The functioning of society, like the functioning of the WWW, sometimes gives the impression that nobody is in charge. But in fact contacts and relationships both in society and on the Web are governed by the ‘authority’ of conventions, standards, laws, rules and feedback mechanisms designed to reinforce their effectiveness. Given the complexity and rapid development of society, there is immense scope for enhancing the authority and functioning of social systems both nationally and globally – a process dramatically illustrated by the efforts of the European Union to arrive at common standards for hundreds of types of interaction between countries. ISO quality standards are designed to facilitate commercial relationships between companies.

The rise of the World Wide Web provides a striking example of both the power of language as a networking device and the power of standards for organizing human interactions and relationships. The WWW was born when Tim Berners-Lee developed HyperText Markup Language and succeeded in having it adopted as a standard protocol for communication between computers on the Internet. Until then, the Internet was limited to a postal system for sending packets of information from one location to another where they could be opened and read locally, as we still receive email messages today. The adoption of HTML made it possible for computers of different design, make and technical specifications to display text, visual and audio content on web pages viewable by any other computer utilizing a web browser. Berners-Lee clearly understood that the power of HTML depended chiefly on its adoption as a networking standard. Therefore, in 1994 he founded the World Wide Web Consortium as a global organization to develop standards for the WWW.

Standards are the common networking language the society employs to facilitate interconnectivity between its myriad activities. The importance of standards in the modern network society also dramatically illustrates their role in the international financial crisis. The absence of an effective international regulatory framework of banking norms and requirements left the rapidly expanding global financial community vulnerable to the greatest economic calamity in eight decades. Recent progress in strengthening the standards for international banking is specifically intended to create a more stable and effective basis for global financial activity. The governance of the World Wide Web and international banking does not occupy the attention of the global community like the meetings of heads of states, important national elections and proceedings in the UN, but it may be even more powerful in determining the overall effectiveness of the global social network.

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6. Power of Integration

The entire process of social development and civilization from early times can best be understood as the progressive evolution of society from small isolated packets into a single integrated web of interactions and relationships. The physical movements of people and materials from place to place, social movements of energy and attitudes, mental movements of information, techniques, knowledge and cultural values weave an increasingly dense, multi-layered fabric of interrelationships. Moore's law for the micro-processor is a subset of a principle that has been operative in society since before the invention of agriculture. Each positive human interaction has the potential to enhance social accomplishment and multiply the welfare of the collective through mutual discovery, production, protection, nurturing, sympathy, loyalty, understanding and affection.

Every new social organization has a tendency to extend itself until it reaches the boundaries of society geographically and integrates itself with every other social institution. This is most evident today in the development of the internet from an organization for the exchange of research information between universities into a global social system for commerce, banking and finance, all forms of media communication, electoral politics, education, entertainment, religion, social and personal relationships.

The concept of integration is critical to understanding the power of networks. The degree of integration of any social system is an important measure of its development and its potential for further growth. Networks have a tendency to integrate isolated nodes and separate lines of activity into a single system. This is a natural property of all social systems. The most perfect example of a highly integrated network is provided by the physiology of the human body, which integrates all biological functions with our physical needs, vital urges and emotional needs, mental awareness and aspirations. Therefore, an intangible thought or emotion can activate the physical system and place it on high alert. Medical science speaks about circulatory, endocrine, gastrointestinal, immune, musculoskeletal, nervous, respiratory, reproductive and urinary systems, as if they were separate divisible components of the human body; in fact, they form inseparable and interrelated subsystems of an indivisible living organism. Each depends on the others for its functioning and in turn supports them to maintain the equilibrium of the whole. Rising levels of carbon dioxide in the blood stimulate respiration to compensate. Healthy growth of the body depends on the balanced and proportionate development of all the body's subsystems. The same is true of the sub-systems that constitute the main channels of interactivity in the social web – transport, communications, governance, production, commerce, education, research, entertainment, recreation, culture and religion. So too, the development of language, roads, cities, markets, money, law, governance, art and culture develop hand in hand in a mutually supportive manner.

