3 Visualization of Scientific Information and Domain Analysis

The analysis of domains is one of the newest research fronts to surge forward as a consequence of the proliferation of information visualization techniques, and proves immensely helpful in revealing the essence of scientific knowledge (Chen; Paul; and O'keefe, 2001). For example, it has been used to show animated visualizations about the extinction of mass media literature, or to demonstrate the potential of visualization based on citation (Chen [et al.], 2002), as well as to explore and access the contents of digital libraries (Chen, 1999b) and to study the evolution of the patterns of citation regarding patents (Chen and Hicks, 2004).

Of course, there is a close but perhaps elusive connection between domain visualization and that which *Hjørland and Albrechtsen* (1995) call domain analysis. The visualization of domains can afford a strong means of support in domain analysis, especially within areas of multidisciplinary knowledge, and in those fields that change and advance rapidly (Börner; Chen; and Boyack, 2003).

Although the relationship between the visualization and the analysis of domains, or visualization of knowledge, has been suggested by authors *Garfield*, *Small*, *White* and *Chen* among others, none has come to explain the whys and whereabouts of this deeply rooted association. What tools, or technical aids, can make a contribution to domain visualization and domain analysis, and vice versa. We believe it is high time to address this question, with a study that adopts a singular perspective or thesis: the analysis of domains based on their visualization, through representation via social networks.

3.1 Domain Analysis

In 1995, *Hjørland* and *Albrechtsen* set forth a new approach or perspective for studying the field of Documentation and Information Science: domain analysis. According to this new viewpoint, the analysis of domains is based on the analytical domain paradigm, which establishes that the best way to understand information is to study a given domain of knowledge as part of the discourse of the communities from which it proceeds, the community being a precise reflection of economic and work divisions of society. This is due to the fact that the organization of knowledge, its structure, patterns of cooperation, language and modes of communication, and criteria of relevancy are the mirror image of the work of these communities and of the role that they play in society. Moreover, the individual psychology of each member, his or her knowledge, the informative need of a person, and the subjective criteria of relevance of each are taken into account. The domain-analytical paradigm is, in the first place, a social paradigm in that it foments a psychological perspective, and sociolinguistic and sociological perspectives of science. Secondly, it is a functionalistic approach, as it attempts to comprehend the implicit as well as the explicit aspects of science while marking or making visible underlying mechanisms of communication. And in the third and final place, it provides for a philosophical–realistic approach, as it aims to establish the scientific bases of a given domain, through factors that remain external to individual perceptions and the subjective realm of users – in contrast, for instance, to the cognitive and conductivistic paradigms (Hjørland and Albrechtsen, 1995).

This perspective is not necessarily limited to of the area of Documentation, but can be applied to any other domain, regardless of its nature or size. In our opinion, what is important is not the development of a new theory or paradigm to let us analyze each one of the disciplines now in existence; rather, the paradigm should ideally form a conceptual baseline for developments in any field, even in the earliest stages of development. Be it separately or in combination, as a set, this can be achieved through a holistic and objective view of such domains.

Whether in Philosophy or in scientific theory, then, there is a trend from the fundamentalistic or empiric theories asserting that science is based on postulates of absolute truths obtained by means of the human senses – empirical thought and positivism – and from reason – rationalism. This positivistic and rationalistic view of science considers language to be something nominalistic, its only utility being that of transporting perceived knowledge – acquired by the senses or by reason. Accordingly, language does not intervene in the process of the perception of reality, but is simply the vehicle through which already existent knowledge is communicated among individuals. This focus emphasizes the individual perception of knowledge, free from cultural traditions; yet in light of its overly objective view of things, it is a philosophy that is outdated. And so, the traditional perspective of epistemology and the Philosophy of Science is being replaced by a more holistic current that acknowledges the importance of language in the perception of reality and which is consequently introducing a historical, cultural, social, and objective dimension into the theory of knowledge and of science. Reality cannot be captured nor be comprehended innocently by an isolated and unprepared individual. Even individualized bodies of knowledge are constructed with elements of history, culture and whatnot, including building materials that may have developed from a more specific domain of knowledge offering one a slightly distinctive possibility of perceiving reality. In short, the methodological individualism that considers knowledge as a mental state of the person is being phased out by a methodological collectivism or holism, which grasps knowledge as a social or cultural process, or as a cultural product (Hjørland and Albrechtsen, 1995).

From this standpoint, we might say that the best way to study a discipline or domain of knowledge would be through *domain analysis*, understood as an illuminating study of the discourse of the community participating in the formation or evolution of a discipline, as well as of certain hidden relationships with the society in which it gestates. In this way, the social, ecological and informative nature of the domain of knowledge under study is accented.

But now, what tools, methods, techniques, and so forth are necessary in order to carry out the analysis of a domain? *Hjørland* again comes up with a response, proposing 11 methods for the analysis of domains within Documentation (Hjørland, 2002). We would add that these methods (not exclusive to Documentation) may be used to discover a holistic and objective panorama within any sort of domain.

Of the 11 methods proposed by *Hjørland* for domain analysis, we focus on one, specifically that of bibliometric studies, as constituting the best approach whence to ponder domain analysis. The other ten may well be used as complementary elements to back-up and give more substance to this holistic vision.

