

- Uzzi B (1997) Social structure and competition in inter-firm networks: the paradox of embeddedness. *Adm Sci Q* 42(1):35–67
- Williamson O (1975) *Markets and hierarchies: analysis and antitrust implications*. Free Press, New York

---

## Interpersonal Networks

- ▶ [Intra-Organizational Networks](#)

---

## Interpersonal Relations

- ▶ [Origins of Social Network Analysis](#)

---

## Intra-Organizational Networks

Rafael Wittek  
Theoretical Sociology – Department of  
Sociology, University of Groningen, Groningen,  
The Netherlands

## Synonyms

[Company chart](#); [Informal network](#); [Informal organization](#); [Interpersonal networks](#); [Organizational blueprint](#); [Organizational grapevine](#); [Organizational social capital](#); [Prescribed versus emergent organizational structure](#)

## Glossary

**Formal Relation** Organizational members connected only through authority or workflow interdependence

**Informal Relation** Organizational members connected only through a personal tie without a formal relation

**Embedded Relation** Organizational members connected through both a formal and an informal relation

**Membership Relation** Organizational members who are part of the same unit, but not connected through a formal or an informal relation

## Definition

Intraorganizational networks are the aggregate of the formal and informal relationships between the members of an organization. Depending on the presence or absence of formal and informal elements in the tie between two members of the organization, four elementary types of intraorganizational relationships can be distinguished. Together they form the intraorganizational network.

*Formal relationships* can be based both on vertical authority relations between a hierarchical superior and a collaborator and on horizontal workflow interdependencies between peers. Formal “relations” are often documented in the organizational chart or blueprint. They define legitimate routes for interaction, advise, approval, and the transmission of information. The chart does not necessarily say much about the actual frequency or importance of the specific formal relationships.

*Informal relationships* in the narrowly defined sense are personal ties between members of the organization who are not connected through a formal relationship. Informal personal ties can be positive or negative and weak or strong, depending on the level of mutual expectations and obligations, the frequency of interaction, and the degree of multiplexity of their relation (a relation is multiplex if it consists of more than one dimension, e.g., friendship and the exchange of advice). Commonly studied informal relations are often categorized into “affective” (interpersonal trust, friendship) and “instrumental” (e.g., advice, communication) ties. More recent organizational network studies also pay attention to negative relations and “sour social capital,” like distrust, betrayal, mobbing, foes, and gossip.

*Embedded relations* consist of ties in which both parties are connected through both a formal and an informal relationship (e.g., a boss and his collaborator have a friendship relation).

Embedded relations can be consistent or inconsistent, depending on the degree to which the logic and objectives of the formal and the informal relation conflict with or mutually support each other (Soda and Zaheer 2012). For example, an embedded relation is inconsistent if functionally interdependent team members are also friends, and friendship norms lead to positively biased evaluations of the quality of each other's work.

Finally, even if they are not connected through a formal (authority or workflow interdependence), an informal, or an embedded relationship, employees can still be connected through a *membership relation*. Simply being part of the same organization subunit or (temporary) project can be highly relevant for how employees behave towards each other. Three types of membership relations can be distinguished. In a one-dimensional membership relation, employees perceive themselves as being part of one unit. In a multi-dimensional membership relation, employees are part of several units (e.g., a project group, a department, a committee). These units can overlap and/or be nested. Ambivalent membership relations emerge where boundaries between organizational (sub)units dilute, and/or formal membership criteria are subject to multiple interpretations (e.g., should interns or workers from temp agencies who join a team – often for considerable periods – be considered as members of the organization?).

Most research on intraorganizational networks focuses on the study of informal relationships and insufficiently specifies the formal or embedded context of the informal ties and has paid only scant attention to the role of membership relations.

## Introduction

Intraorganizational networks matter at three levels. For *individuals*, their personal network at work influences opportunities, perceptions, and behavior during all stages of their contact with the organization: from getting hired to getting promoted and getting fired and from

learning the tricks of the trade to getting ones job done. For *workgroups*, the structure of the informal network matters during all phases of the production process (input, throughput, and output). For example, it can be decisive in a workgroup's ability to coordinate, to sanction free riders, to prevent and solve conflicts, and to foster creativity and innovation. On the level of the *organization*, the configuration of formal and informal structures is a key element of its governance structure. Some even see "Network Forms of Organization" as a specific (new) organizational form, characterized by enduring exchange relations that "lack a legitimate organizational authority to arbitrate and resolve disputes that may arise during the exchange."

