Knowledge Networks[1]

Knowledge Networks Defined

We live in a Knowledge Society. After going through its hunting/gathering, agricultural and industrial stages, the primary production factor of humanity is now knowledge. Without it, society would come to a grinding halt. However, what is knowledge? It is not a material resource that can be easily quantified. There are many definitions of this all-important, yet elusive concept. A common interpretation is that it concerns a theoretical and practical understanding of a subject embodied in expertise and skills that help its owner to resolve concrete problems. Creating, processing, and applying knowledge often is a collective process, requiring much communication, coordination, and collaboration between many stakeholders. To support this distributed, complicated knowledge management process, *knowledge networks* are of the essence. Such a network is typically a complex, evolving socio-technical system of enabling communications infrastructure, a network of knowledge resources and services, and a social network of collaborators. In this entry, we examine what knowledge networks are and how they operate.

Society is awash in *data*, with which knowledge is often confused. With computing power doubling roughly every two years (generally known as "Moore's Law") and computers and people getting ever more connected through the Internet and mobile technologies, there is an explosion of possibilities to store, transform, link, and share data. However, data by themselves are meaningless, as they are nothing more than a representation of individual facts, descriptions of particular states of the world. To be meaningful, data need to be turned into *information* by connecting selections of them to a particular context of use, such as decision making. With information, questions like "who", "what", "where" and "when" can be answered. Still, information, though meaningful and potentially of use, is not necessarily useful in practice. *Knowledge* provides a framework for efficiently evaluating and selecting relevant information for resolving concrete problems. Knowledge is distilled from information by an, often very long, process of learning about a domain.

To illustrate the differences between these terms, say that a political organization wants to know which persons best to approach to help out in an election campaign. It has a large database of facts about which users viewed what pages of their website at what date and time. A software program selects from these data those persons who live most closely to the campaign headquarters and who have accessed the site within the past month. Still, the output contains hundreds of potential candidates, too many to approach personally. A seasoned campaigner

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therefore looks at the web pages these people accessed, the area where they live, the organizations they work for, their browsing histories, and so on, and makes a shortlist of candidates based on her own extensive campaigning experience. This knowledge could not have been provided by the computer.

Knowledge is usually not embodied in an individual person who accesses only a single knowledge resource. Instead, it is often distributed over many knowledge resources and people, together forming a knowledge network. A network is an interconnected system of things or people. A knowledge network can be defined as the combined system of (1) an enabling communications infrastructure (2) meaningfully linked data and information resources (which together we call knowledge resources), as well as the services that make these resources accessible, and (3) the social network of people who have, create, process, and apply knowledge to their professional activities.

Communications Infrastructure and Knowledge Resources

A necessary condition for a knowledge network is a communications infrastructure. The Internet is a global network of networks linking up countless computers, knowledge resources, and human users through a uniform technical protocol. It provides them with a wide spectrum of information and communication services, such as web sites, e-mail and social networking and media sites.

Superimposed on this communications infrastructure are the networks of meaningfully related knowledge resources, such as the hyperlinked documents and data of the World Wide Web. Vannevar Bush, in his seminal article *As We May Think*, published towards the end of WWII, outlined a vision of a hypothetical Memex system, which consisted of numerous multimedia knowledge resources that could be annotated and associatively indexed by its users. This would allow professionals to easily select those knowledge resources relevant to a particular problem at hand, and follow the trails of meaningful associations made by themselves and trusted friends and colleagues. This vision has been the driving force behind the World Wide Web. Core elements of the Web were outlined by such such visionaries as Ted Nelson, Doug Engelbart, and Tim Berners-Lee. The latter realized its initial implementation consisting of documents that could be connected by their authors through so-called hyperlinks. The Web currently comprises a vast, global knowledge base of billions of linked documents. It has become embedded in the fabric of our globalizing society and has given an unimaginable boost to research, education, business, and many other professional and social domains. However, a major weakness of this Web is that the meaning of these documents and their linkages can only be understood by people. As a result, its effective use is hampered, as human beings are incapable of handling the resulting information overload: how to separate the wheat from the chaff when every query returns way too many hits to scrutinize of potentially useful pages? Tim Berners-Lee and others

therefore proposed an extension of the original Web. In the “Semantic Web”, information is given a well-defined meaning, which allows computers and people to cooperate better. By bringing formalized structure to the content and links of Web pages, an environment is created where software agents can roam from page to page, searching for more relevant answers to complex knowledge requests. For example, instead of providing thousands of seemingly random links to Web pages of travel agents, hotels, and cities, a Semantic Web-powered software agent can provide the user with a concrete proposal for flight reservation, hotel accommodation, and sites-to-see, tailored to her specific preferences. Beyond basic access to and search of these knowledge resources, the Web increasingly also offers a wide array of content and communication services. The recent advent of social media such as YouTube, Wikipedia Facebook, LinkedIn, and Twitter, to name but a very small tip of the “Web 2.0” iceberg has led to an explosion of services for creating and sharing all kinds of content and for facilitating social interactions between millions of people. Thus, there is now a very rich substrate for knowledge networks to emerge from. The hearts of these networks, however, are not technology and knowledge resources, but people.

Tacit Knowledge and Wicked Problems: The Human Essence

Although the Semantic Web is an important step forward for making knowledge resources more accessible and useful, it is still in its infancy and far from realized in practice. Two more principled reasons for knowledge networks being primarily human instead of computer-based are that much knowledge is “tacit”, instead of explicit, and that many knowledge networks address “wicked problems”.