The known physiological processes of the human body offer useful insights into the functioning of sophisticated, multi-dimensional, multilayered social organisms. The body combines and integrates multiple biological systems, just as society combines and integrates multiple systems for its survival, growth and development. The body also integrates these physical systems in a manner yet to be understood with subconscious needs, urges and impulses for maintenance of the body; semi-conscious desires, feelings and emotions for accomplishment, enjoyment, interaction, relationship and emotional bonding with other peo-

ple; and mentally self-conscious perception, discrimination, judgment, ideation, aspiration, imagination, creativity and value-formation for acquisition of knowledge, development of personality, self-affirmation and individuality. The social organism integrates physical, social and psychological factors in a similar manner, making it difficult to separate democratic forms of government from the culture of liberalism in which they were fashioned or to distinguish the health of an economy from the confidence level and psychological expectations of its members. Both the body and society consist of myriad interconnected subsystems which combine and integrate at multiple levels to contribute to the overall functioning of an integrated living organism – one individual, the other collective.

A significant difference between the human body and the social network is their degree of integration. Under normal conditions, the subsystems of the human body develop in coordination with one another from the embryonic stage to physical adulthood. Skeleton, musculature, nervous and circulatory systems extend and differentiate in perfect symmetry and synchronicity and in tandem with the development of the bodily organs. Even a tiny gap in their development can lead to major deformities or life threatening diseases, as seen in the cancerous growth of bodily tissues. An excess or deficiency of a single substance, such as insulin, is sufficient to endanger the survival of the entire organism. The body is subject to more than 6000 endocrine disorders resulting from hormonal imbalances, but most of them are relatively rare.

In contrast, the social organism begins as a series of isolated nodes and clusters, developing at first independently of one another, and as a series of discrete and loosely connected fields of activity which become more closely linked and integrated over time. Therefore, the social organization can best be conceived as a work in progress, a haphazardly developing, incomplete organization striving to become an integrated living organism – very much alive with energy, awareness and capacity for initiative and response, but lacking the smooth and harmonious integration of the physical body. This is one reason for the prevalence of pressure, tension, competition, confrontation, crisis and open conflict characteristic of social systems.

Both the body and society undergo continuous change. The body grows, undergoes hormonal changes and then slowly begins to degenerate, undergoing hormonal changes during all phases of its life. Society expands horizontally, continuously develops new and higher levels of organization and functioning, and progressively evolves from physical to social to mental levels of activity. Thus, balance and equilibrium are relative and progressive terms, ever-changing with changes in the physical and social organism.

Problems arise in society at precisely the points where nodes, clusters, subsystems and sectors are inadequately coordinated and integrated. In recognition of this fact, Malthus warned two centuries ago that unchecked population growth would outpace the growth of food production, perpetually consigning the masses of humanity to a subsistence level existence. He could not have anticipated the revolution in agriculture brought about in the 19th and 20th centuries by farm mechanization and improved production techniques. The population explosion in the developing world in the 1950s resulted from rapid dissemination of modern medical technology. Raising levels of education and altering reproductive behavior took much longer, resulting in a sudden and drastic imbalance between fertility rates and death rates. The rapid

development of labor saving technology spurred the Industrial Revolution in America during the 18th century when labor was perennially in short supply, while today the spread of automation is eliminating jobs and displacing workers faster than new jobs are created to absorb the expanding labor force. So sensitive is the social organism to imbalances that a sudden surge in demand on a regional power grid can disable the entire system, pulling the plug that drives the entire society, like the outage that paralyzed the Northeastern and Midwestern USA in August 2003 and the one that affected 600 million people in North India in July 2012 during soaring summer temperatures. The tremendous growth of the global air transport industry over the past 50 years would not have been possible without the corresponding development of sophisticated systems for weather tracking and on-line reservations. *The laws of ecology apply to society as well as to the environment.*