Until fairly recently, sociologists believed that bibliographic citations were some sort of system for the control of intellectual property safeguarded in scientific publications. The importance that they wielded, additionally, in reflecting cognitive and social connections among researchers went unacknowledged (Merton, 2000). But in the field of Documentation, authors soon began to appreciate this alternative facet of citation. Networks borne through the citation of scientific documents can clearly signal the emergence of new research fronts (Price, 1965) just as they can be used to obtain ethnographic information referring to the presence and nature of social relations – for example, to discover through citation a close colleague whom one has never met in person (White, 2001). The use of this technique can be extended beyond bibliometrics or sociology to become a general notion in which different subdisciplines flow together, including: scientometrics, infometrics, and bibliometrics in the strict sense. Because of the focus of our research, for us it has become a synonym for metric studies surrounding science.

Bibliometrics configure a discipline with a long tradition, which has had to adopt different techniques with the passing of time. In its beginnings it involved mathematical distributions, the creation of rankings, with bivariate analysis; in later years, it has introduced a wide array of techniques involving Multivariate Analysis (MA). Among these we find statistical methods, connectionist techniques, and social networks, which we will deal with in greater detail under Sect. 4.4.

Cocitation analysis may also be used by Documentation professionals who wish to find out how one given author is related with the rest of the scientific community in a specific or a broad area of work; by those who wish to study the structure of a scientific domain; or by those who want to gain awareness of new advancements on the horizons of science. It would be very desirable in general to be able to combine citation analysis with social network analysis in order to explore how social structures penetrate or are reflected by the intellectual structure of the individuals therein. But until now, bibliometric experts did not dispose of tools geared to the study of social networks, and sociologists were not tuned into the utility of citation as an informational source on its own accord nor of the developments in visualization techniques that might be applied to this end (White, 2000).

Hjørland defends bibliometrics as a tool and method for domain analysis in many different forms. For example, as a tool it can be used for the generation of bibliometric maps by means of cocitation analysis. This is the case of the maps for the visualization of a discipline (White and McCain, 1998b), whose representations bring to light factors that are external to the user's subjective perception, by breaking through aprioristic mental schemes and, as a consequence, facing the representation of a reality that was not previously perceived. Moreover, bibliometrics can be used as a method for the analysis of domains, as it shows the real relationships between and among individual documents and reveals the explicit acknowledgment that some authors make of others, while in the meantime reflecting relationships among different scientific fields (Garfield, 1976).

Bibilometrics can show and describe tendencies in different areas of knowledge, but in itself it cannot interpret the utility, the fit, the benefits, and the drawbacks of such tendencies. For this purpose we need to resort to broader disciplines such as Sociology and Philosophy, which permit a sociocultural interpretation of data and of bibliometric displays (Hjørland and Albrechtsen, 1995). This calls upon the holistic forces of domain analysis (Garfield, 1992). The present text does not go so far as to explore the perception of human beings regarding visual representation, an interesting matter that is taken up by *Polanco, Francois and Keim* (1998).

From the bibliometric standpoint, the holistic vision in domain analysis is given by the authors of the scientific community. It is the authors themselves, from their respective realms, who constitute and construct part of the discourse of that overall domain. They are responsible for their background, their interests, the relations and interactions among domains. And all this takes place through language, that is through the references of the bibliographic citations in their works. The objective vision in domain analysis is thus given through citation, but by a variant used to generate bibliometric maps or domain representations: cocitation.

We will not deny the fact that author citation can bear a certain degree of subjectivity and intentionality at its core, yet these limitations disappear when cocitation is put to use in a vast realm. Why? Because the different author viewpoints, as seen through cocitation, result in a data set where the opinion of one subjective author cannot prevail. What prevails is the consensus of the bulk of authors. Moreover, cocitation affords invaluable information about how these authors, as experts in a domain, perceive the interconnectivity of their paths of study or interest by means of the studies published to date. In this way, a particular thematic area or research front can be quickly spotted by authors or researchers somewhat familiar with the domain.

This general and objective vision derived from the bibliometric focus, with respect to domain analysis in this case, has been approached by a number of authors dedicated to the analysis and visualization of domains, though until now it had not been postulated in such a patent manner. The finality has thus far been more oriented toward a justification of the maps or visualizations obtained, than to the subsequent analysis of the domain portrayed therein. For instance, Small considers cocitation to represent a relationship established by the citing authors; and so when its strength is measured, what we are doing is calculating the degree of relation or association among documents, just as the community of citing authors sees it. And due to this relevance of author citations, the patterns of relationship can change over time just as the co-occurrences of citations change, making clear how a field evolves in a certain direction or directions.

This can lead us to a more objective manner of looking into the structure of specialized fields of science, as the changes produced in cocitation patterns, over time, give indications of the diverse mechanisms behind the development of a given field (Small, 1973). For *Franklin* and *Johnston*, the bibliometric model based on cocitation, while grouping authors, works, documents or journals according to thematic affinities, allows for a measurement of the interaction among the different research fronts, to the point where we can turn the set into a hierarchy of specialized areas related amongst themselves (Franklin and Johnston, 1988). This hierarchy would not be an a priori classification of knowledge, but rather a self-organizing classification on the basis of the work of the scientific community as a whole. *Ding*, *Chowdhury* and *Foo* sustain that from this point of view – the Sociology of science and the Philosophy of science – cocitation contributes to making manifest the cumulative advancement of science, showing established interactions and creating new ones (Ding; Chowdhury; and Foo, 1999). For White, cocitations automatically group materials, methodologies, and social affinities just as they are perceived by the citing parties. The sense of a greater or lesser affinity between pairs of citations can be seen by counting cocitations – an overall aggregation for which no single citing author could possibly be held responsible (White, 2003).