For each of these levels, a wide array of literatures and theories has emerged. There seems to be no subfield that did not try to incorporate social networks into their research agendas. Organizational behavior scholars, labor market researchers, decision theorists, to name but a few, study individual level effects of intraorganizational networks. Small-group researchers from all social science disciplines are interested in the antecedents, processes, and consequences of intraorganizational network structures. Economists and sociologists use theories of organizational governance to analyze under which conditions network organizations yield transaction cost advantages compared to other governance structures, in particular hierarchies and markets.

## Key Points

Intraorganizational networks are traditionally analyzed as "pipes" connecting organizational positions and their incumbents. The major mechanism is one of instrumental relationalism: the formation, change, and effects of networks are driven by purposeful social exchange, motivated by calculated investments in social capital, and governed by straightforward cost-benefit reasoning. An individual's network position determines his or her opportunities to have access to scarce material and immaterial resources – like information, resources, and social support.

The resulting level of social capital of individuals and workgroups, in turn, affects a large variety of outcomes, ranging from individual performance, career prospects, creativity, well-being, and job satisfaction to the innovativeness and flexibility of workgroups and organizations.

More recent approaches emphasize that intraorganizational ties also function as “prisms” through which individuals frame social expectations and obligations. The major mechanism is one of constructive relationalism: intra-organizational networks are the result of cognitively mediated functional interdependencies. This shifts the focus from social exchange of goods and services to the sustaining or hampering role of social ties for joint production. This approach endorses a more complex behavioral model, in which the cognitive activation of network perceptions, the institutional and cultural context, and relational signaling processes are important elements for modeling the emergence, dynamics, and effects of intraorganizational networks.

## Historical Background

The study of intraorganizational networks is strongly intertwined with four developments in the social sciences. First, the “discovery” of the informal organization is usually attributed to the so-called Hawthorne experiments, carried out in Western Electric’s Hawthorne plant between 1924 and 1932. In particular, sociometric data from the “bank wiring room experiments” showed the impact of informal ties on performance: independently of the formal structure, informal cliques emerged, developing and enforcing productivity restricting group norms to the point that the introduction of individual performance related pay even decreased performance. The Hawthorne studies marked a shift in perspective in organizational research from conceiving organizations as closed and rational systems – self-contained, pre-designed formal structures that functioned according to the principles of a rational bureaucracy – to seeing “the company behind the chart”: a natural and open system, with

emergent social relations, highly susceptible to outside influences and “nonrational” impulses affecting the perceptions, emotions, attitudes, and behavioral decisions of its members. The Hawthorne studies and what later should become known as the *Human Relations Approach* sensitized organization scholars not only to the importance of social relations, group membership, and identities but also to a more complex model of human nature than envisioned by the dominant closed rational system framework. Nevertheless, these theoretical developments had only marginal impact on the emerging field of intraorganizational social network studies.

Second, a major impulse came from organizational ethnographies, carried out in the tradition of the *Manchester School*. They combine the application of sociometric data collection techniques with an in-depth ethnographic case study approach which allows them to uncover not only relational patterns but also the norms, rules, and mechanisms behind social dynamics. Four early studies exemplify this approach. One of the first longitudinal intraorganizational network studies was carried out in a Canadian furniture retail sales store during the 1950s (French’s 1963). This descriptive study maps the friendship relations of 25 salesmen at three points in time, the negative relations at one point in time, and the pattern of (non)compliance to informal norms (“don’t snitch to management,” “don’t steal a regular customer from a colleague”), regulating the functional interdependencies among them. Kapferer’s (1969) research in a Zambian mine focused on the development and resolution of conflict among 15 workers. Sociometric information covered were conversation, joking, job assistance, cash assistance, and personal assistance. A “crisis in a cloister” is the focus of Sampson’s (1969) study of a conflict in a monastery, which resulted in the expulsion of four monks and the voluntary departure of many others. Retrospective sociometric information was collected for three time periods and a large variety of relations, including liking, dislike, and influence. Finally, Thurman (1979) studied 2 major disputes among 15 employees in the overseas office of a large international

corporation. The structure of the informal network helped explain the success and failure of “leveling coalitions” against the target of the conflict. A common thread in these and similar studies consists in the finding that organizational networks are often characterized by inconsistent embedded relationships in which informal and formal relations are at odds with each other.