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7. Unlimited Accomplishment

Although it may appear to the untrained eye as random or chaotic, movement in living systems is always purposeful, even when that purpose is purely recreational. Social networks develop to meet human needs. They are organized for accomplishment. Society can best be conceived of as a multi-purpose web designed to serve all of the primary and secondary functions of the human collective related to survival and reproduction, defense and governance, production and exchange, acquisition and dissemination of knowledge, recreation and entertainment, culture, religion and spirituality. The society represents the organization of the collective for the purposes of accomplishing myriad objectives. Therefore, anything that enhances the effectiveness of the social web, magnifies the power of the entire society to fulfill its intentions.

At a time when the concept of limits raises serious concerns regarding humanity’s future development, the perspective of society as a web acquires special significance. Society reveals itself as an infinite ocean of power for accomplishment. At any point in time, humanity exploits only a tiny portion of the potential interconnectivity and interactivity between an infinity of points and possibilities. *The potential for enhancing the connectivity and performance of the social web is unlimited and can never be exhausted.* As the number of nodes increases, the possibilities for interaction and its resultant effective power grow exponentially, magnified by the interaction between groups or clusters of nodes and by the capacity for simultaneous interaction for multiple purposes – production, governance, education, enjoyment – and at multiple levels – for movement and interactions between people and things, products and services, activities and attitudes, information and ideas, aspirations and values.

Historically, this potential has been most vividly revealed in times of war and other national emergencies when society mobilizes all its available resources to meet a crisis. America nearly doubled its GDP during World War II in order to supply materials for the armed forces and civilian populations at home and in Allied countries overseas. During the war, the US produced more than 324,000 airplanes, more than 1000 military vessels, including 22 aircraft carriers and 203 submarines. At the onset of the war, the US possessed virtually no merchant shipbuilding capacity. With the Axis nations torpedoing merchant vessels at an alarming rate, Great Britain was in desperate need of both armaments and civilian provisions.

Under America's Liberty Ships program, the time required to build a merchant ship was brought down from a month to less than five days. America produced eleven million tons of shipping in 1942, but enemy submarines sank twelve million tons. The next year it produced twenty million tons of shipping. The Liberty Ship proved to be a crucial factor in the final outcome of the war. Social mobilization during times of war and national calamity illustrates the latent capacity of society which normally remains unutilized because its interdependent social systems are not fully developed for optimal performance.

This latent power of society – most especially the unutilized productive power of its human capital – is dramatically illustrated by the sudden emergence of Wikipedia as one of the wonders of the world, an unprecedented product of global social collaboration. In a little more than a decade, millions of individuals around the world have collaborated to create a free encyclopedia containing more than 24 million articles in 285 languages with only nominal expenditure. The 4.2 million English language articles alone are equivalent in size to 1700 printed volumes of the Encyclopedia Britannica. This untapped social potential is ever-present, but has never been fully harnessed for productive purposes. Global society is still in the early stages of discovering how to best organize this potential for the betterment of all human beings.

Author's note to the Editor on the themes for subsequent articles in the series: Article 2 will focus on the political and economic dimensions of society as a web – the role of trade, markets and money, the initiation of political movements, development of political institutions and law. Article 3 will focus on the intellectual and cultural dimensions of the social web – acquisition and dissemination of knowledge, development of science and technology, spread of education, development of human values, the evolution of consciousness and the rise of individuality.

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Notes

1. Eugen Weber, *Peasants into Frenchmen: The Modernization of Rural France 1870-1914* (Stanford: Stanford University Press, 1976).
2. Thomas Standage, *The Victorian Internet: The Remarkable Story of the Telegraph and the Nineteenth Century's On-Line Pioneers* (New York: Walker and Co., 1998).
3. Mitchell Stephens, History of Newspapers <http://www.nyu.edu/classes/stephens/Collier%27s%20page.htm>