Finally, for an adequate approach to the bibliometric treatment of domain analysis, according to *Hjørland*, four key factors must be taken into account:

1. The danger of bias that may be introduced by the data as a consequence of the lack of coverage, documental types, classifications established beforehand, and so on must be carefully accounted for at the time of analyzing and interpreting the information within a domain.
2. The second factor is that every bibliometric map is determined by the patterns of citation of each discipline.
3. The third factor lies in the holistic methods that should be used by researchers when data are analyzed.
4. The fourth and final essential ingredient is the dynamic character of epistemological bases of science.

Yet there is also a fifth necessity that is not mentioned by *Hjørland* and which deserves mention and reflection at this point. The party making the interpretation should be equipped with some previous knowledge of the domain at hand, for example the history of science, the sociology of science, and so on, as this conforms the foundation for an adequate reading of the evolution and the paradigmatic changes occurring within the domain, if any. This fifth factor reinforces the bibliometric perspective, and it serves to close the circle of the holistic vision, as it connects the knowledge provided by the discourse of the pertinent communities with that of the individual, who, whether or not a member of that community, tries to analyze it.

3.2 Social Networks

In spite of their widespread acknowledgment in so many fields, social networks and their analysis are a practically unknown approximation in both theoretical and methodological spheres in the area of Documentation. This trend is changing, however. Social network analysis may stand as a quantitative and qualitative leap in the representation and analysis of the structure of all sorts of scientific domains, whether they be geographic, thematic, or institutional.

In the works of *Liberman* and *Wolf*, the scientific community structures its relations according to models of social networks, where the nodes or actors represent individuals, scientific disciplines, and so on, and the links are the knowledge exchanged by these actors (Liberman and Wolf, 1997). For a detailed review of what social network analysis and graph theory means, we suggest the work of *Wasserman and Faust* in 1998.

3.2.1 Basic Notions

Over time, social networks have developed a terminology of their own, which has grown in parallel with the great variety of studies carried out under different disciplines and perspectives. Hence, beyond some notions that have earned general consensus, there is a proliferation of varied concepts and ideas harbored under apparently well-established terms. This leads to much confusion with regards to key concepts for the analysis of social networks (Herrero, 1999). For this reason, we very succinctly expound the basic terminology of this theory below.

Actor

In social networks, there are two fundamental elements for comprehension. One of these is the actor, a name given to each of the entities or objects of study forming part of the network. In a social network graph, the actor may also be referred to as the node, vertex, or point. The actor does not necessarily have to represent a concrete unit or individual; it may also be a company, institution, or social group.

Link

It is the other key element in the graphic analysis of networks, as the element in charge of connecting one or more actors with others (Fig. 3.1). This may also be called a connection or line, and it may be directional or non-directional, depending on whether it indicates the orientation – from one actor to another – or does not. In the first case, the link is called an arrow or arc (directional link), whereas in the latter case it is non-directional or reciprocal. Links may or may not be weighted, depending on whether they indicate the degree of connection in numerical terms.

There is a special type of link, the self-link or loop, which is produced when an actor makes reference to itself (Fig. 3.2).

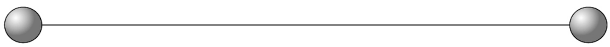

Fig. 3.1. Actors and non-directional link

Fig. 3.2. Loop or autolink

Group

A finite set of actors and links, which, for theoretical, conceptual, or empiric reasons, are treated as a closed grouping of individuals (Fig. 3.3).

Subgroup

Subset or finite grouping of actors and links that is part of a greater unit or network (Fig. 3.4).

Relation

Set of links that exist between or among actors of a group or a specific set of actors.

Adjacent Actors

Actors that can be found in direct relation or connection via a link.

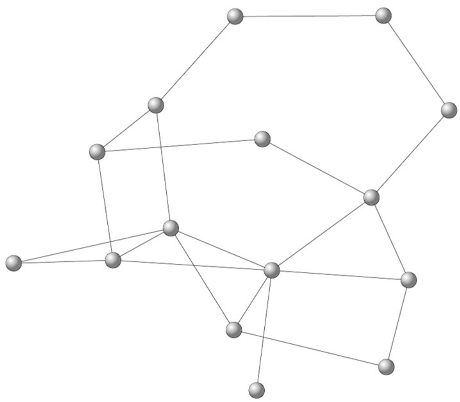

Fig. 3.3. Group of actors in a network

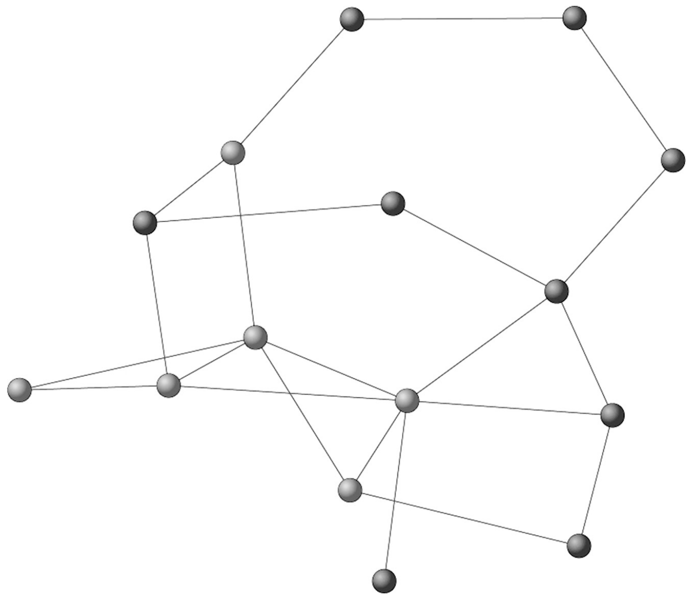

Fig. 3.4. Subgroup of light nodes in a network

Direct Connections

Those produced between adjacent actors, that is, with no intermediary node. They may also be referred to as direct links. For example, the relation of adjacency – discontinuous – existing between actor two and its neighbors in Fig. 3.5.