The third early source inspiring intra-organizational network research was *Social Exchange Theory* and its application to small groups. Homans (1950) analyzed social ties in organizations as an exchange of social approval (“liking”) for compliance with group obligations, building (among others) on a reanalysis of the Hawthorne bank wiring room experiments, and his own sociometric study of the “cash posters” in the accounting division of a firm. In Blau’s (1955) influential sociometric study of two governmental tax agencies, civil servants exchange advice for deference and professional status. But despite the rich empirical insights produced by the early case studies in the tradition of the Manchester School and the strong explanatory potential of the emerging social exchange and human relations paradigms, intraorganizational network research stagnated during the 1960s to the 1980s. Reasons for this decline were the problem of getting access to organizations, the sensitive privacy issues related to sociometric surveys, which usually require that respondents disclose their identity to the researchers, and the limited ability to “generalize” from the findings of a single case study.

As a result, during the 1980s, the focus shifted towards the study of formal characteristics and structures of organizations (e.g., centralization, span of control, size) and to interorganizational networks (e.g., interlocking directorates), both of which can be more easily assessed through (publicly available) secondary data sources. The rise of transaction cost and institutional *theories of organizational governance* during the 1980s and 1990s also sparked some renewed interest for detailed ethnographic studies of intraorganizational networks, in particular for their role in processes of organizational control (Gargiulo 1993; Wittek et al. 2003).

## Intraorganizational Networks: Theories and Social Mechanisms

Intraorganizational network research always had a strong *structuralist legacy*, which assumes that the major determinants of human decision-making behavior, cognitions, or emotions are not their individual attributes, attitudes, or other psychological traits but their position in a social structure. Individuals in similar network positions are confronted with similar opportunities and constraints, which in turn trigger the same kind of individual perceptions, action opportunities, and responses. In these constraint-driven structuralist accounts, there already was little room for a more grounded behavioral theory and the problem of “agency.” The surge of new, powerful statistical parameters and algorithms, which allowed to detect positions in and “hidden” structural properties of networks, further reinforced this structuralist legacy during the 1970s.

Theories of action in the form of *instrumental relationalism* entered intra-organizational network research in the late 1980s (Jansen 2002) in the form of two milestone contributions, which still define the core of the widely applied *Social Capital Approach* (Flap and Völker 2012). Rational choice-based exchange theory suggests that network closure is beneficial for norm compliance and therefore for group performance, because it fosters social control. Ronald Burt’s (1992) *Structural Hole Theory* combines ideas from social exchange theory with structuralist theories of power, shifting the attention to the individual “network entrepreneur” who actively creates and strategically exploits structural opportunities as they emerge due to the absence of ties between his or her contacts. This framework emphasizes the disadvantages of network closure and the corresponding benefits of brokerage positions for individual achievement. Both the closure and the brokerage mechanism were frequently subjected to empirical tests.

During the 1990s, growing dissatisfaction with instrumental relationalism converged into the emergence of an alternative behavioral foundation, *relational constructivism* (Jansen 2002). It builds on a more complex model of human

nature than the thin version of rational choice theory that was at the core of instrumental relationalism. A key role is reserved for individual identities, institutional embeddedness, and the cognitive mediation of functional interdependencies. Rather than being simple “pipes” for the exchange of resources, social relations function as “prisms” (Podolny 2001) framing mutual expectations and obligations. *Relational Signaling Theory* (Lindenberg 2000) explicates the social mechanisms underlying the creation, maintenance, and decline of cooperative relations in organizations. It suggests that in settings with a high degree of functional interdependence, individuals will constantly screen each other’s actions for positive or negative relational signals, in order to assess whether the other party is still in a cooperative frame.