Much R&D is done on computer-based approaches to knowledge representation and reasoning, drawing from various disciplines such as Artificial Intelligence, Knowledge Representation, and Natural Language Processing. Although increasingly powerful, the algorithms and “software agents” developed are only capable of knowledge processing tasks in very restricted problem domains that have well-defined rules, such as needed for playing chess. However, such machine approaches are completely at a loss when, for example, they need to assess what is the best definition of a complex business case, with its myriad, messy considerations and trade-offs to be made about markets, corporate strategy and culture, and product and service design. Much of this knowledge cannot be made explicit and subsequently stored in and reasoned about by computers. Instead, this knowledge is tacit, stored in the heads of people in the form of intuition, skills, and expertise. Instead of replacing human beings, formal and automated approaches should therefore at best be seen as augmenting complex human knowledge creation and sharing tasks.

Ikujiro Nonaka has proposed an influential model of how explicit and tacit knowledge interact in order to create new knowledge. Many variations on this model have been proposed in the knowledge management literature, but it captures the essence of how human and machine-based

knowledge activities interact in knowledge networks. In his SECI model, Nonaka proposes that through a process of *socialization*, individuals share tacit knowledge through often physical interactions. A coffee corner conversation is a very good example. In an *externalization* process, tacit knowledge is converted into explicit representations, such as documents or databases. *Combination* converts explicit knowledge into more complex forms of explicit knowledge. Computers can be very helpful here, such as spreadsheets doing complex interest calculations. Finally, *internalization* ensures that individuals acquire relevant knowledge from external sources through action and practice.

Besides tacit knowledge being so prominent, there is another reason for the leading role of human beings in knowledge networks. Many, if not most of the interesting problems these networks address are so-called "wicked problems". This class of problems, introduced by Rittel and Webber, includes almost all environmental, social, scientific and economic issues, ranging from organizational innovation processes to how to assess and deal with climate change. Typically, these problems have no definitive formulation and solutions are neither true nor false, only better or worse. This means that there is a lot of room for interpretation and negotiation of facts, values, and contexts. For example, say the UN need to decide how much carbon emissions should be reduced and by whom. Much of the science is uncertain about to what extent climate change is man-induced and what effects emission reductions would have, given the many feedback loops in the world's climate systems. Furthermore, to decide which part of the reduction should be covered by which nations is a political isssue, in which many incommensurable criteria like degree of development, fairness, and effectiveness of interventions need to be weighed against each other. Only people can thoroughly understand and balance the implications of all these factors to the fullest extent.

Knowledge Networks: Collaborative Communities

Summarizing, necessary components of each knowledge network are a communications infrastructure like the Internet, and the network of knowledge resources and services like the (Semantic) Web that this infrastructure enables. The essential human component of knowledge networks generally does not consist of one or more isolated individuals, but of social networks of collaborating human beings. Social networks in this book have been defined as groupings or loosely connected webs of individuals tied by one or more specific types or interdependencies. In knowledge networks, these interdependencies typically are shared practices, interests, and goals. These joint goals are key to knowledge networks and vary considerably depending on the domain and scope of the network. In an educational network, a shared goal could be to set up and offer a well-aligned set of courses. In a scholarly network, the goal could be to set up a quality electronic journal. A business network could have the aim to develop an innovation platform. All of these networks are collaborative communities, in which collaboration by members is necessary to accomplish the shared goals and knowledge is the primary production factor. They

are communities in that they are not just aggregates of people, temporarily interacting. Key to communities is that long and lasting interactions bind community members and that these take place in some form of common space. This space is increasingly a hybrid of online and face-to-face environments.

Two main forms of collaborative communities are communities of interest and practice. *Communities of interest* are communities of people who share a common interest or passion. With the advent of the Internet, such communities have become increasingly specialized and globalized. It is now possible to find like-minded experts on a highly-specialized topic of interest to a degree that never existed before due to distance barriers.

Communities of practice are the archetypical knowledge-intensive social network. They consist of people who engage in a process of collective learning in a shared domain of human endeavor. Their members share common work goals and have a high interest in learning, investigating, developing, and improving the knowledge subject. Communities of practice often cut through organizational hierarchies and boundaries, linking individuals, teams, organizations, and interorganizational networks. The learning taking place in these communities is also known as sensemaking and can involve many participants, knowledge resources, and tools. Cultivating such communities of practice is both an art and a science. Wenger, McDermott and Snyder have made a well-known summary of the principles at work, such as designing for evolution, opening dialogue between inside and outside perspectives, inviting different levels of participation, and creating both private and public community spaces.

Knowledge Networks: Evolving Socio-Technical Systems

Knowledge networks are not declared, but are living, growing socio-technical systems. In these systems, the social system of knowledge workers coevolves with the technical communications infrastructure and knowledge resources and services: the technology affords and constrains the interactions of its users, while the knowledge requirements of the collaborative community leads to new (uses of) knowledge resources and services. These socio-technical systems often start small, for instance, with a few researchers writing a paper together using just e-mail and a simple database. Still, they can grow to be very large scale ecosystems of people, using numerous online knowledge bases, discussion fora, (micro)blogs like Twitter and Wordpress, and advanced collective knowledge mapping and sensemaking tools, as is the case in the global climate change research community. In short, knowledge networks are very complex, ever-changing socio-technical hybrids, balancing a rich soup of social, technical, and meaning aspects. Knowledge networks will see increasingly sophisticated meshings of collaborative communities with communications infrastructure, knowledge resources, and services. New forms will continue to emerge that combine the unique capacity of collaborating human beings for interpreting the relevance of complex, evolving knowledge resources in the work contexts to which they are

applied, with the power of ever more accessible, usable, and advanced information and communication technologies. Knowledge networks are our future.

See Also:

Educational Networks, Hyperlink Networks, Internet History and Networks, Scholar Networks, Scientific Communities, Semantic Networks

Further Reading

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