Neighborhood

Set of actors with which a given actor or node is adjacent (Fig. 3.6).

Indirect Connections

Those made between non-adjacent nodes, through intermediary actors. They can also be called indirect links.

Path

This is the sequence of links and actors that connect two non-adjacent actors, without repeating any of them. The length of the path is determined by the number of links. It makes manifest the existence of an indirect connection (Fig. 3.7).

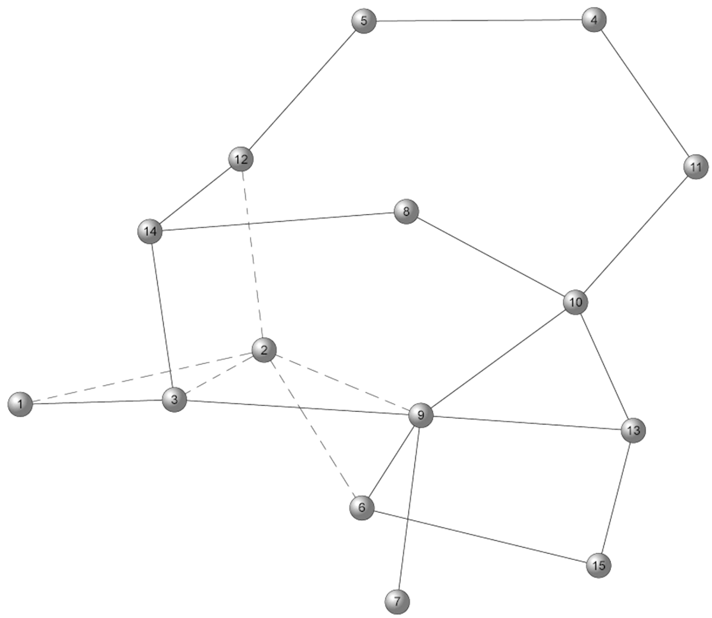

Fig. 3.5. Relations and adjacent connections to actor two

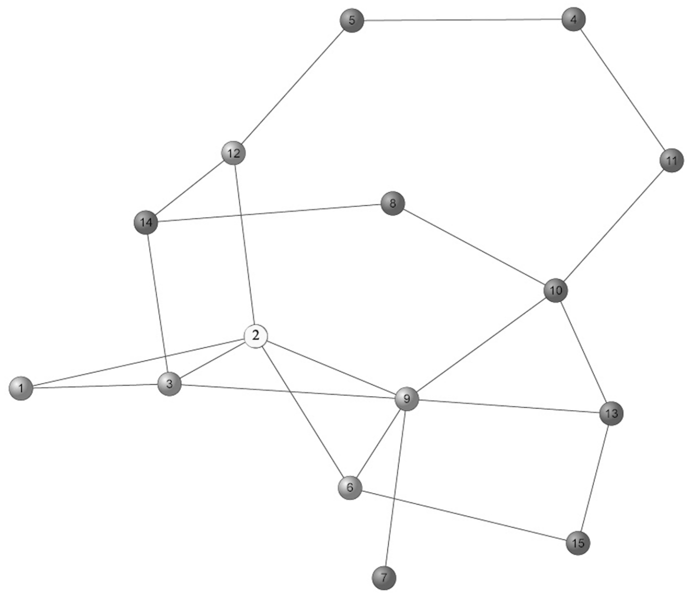

Fig. 3.6. Neighborhood of actor two

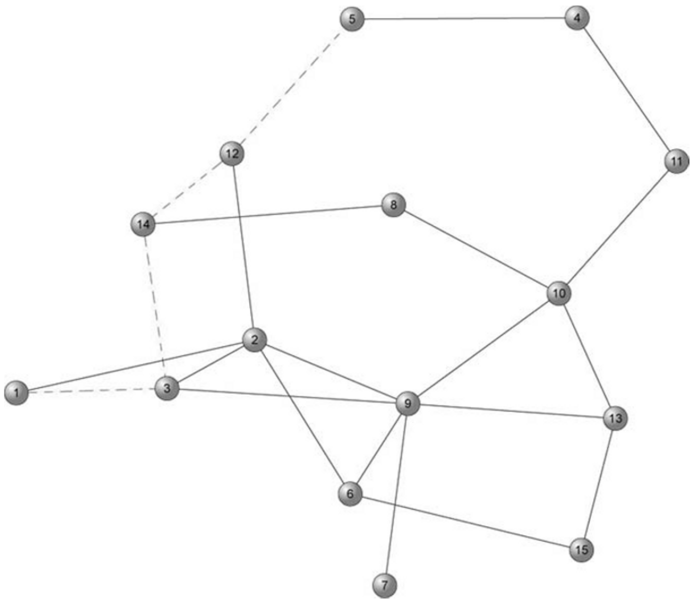

Fig. 3.7. One of the possible paths between actors one and five

Geodesic Distance

It is the shortest path between two nodes or actors of the network, and can also be denominated geodesic length, or simply distance (Fig. 3.8).