### Illustrative Examples

An empirical study of the impact of network positions on cognitions of 86 employees of a computer software firm (Walker 1985) illustrates a *structuralist mechanism*. In addition to the formal reporting relationship, respondents indicated, for each colleague, the frequency of “sending” and “receiving” eight different types of ties (feedback, problems, extra time, technical information, marketing information etc.). “Cognitions” reflected individual employee’s assessment of how strongly 31 different means (e.g., close contact with end user during the development phase) contributed to the accomplishment of four different types of product goals (performance, generativity, endurance, and coherence). Network positions were assessed through structural equivalence analyses. Two individuals are structurally equivalent if they have the same pattern of relations to similar others. Completely in line with structuralist reasoning, “network position was found to be a stronger and more stable predictor of differences in cognition than the type of function an individual had and the type of product worked on” (Walker 1985:103).

A longitudinal network study modeling the emergence of advice relationships among 57 employees of a Dutch Housing Corporation (Agnessens and Wittek 2012) illustrates the logic behind *instrumental relationalism*. The study reconstructs the assumptions between the social capital and the social status approach. Though both are rooted in a social exchange framework, their behavioral micro-foundations differ slightly, with competing hypotheses about the structure of the advice network being the result. For example, where the social capital approach predicts an overrepresentation of reciprocal dyadic relations and cyclical triadic relations, the social status approach predicts the opposite, i.e., an overrepresentation of nonreciprocal dyads and triads. The analysis yields partial support for both perspectives: overrepresentation of reciprocal relations at the dyad level (in line with the social capital approach) and overrepresentation of noncyclical triads (in line with the social status approach).

An ethnographic study on the escalation of informal conflict management in the management team of a German Paper Factory (Wittek et al. 2003) illustrates the logic behind *relational constructivism*. It uses data on 67 conflicts involving 22 managers, and 4 waves of sociometric information, covering a period of 3 years. Social escalation is defined as the involvement of one or more third parties in a conflict. Building on Lindenberg’s relational signaling theory, strong social ties are expected to foster de-escalation only as long as the organizational context sustains unambiguous exchange of positive relational signals. Multilevel analysis indeed confirms this – but the protective effect of strong ties disappears through time. The result is a decline in frame-stabilizing arrangements in the firm, reflected in a drastic decrease of the frequency of meetings, and a major organizational change through which acts that were previously considered as strong positive relational signals – like the provision of unsolicited advice – became ambiguous, since they could now also be interpreted as attempts to improve one’s status at the expense of other team members.



## Key Applications

The field of intraorganizational network studies meanwhile produced empirical studies on a large variety of topics, covering antecedents, dynamics, and outcomes of networks at the level of individuals, work-groups, and organizations.

Organizational networks can affect individuals during all phases of their contact with an organization. Job seekers with friends occupying a power position in a prospective employing firm are more likely to be hired. Once at work, friendship relations play an important role for the socialization of new colleagues into the culture of the organization and learning the tricks of the trade. A personal network with structural holes increases the chances for and speed of promotions for senior men (Burt 1992). Ties to powerful members in the organization increase the success in salary negotiations, particularly for minorities. Strong ties to colleagues who are satisfied with their job increase the likelihood of being satisfied with one's own job (Agneessens and Wittek 2008), and consistent embedded relations increase individual performance (Soda and Zaheer 2012). One's friends are also targets for organizational voice (Pauksztat et al. 2011). Being tied to popular others in the organization protects from becoming the object of negative gossip (Ellwardt et al. 2012). Finally, employees who are only weakly embedded into the informal network of the organization are more likely to leave and those who see their friends leave, also are more likely to leave the organization themselves (Krackhardt and Porter 1985).

At the level of workgroups and organizations, intraorganizational networks play a role during all processes related to the input, throughput, and output. On the input side, the structure of the informal network influences outside information seeking. With regard to throughput, a study of a multinational electronics company showed that frequent contact between product development units increases shared knowledge, which in turn speeds up projects (Hansen 2002). Finally, a major concern of intraorganizational network research has always been the relationship

between networks structure and output measures like workgroup performance. A meta-analysis indeed reports a positive relationship between the density of intraorganizational networks and team performance (Balkundi and Harrison 2006).

## Future Directions

Of the many developments at the current frontier of the field, three are particularly noteworthy. First, considerable progress can still be made with regard to *theory formation*. Many assumptions, mechanisms, and implications of key hypotheses are still insufficiently explicated, and formal analysis can yield interesting clarifications. This holds for theorizing in both the instrumental and constructivist traditions.

In the instrumentalist branch, game theoretical analyses of the cohesion-performance mechanism (Flache and Macy 1996) have demonstrated that dense informal networks of strong ties may *reduce* rather than increase team performance, if one assumes that team members do not only exchange social approval for contributions to group production – as envisioned in the standard account of instrumental relationalism – but might also end up in an unproductive exchange of approval for approval. Similarly, a formal model of what happens “if everyone strives for structural holes” shows that in the long run, stable networks will distribute benefits equally – implying that network entrepreneurs will not be able to sustain their structural advantage (Buskens and van de Rijt 2008). Despite some progress, the study of network games and their potential implications for organizations is still in its infancy.

In the constructivist branch, at least two promising developments can be discerned. The first one relates to multilevel networks. Though intraorganizational networks are multilevel by nature, it is only recently that they are subject to systematic theorizing and empirical testing as well as to statistical modeling (Lazega et al. 2008). The second one explicates the role of cultural consensus and cognitive social

structures for network processes (Krackhardt and Kilduff 2002). These efforts benefit from combining insights from cultural theory and cognitive psychology. For example, Ma et al. (2011) show that national cultural contexts moderate the effect of social network structures on opportunity recognition, with structural holes increasing opportunity recognition in individualistic cultures, but decreasing it in collectivistic cultures. Investigating the impact of job threat, another study shows that someone's status affects which parts of the network are cognitively activated in his or her mind (Smith et al. 2012). Low status individuals were found to activate smaller subsections of their network than high status individuals. Cognitive activation of network perceptions is likely to be influenced by unconscious and biologically based "honest signaling" mechanisms, as is demonstrated by an emerging area of research using modern information technology ("sociometric badges") to detect and analyze signaling content of verbal communication (Pentland 2008).

Second, statistical models for the analysis of *social network dynamics* will continue to have a strong impact on the development of intraorganizational network research. Though questions about the origins of intraorganizational structures are fundamental to the field, the theoretical and methodological tools to answer them are relatively recent. Examples for the former are studies on the origins of structural holes (Zaheer and Soda 2009) and the stability of brokerage positions (Wittek 2001). Stochastic actor-oriented models (Snijders 2001) have already been successfully applied by intraorganizational network researchers to disentangle selection and influence effects (e.g., Agneessens and Wittek 2008) as well as the coevolution of multiple relations (e.g., friendship choices and the allocation of power reputations, Labun 2012). New techniques enabling to model the dynamics of events in social networks will further extend the range of possible applications for the analysis of network dynamics.

A final challenge remains the development and design of *network interventions*: "purposeful efforts to use social networks

or social network data to generate social influence, accelerate behavior change, improve performance and/or achieve desirable outcomes among individuals, communities, organizations, or populations" (Valente 2012:49). Such interventions can take at least four different forms (Valente 2012): identification of individuals (e.g., change agents) based on some network property; "segmentation," i.e., identifying groups of people whose behavior is to be changed at the same time (e.g., detecting core members of a network); "induction," i.e., stimulating peer-to-peer diffusion of information or behavior; and "alteration," i.e., changing the network by adding or removing actors and/or their relationships or changing the content of the ties. An example for an alteration intervention is a study in a call center of a large bank, where company policy required workgroup members to schedule non-overlapping breaks (Waber et al. 2010). After a change in the structure of the breaks that allowed for more overlap, the social cohesion of the teams increased significantly. Though the power of such network interventions is widely recognized by managers and organizational consultants, controlled experiments that would validate the effectiveness of network interventions are still rare. This is understandable, given the obvious limitations of carrying out such real life experiments in the field. Given such limitations, it is understandable that researchers search low cost and low effort substitutes for in-depth sociometric field experiments and longitudinal intraorganizational network studies. As a result, there is a big temptation to consider the huge amount of intraorganizational relational data that is currently produced through online communication as a substitute for more traditional forms of intraorganizational network research. In combination with modern data mining techniques, this kind of data certainly has the potential to produce useful new insights. However, the strongest potential for generating new insights almost certainly lies in the application of theory-guided multi-method research designs, which allow to adequately assess the role of organizational context which will always remain a major driver behind any intraorganizational network process.