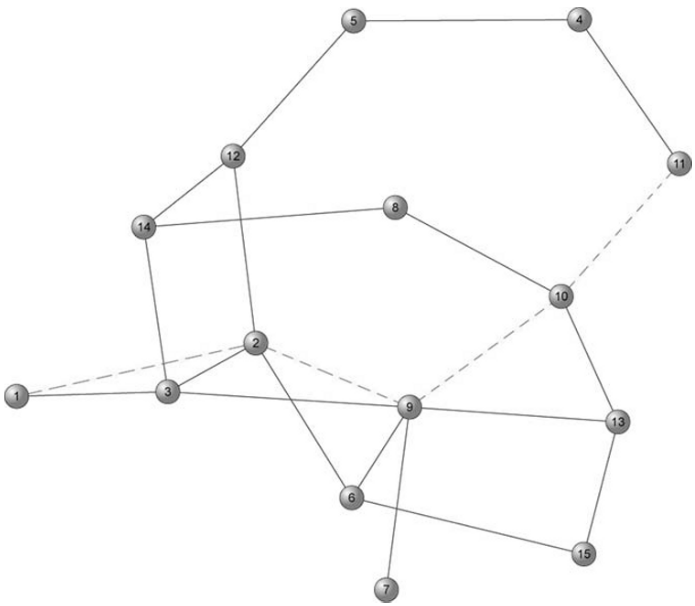

Fig. 3.8. One of the possible distances between actors 1 and 11

Diameter

It is the longest path between two specific nodes or actors (Fig. 3.9).

Isolated Actors

Actors that have no link or relation with any other actor in the network (Fig. 3.10). They may also be called disconnected actors.

Connectivity of a Graph

A graph is said to be connected if there exists a path between each pair of nodes; if not, the graph is said to be disconnected (Fig. 3.11).

Components

This name is given to each one of the subgraphs or subgroups that make up a network.

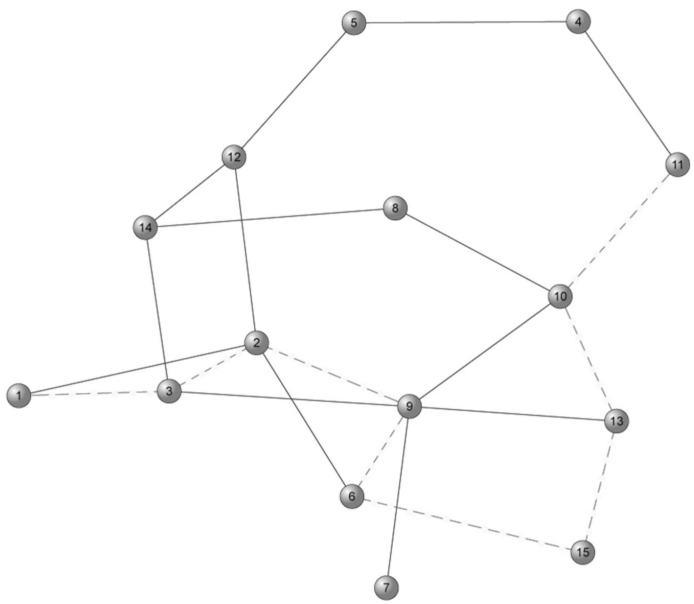

Fig. 3.9. Diameter between actors 1 and 11

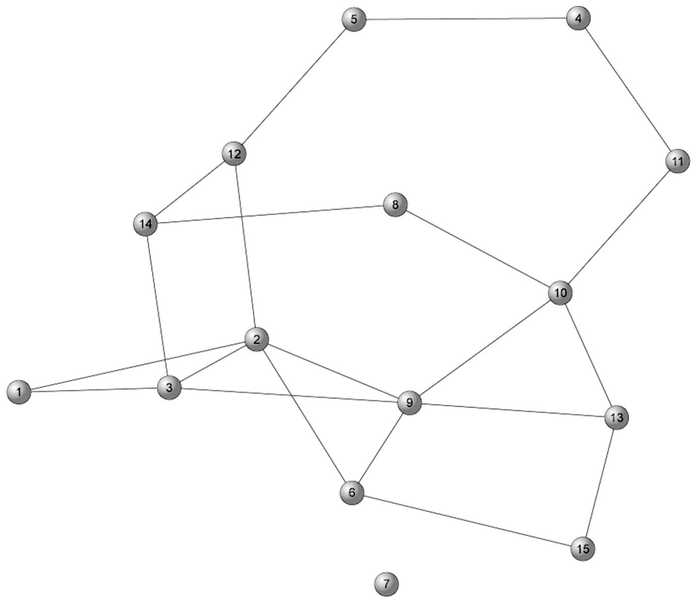

Fig. 3.10. Network with an isolated actor

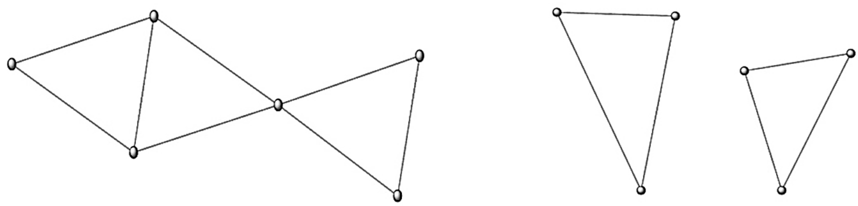

Fig. 3.11. Connected graph, beside a disconnected graph with two components

Cutoff Point

A node or actor is considered to be the cutoff if, by eliminating that node, and therefore its links as well, the graph is left disconnected, or increases its number of components. Other denominations used for the cutoff points are intermediary, and broker (Fig. 3.12).

Bridge

It is a critical element in the connectivity of a graph. If, by eliminating a specific link between two actors, the graph becomes disconnected, or else increases its number of components, that link is known as a bridge of the network (Fig. 3.13).

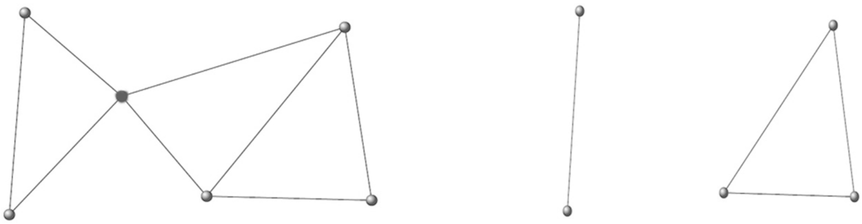

Fig. 3.12. Intermediary node or actor in a network

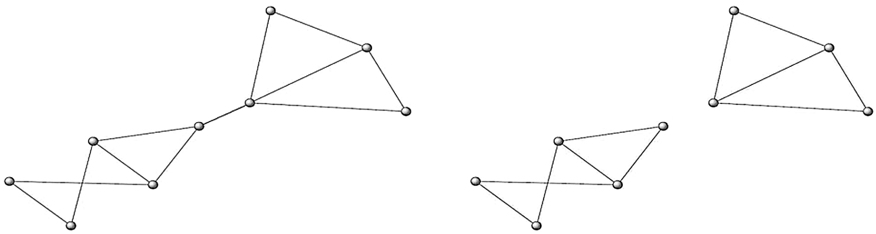

Fig. 3.13. Link that acts as a bridge between two components

Measures of Centrality

These are measurements destined to detect and identify the most important or central actors of a network. This type of measure is based on graph theory. The idea of centrality does not refer to the position of an actor, but rather to its degree of integration or cohesion in the network. Following *Freeman* (1979)**,** the measures of centrality are of three sorts: degree, closeness, and level of intermediation, also known as betweenness. Within these three we can distinguish the following:

a. Centrality of Degree. Also known simply as degree, it is the simplest unit of centrality. It is defined as the number of direct links that an actor has. An actor with a high degree of centrality will have a broad neighborhood, will occupy central positions, will be more visible, and will become an important element for the interconnection of the network.
b. Centrality of Closeness. This type of measure is based on nearness or distance, measuring just how close an actor is to the rest of the actors of the network. The more central the situation of an actor, the greater its capacity of interaction with the rest of the actors.
c. Centrality of Intermediation or Betweenness. The interaction between two non-adjacent actors may depend on other actors in the network, and particularly on those situated on the path of the corresponding non-adjacent nodes. This type of actor or intermediary of paths

between actors serves to control the interactions of the network. The centrality by intermediation or betweenness measures the degree to which a given actor – intermediary – forms part of the shortest path or geodesic distance between other actors.

3.2.2 Concept of Social Network

Many of the terms habitually used in social network theory and analysis proceed from the field of Anthropology. Indeed, it is precisely an anthropologist, *Barnes* (1954), who holds the honor of creating the concept of social network. For Barnes, it meant a set of ties that join members of a social system throughout and beyond social categories and closed groups.

According to *Wasserman* and *F*aust (1998), a social network consists of a finite set of elements – actors – and the relations defined among them, where the presence of the latter is a critical and defining characteristic of the network: what is most important in social networks is not the individual, but the structure, defined as the set of individuals and their connections.

Molina, *M*uñoz and *L*osego (2000) affirm that social networks are centered on the identification and analysis of structures, on the basis of the relationships existing between certain elements, regardless of their attributes or characteristics. It is assumed that these structures exert some sort of influence on the behavior of the elements that make up the system.

There is no overall agreement amongst authors dedicated to the study of social networks as to their definition; yet a wide consensus surrounds the most important principles of social networks, which can be summed up as four (Wasserman and Faust, 1998):

- Individuals and their actions are contemplated as independent elements.
- The connections between individuals are studied as chains of transference.
- The networks centered on individuals show a network structure in which these appear as a source of opportunities or limitations for individual action.
- The network models conceptualize structures as if they were fixed patterns of relations among individuals.

3.2.3 Brief Historical Review

The roots of social networks can be found in the 1930s, in Psychiatry and in Social Anthropology (Moreno, 1934), which separately initiated the study of small groups of individuals by means of their components: actors and links. Yet the true growth spurt in their development can be traced to Psychology, which introduced measures designed to obtain the patterns of the social connections that link sets of actors (Freeman, 2000a). The main aim was to detect social groups – actors closely interrelated – or else social positions – actors within a social system that are related in similar ways. In order to represent the connections between the actors and apply measures with which to infer patterns of behaviour, matrixes of coinciding data were used. While rough at the edges and offering only limited information at first glance, this approach gradually took shape as the most adequate method for studying the relations between individuals and groups.

The graphic representation of information for the analysis of this type of pattern was introduced by *Moreno*: "…the sociogram is more than a mere system of representation… it is a method that makes possible the exploration of sociometric events, where the particular emplacement of each actor and its interrelations with other actors can be shown. To date, it is the only possible scheme for carrying out the structural analysis of a community."

The sociogram affords the advantage of transforming mathematical information contained in numerical matrixes into visual information, or graphs. From the viewpoint of abstraction, visual information promises huge benefits with respect to purely numerical information, as it enhances transmission of the structural basis of the network and highlights the relevance of the different actors.

In a matrix, the social actors are represented as lines (cases) and columns (variables); while the links are the values existing in the correspondence between these two (Table 3.1).

In a sociogram, the actors are depicted as nodes or vertices, and the links are the relations existing between actors who interact in mutual fashion (Fig. 3.14).