## Cross-References

- ▶ [Economic Network Analysis Based on Infection Models](#)
- ▶ [Futures of Social Networks: Where Are Trends Heading?](#)
- ▶ [Inter-organizational Networks](#)
- ▶ [Managerial Networks](#)
- ▶ [Siena: Statistical Modeling of Longitudinal Network Data](#)
- ▶ [Social Capital](#)
- ▶ [Social Interaction Analysis for Team Collaboration](#)
- ▶ [Structural Holes](#)
- ▶ [Trust in Social Networks](#)

## References

- Agneessens F, Wittek R (2008) Social capital and employee well-being: disentangling intrapersonal and interpersonal selection and influence mechanisms. *Rev Fr Sociol* 49(3):613–637
- Agneessens F, Wittek R (2012) Where do intra-organizational advice relations come from? The role of informal status and social capital in social exchange. *Soc Netw* 34:333–345
- Balkundi P, Harrison D (2006) Ties, leaders, and time in teams: strong inference about network structure's effects on team viability and performance. *Acad Manag J* 49(1):49–68
- Blau PM (1955) *The dynamics of bureaucracy: a study of interpersonal relations in two government agencies*. The University of Chicago Press, Chicago
- Burt R (1992) *Structural holes*. Harvard University Press, Cambridge
- Buskens V, van de Rijdt A (2008) Dynamics of networks if everyone strives for structural holes. *Am J Sociol* 114(2):371–407
- Ellwardt L, Labianca J, Wittek R (2012) Who are the objects of positive and negative gossip at work? A social network perspective on workplace gossip. *Soc Netw* 34:193–205
- Flache A, Macy MW (1996) The weakness of strong ties: collective action failure in a highly cohesive group\*. *J Math Sociol* 21(1–2):3–28
- Flap H, Völker B (2012) Social capital. In: Wittek R, Snijders TAB, Nee V (eds) *Handbook of rational choice social research*. Stanford University Press, Palo Alto
- French C (1963) Some structural aspects of a retail sales group. *Hum Organ* XXII:146–151
- Gargiulo M (1993) Two step leverage: managing constraint in organizational politics. *Adm Sci Q* 38(1):1–19
- Hansen MT (2002) Knowledge networks: explaining effective knowledge sharing in multiunit companies. *Organ Sci* 13(3):232–248
- Homans GC (1950) *The human group*. Harcourt, Brace, New York
- Jansen D (2002) *Netzwerkansätze in der Organisationsforschung*. Kölner Zeitschrift für Soziologie und Sozialpsychologie, Sonderheft 42:88–118
- Kapferer B (1969) Norms and the manipulation of relationships in a work context. In: Mitchell J (ed) *Social networks in urban situations*. Manchester University Press, Manchester
- Krackhardt D, Kilduff M (2002) Structure, culture and Simmelian ties in entrepreneurial firms. *Soc Netw* 24(3):279–290
- Krackhardt D, Porter L (1985) When friends leave: a structural analysis of the relationship between turnover and stayers' attitudes. *Adm Sci Q* 30:242–261
- Labun A (2012) *Social networks and informal power in organizations*. ICS Dissertation series 194, Groningen
- Lazega E, Jourda M, Mounier L, Stofer R (2008) Catching up with big fish in the big pond? Multi-level network analysis through linked design. *Soc Netw* 30(2):159–176
- Lindenberg S (2000) It takes both trust and lack of mistrust: the workings of cooperation and relational signaling in contractual relationships. *J Manag Gov* 4:11–33
- Ma R, Huang YC, Shenkar O (2011) Social networks and opportunity recognition: a cultural comparison between Taiwan and the United States. *Strateg Manage J* 32(11):1183–1205
- Pauksztat B, Steglich C, Wittek R (2011) Who speaks up to whom? A relational approach to employee voice. *Soc Netw* 33(4):303–316
- Pentland AS (2008) *Honest signals*. MIT, Boston
- Podolny J (2001) Networks as pipes and prisms of the market. *Am J Sociol* 107(1):33–60
- Sampson SF (1969) *Crisis in a cloister*. Ph.D. dissertation, Cornell University. University Microfilms #69–5775. Ann Arbor Science Publishers, Ann Arbor
- Smith EB, Menon T, Thompson L (2012) Status differences in the cognitive activation of social networks. *Organ Sci* 23(1):67–82
- Snijders TA (2001) The statistical evaluation of social network dynamics. *Sociol Methodol* 31(1):361–395
- Soda G, Zaheer A (2012) A network perspective on organizational architecture: performance effects of the interplay of formal and informal organization. *Strateg Manag J* 33(6):751–771
- Thurman B (1979) In the office: networks and coalitions. *Soc Netw* 2:47–63
- Valente TW (2012) Network interventions. *Science* 337(6090):49–53