The sociogram developed by *Moreno* marked the onset of sociometrics, which in turn gave rise to the analysis of social networks through the measurement of interpersonal relationships with reference to reduced groups.

Table 3.1. Matrix of data cocitation

	1	2	3	4	5	6
1	0	1	0	0	0	0
2	1	0	0.525	0	0.33	0
3	0	0.525	0	0	0.217	0.609
4	0	0	0	0	0.139	0
5	0	0.33	0.217	0.139	0	0
6	0	0	0.609	0	0	0

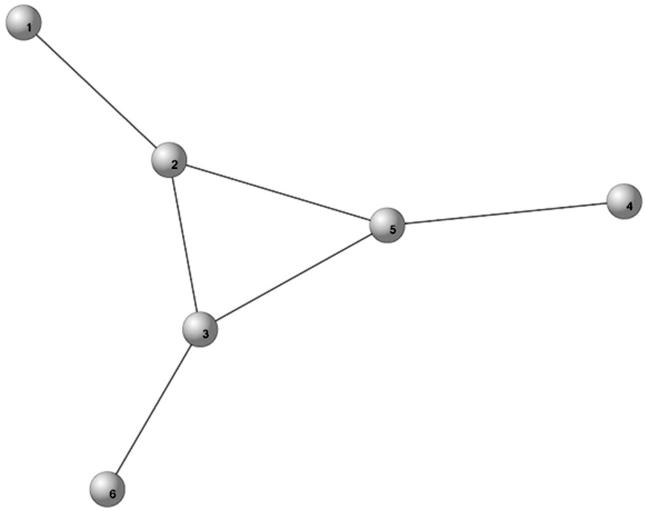

Fig. 3.14. Social network of nodes and links, or sociogram

In the early years, sociograms were drawn by hand, so that results were largely determined by the artistic dexterity of the person in charge of the network representation. With the development of computers since the 1960s, however, researchers increasingly liberated from the processing of huge volumes of data became able to produce results comparable with those obtained manually, but with greater scientific validity and reliability (Corman, 1990).

The incorporation of computer technology to social networks meant a real boost, allowing, in the words of *Freeman* (2000b),

- the representation and analysis of complex structures;
- the construction of graphs in two or three dimensions; and
- the application of techniques of MA, such as Factor Analysis (FA) to social networks, for the positioning and spatial reduction of representations.

From the 1970s onward, with the progress of discrete mathematics and, in particular, graph theory, a conceptual framework arose, lending the analysis of social networks a "formal language for the description of networks and their characteristics" and "the possibility of interpreting the data of a matrix as formal concepts and theorems, which can be directly related with the characteristics unique to social networks" (Scott, 1992).

Just as the sociogram constituted the means of graphically representing a matrix of relational data, the language of graph theory took hold as another much more general form of doing much the same. Graph theory is not simply another mathematical approach, but stands rather as the turning point of most ideas behind the analysis of social networks. Thus we can say that a sociogram is the graphic representation of a data matrix that receives the name of graph or graphics, which by virtue of graph theory is transformed into concepts and theorems, giving as a result a social network made up of actors and links.

After the 1980s, with the introduction of personal computers, the graphic representation of social networks was even closer at hand. Computer screens helped researchers apply the different techniques of grouping and detection of social positioning on a medium other than paper. At the same time, these sociograms could be more easily validated by independent researchers, to contrast the results of studies.

From then till now, social networks and their analysis have been used in a wide array of research areas, such as work mobility, the impact of residence on the individual, political and economic systems, decision-making, social support, communities, problem-solving groups, diffusion, corporative relations, beliefs, perception and cognition, the market, the sociology of science, power and influence, consensus and social influence, formation, communications between computers, organizational structures, health and disease (AIDS), article or journal citation and cocitation studies, the visualization of scientific domains as interfaces for information retrieval, and – as of very recently – in the analysis and structure of science.

3.2.4 Social Network Analysis

The appearance of social networks as a tool for studying the social behaviour of small groups of individuals, the development of the sociogram as a technique for the graphic representation of such relations, and the appearance of graph theory as a conceptual framework for the description and analysis of social networks shared a common objective: to unbury, in a deep but appropriate manner, the underlying structures of social networks. But where was this analysis to lead us?

Cassi (2003) believes that, because the social network is based on the interdependence of actors and their actions, its analysis should be focused more heavily on the relations than on the characteristics or attributes of the elements it comprises.

For *Freeman* (2000a), the analysis of social networks is an interdisciplinary specialty of the behavioral sciences, whose objective is to observe the interdependent elements under study (the actors) and how the interactions or relations taking place among them affect each actor. The analysis of social networks implies the elaboration of theoretical and empiric models in order to discover patterns of relations among actors and the precedents and consequences of such patterns.

Molina (2001) affirms that the analysis of social networks studies specific relations between a defined series of elements; and that unlike traditional analyses, it focuses on the analysis of the relations and not on the attributes of the elements. It deals, therefore, with relational data and is capable, by this means, of identifying and describing a structure in an operative way, not metaphorically.

Rodriguez (1995), on the other hand, sustains that the analysis of networks attempts to explain the behavior of network elements and of the system as a whole. This implies rejecting attempts to explain social processes and individual conducts based exclusively on the attributes of the actors. In the face of this type of individualistic analysis, so typical of the social sciences, network analysis tries to explain the behavior of individuals as the result of their social relations.

Wasserman and *Faust* (1998) are of the opinion that network analysis integrates theories, models, and applications that are expressed in terms of conceptual relations. That is, they consider that relations are the fundamental component of the network theory.

From these definitions, it is derived that network analysis provides a new method for the examination of processes with respect to those used up until now. The main difference resides in that it is not based on an individualistic analysis of the characteristics of the authors, but rather is elaborated with relational information concerning the actors who constitute the network structure.

The analysis of social networks, also known as structural analysis, has left many a researcher with a wrinkled brow. As *Welman* (1988) puts it, some underestimate it with the argument that it is mere methodology and lacks sufficient merit for dealing with substantive problems; others shy from its strange terms and techniques, not having played with blocks and graphs since primary school; others cut out a part of the whole, asserting, for instance, that their studies about the structure of classes do not require concentrating on the ties of friendship emphasized by network analysis; others disdain it as something that is not at all novel, implying that social structure has always been an object of study; others hook onto variables such as network density, as if to compress the variance explained; others, attracted by the possibility of studying non-hierarchical structures in a non-group context, broaden structural analysis into an ideology of networks to fight for egalitarian and open communities. Some even use network as a verb, to advocate the creation and deliberate use of social networks with desirable aims, such as employment or community integration.

Such pseudo-conceptions have risen due to the fact that many analysts and professionals have misused social network analysis as a catchall of terms and techniques. Still others have frozen the term to reduce it to a method, while others smooth it into a metaphor. Many have limited the power of this focus by treating all the units as if they had the same resources, all the ties as if they were symmetrical, and all the contents of ties as equivalents. Nonetheless, structural analysis does not derive its power of partial application from this or that concept or measure. It is a comprehensive and paradigmatic form of considering the social structure in a serious manner, from the direct study of the way in which the patterns of union assign resources in a social system. Therefore, its force stems from the integrated application of theoretical concepts, manners of obtaining and analyzing data, and a growing cumulative corpus of substantive findings.

3.3 Scientography

Scientific information is found scattered over disciplines which, for the non-expert, or even sometimes for the experts themselves, bear little or nothing in common. When one studies a domain pertaining to a specific field of knowledge along traditional lines, he may be left with the sensation of not grasping the domain in its entirety.

Science maps can be very useful for navigating around in scientific literature and for the representation of its spatial relations (Garfield, 1986). They adequately depict the spatial distribution of areas of research, while at the same time offering additional information through the possibility of contemplating these relationships (Small & Garfield, 1985). From a general viewpoint, science maps reflect relationships between and among disciplines; and the positioning of their tags clues us into semantic connections while also serving as an index to comprehend why certain nodes or fields are connected with others. Moreover, these large-scale maps of science show which special fields are most productively involved in research, providing a glimpse of changes in the panorama, and which particular individuals, publications, institutions, regions, or countries are the most prominent ones (Garfield, 1994).

The construction of maps from bibliometric information is also known as scientography. According to Garfield, this term was coined by the person in charge of basic research at the Institute of Scientific Information (ISI), George Vladutz, to denominate the graphs or maps obtained as a consequence of combining scientometrics with geography (Garfield, 1986). Although "scientography" not a widely familiar term, possibly due to the proliferation of terms such as "domain visualization" or "information/knowledge visualization" that make reference to similar notions, in our opinion it is the most adequate term for describing the action and effect of drawing charts of scientific output.

And so scientography, by means of its product known as scientograms, has become a tool and method for the analysis of domains in the sense used by *Hjørland & Albrechtsen* (1995), consolidating the holistic and realistic focuses of this type of analysis. It is a tool in that it allows the generation of maps; and a method in that it facilitates the analysis of domains, by showing the structure and relations of the inherent elements represented. In a nutshell, scientography is a holistic tool for expressing the discourse of the scientific community it aspires to represent, reflecting with accuracy the intellectual consensus of researchers making up that community, on the basis of their own citations of scientific literature.

3.4 Scientography and Domain Analysis

Scientography can be considered a tool and method for the analysis of domains, supporting the holistic approach and the objective of this type of analysis. It is a tool in that it permits the construction of bibliometric maps, and it is a method because it facilitates domain analysis by showing in graphic form the structure and relationships of the elements represented in the domain. These maps reflect the bulk of opinions and viewpoints of the persons who make up the given community.

Scientography is also a holistic method for another reason: because it allows the domain to be analyzed in light of the community discourse; and it is an objective method because through it we are able to analyze the non-subjective structure, formed by the intellectual consensus of the component relations among its elements.

This synthesis between the tool-methodology and the holistic-objectivism of scientography is further strengthened by the use of social networks in the graphic representation of bibliometric maps. These make it possible to discover and demonstrate theories about the graphs themselves and, consequently, about the models they represent. This makes them highly useful for the formal representation of social relations, as well as for detecting and quantifying their structural properties. Researchers can, through them, discover otherwise hidden patterns and trends.

In the area of Documentation, the visualization of information by means of the graphic representation of social networks has become one of the main techniques with which to make manifest the intellectual relations and the structure of scientific knowledge. This new approach not only magnifies the possibilities of analysis of traditional domains, or of scientific disciplines; it also constitutes a key tool with which to study the interaction and evolution of science by means of the disciplines and specialities it embraces.

In summary, we can say that scientography – understood as the bibliometric mapping of social networks – is a tool and a method, which can be applied to reveal the explicit acknowledgment of some authors by others, and therefore the overall interactivity and evolution of any particular domain of study.

Springer
http://www.springer.com/978-3-540-69727-5

Visualizing the Structure of Science
Vargas-Quesada, B.; de Moya-Anegón, F.
2007, VIII, 312 p. 83 illus., Hardcover
ISBN: 978-3-540-69727-5