- Waber BN, Olguin Olguin D, Kim T, Pentland A (2010) Productivity through coffee breaks: changing social networks by changing break structure. Available at SSRN: <http://ssrn.com/abstract=1586375> or <http://dx.doi.org/10.2139/ssrn.1586375>
- Walker G (1985) Network position and cognition in a computer software firm. *Adm Sci Q* 30(1):103–130
- Wittek R (2001) Mimetic trust and intra-organizational network dynamics. *J Math Sociol* 25(1):109–138
- Wittek R, van Duijn M, Snijders TAB (2003) Frame decay, informal power and the escalation of social control in a management team: a relational signaling perspective. *Res Sociol Organ* 20:355–380
- Zaheer A, Soda G (2009) Network evolution: the origins of structural holes. *Adm Sci Quart* 54(1):1–31

---

## Intrusion Detection

- ▶ [Network Anomaly Detection Using Co-clustering](#)

---

## Inventor Networks

- ▶ [Innovator Networks](#)

---

## Invertible (Nonsingular) Matrices

- ▶ [Matrix Algebra, Basics of](#)

---

## Invisible Web

- ▶ [Pornography Online](#)

---

## ISO/IEC 10646: The Universal Character Set

- ▶ [Unicode](#)

---

## Iterative Classification

- ▶ [Collective Classification](#)

---

## Iterative Methods for Eigenvalues/Eigenvectors

Raymond H. Chan<sup>1</sup>, Yuyang Qiu<sup>2</sup>, and Guojian Yin<sup>1</sup>

<sup>1</sup>Department of Mathematics, The Chinese University of Hong Kong, Shatin, NT,

Hong Kong SAR, People's Republic of China

<sup>2</sup>College of Statistics and Mathematics, Zhejiang Gongshang University, Hangzhou, People's Republic of China

## Synonyms

[Eigenvalue and eigenvector – characteristic value and characteristic vector](#); [Eigenvalue with the largest magnitude – dominant eigenvalue](#); [Nonsingular – invertible](#); [Vertex – node](#)

## Glossary

**Eigenvalue/Eigenvector** The fundamental entities that characterize any given matrix and can be obtained by finding the roots of the characteristic polynomial of the matrix or by iterative methods

**Social Network Analysis** A research area in social and behavioral sciences that uses networks to represent and hence analyze social phenomena

**Iterative Method** A procedure for solving a problem by generating a sequence of improving approximations to the true solution of the given problem

## Definition

Eigenvalues and eigenvectors are fundamental concepts in linear algebra (Golub and Van Loan 2012; Golub and Vorst 2000) and are defined as follows:

**Definition 1** *Let  $A$  be an  $n$ -by- $n$  real matrix (i.e., in  $\mathbb{R}^{n \times n}$ ). If there exist a scalar  $\lambda \in \mathbb{C}$  and a nonzero vector  $\mathbf{x} \in \mathbb{C}^n$  such that*