The «Swiss Alpine Conservation Movement» (1980–2005): Possibilities and Limitations of a Two-Mode Network

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Abstract

This paper makes the case for using two-mode networks, and participation networks in particular, as a valuable tool for historical network analysis (HNA). In two-mode networks, the historical source material is presented in adequate detail while allowing for a more accurate handling of the empirical complexity. The projection into one-mode networks enhances the use of HNA as a heuristic tool. In this paper, the possibilities and limitations of two-mode networks and their relative projection are illustrated by a case study of the Swiss Alpine conservation movement. The Swiss Alpine conservation movement was a social movement that arose in Switzerland in the 1980s. The movement successfully opposed the increasing transit traffic of the European Community and the negative impact of this traffic on the Swiss population and the natural Alpine environment.

Historical network analysis (HNA) has become an essential method in Digital History and Digital Humanities.[1] HNA borrows concepts, methods, and basic premises from the social sciences.[2] The interest of historical and social network analysis (SNA) is quite similar: They focus on the relationship between individuals and their surrounding structure, with social relationships viewed as building blocks of the social world.[3] SNA explores the relationships between social actors through the empirical collection of information and the application of mathematical computations. In addition, these findings can be visualized using network graphs consisting of «nodes» (i.e. actors, or more general, entities) connected by «edges» (i.e. relations), commonly depicted as circles and lines. These models of social relations, nowadays created by computer software, are the result of statistical calculations and algorithms.

Social interactions, relationships, and research questions about them tend to be quite complex. In SNA, researchers use models of different levels of complexity to map these social relations. The basic type of network is a one-mode

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2 On Digital Humanities and the productive use of networks, see: Fotis Jannidis, Hubertus Kohle, Malte Rehbein (eds.), Digital Humanities. Eine Einführung, Stuttgart 2017, esp. pp. 147–161.

3 Martin Düring, Linda von Keyserlingk, Netzwerkanalyse in den Geschichtswissenschaften. Historische Netzwerkanalyse als Methode für die Erforschung von historischen Prozessen, in: Rainer Schützeichel, Stefan Jordan (eds.), Prozesse. Formen, Dynamiken, Erklärungen, Wiesbaden 2015, pp. 337–350, here: p. 338.

Figure 1: Network types: one-mode network (left), two-mode network (right); grey: person, light grey: event/social club.

network displaying one type of node and one type of edge. For example, the network in *Figure 1, left*, shows a relationship – friendship, kinship, or correspondence – between person A and person B. For more complex social situations, multi-mode networks, amongst them, two-mode networks – which will be discussed in this paper – can be used. As the name suggests, two-mode networks consist of two types of nodes. Edges only connect nodes of different types.[4] Two-mode networks are also referred to as bipartite, bimodal, or affiliation networks. For example, the network in *Figure 1, right*, shows person A and person B attending the same event or them being part of the same social club (symbolized by the light grey node). Thus, person A and person B are indirectly connected.

Two-mode networks have a long tradition in social network analysis and have become quite common in historical studies.[5] The basic assumption is that being in the same places or sharing common frameworks of interaction, enables the formation of social ties.[6] Studies in social sciences usually focus on the affiliation of actors to associations, extracting relational data from affiliation or participation lists, or on actor-event relationships such as co-authorship and citation networks. One prevalent use of two-mode networks in historical network analysis similarly relates persons to texts, as in Aline Deicke's study of polemical pamphlets during the Reformation.[7] Studies of connections between persons and places are also common,[8] for example Kaiser et al.'s investigation of artist migra-

4 For an introduction to two-mode networks, see: Albert-László Barabási, Network Science, Cambridge 2016, section 2.7 «Bipartite Networks» networksciencebook.com/chapter/2#bipartite-networks.

5 Allison Davis, Burleigh B. Gardner, Mary R. Gardner, Deep South. A Social Anthropological Study of Caste and Class, Chicago 1941 is commonly cited as a pioneering study. However, Dickison, Magnani, and Rossi, argue that the idea of different types of nodes is anticipated in a 1934 study by Jacob Levy Moreno. Mark E. Dickison, Matteo Magnani, Luca Rossi, Multilayer Social Networks, Cambridge 2016, p. 24.

6 Alexander Rausch, Bimodale Netzwerke, in: Christian Stegbauer, Roger Häußling (eds.), Handbuch Netzwerkforschung, Wiesbaden 2010, pp. 421–432, here: p. 421.

7 Aline J. E. Deicke, Networks of Conflict: Analyzing the 'Culture of Controversy' in Polemical Pamphlets of Intra-Protestant Disputes (1548–1580), in: Journal of Historical Network Research 1 (2017), pp. 71–105.

8 In archaeology, two-mode networks are used to connect objects to the place they are found. For an overview of archaeological network analysis, see: Anna Collar, Fiona Coward, Tom Brughmans, Barbara Mills, Networks in Archaeology. Phenomena, Abstraction, Representation, in: Journal of Archaeological Method and Theory 22/1 (2015), pp. 1–32.

tion in Austria.[9] The affiliation of persons to organizations presents another valuable use for two-mode network analysis, as in Henrike Rudolph's exploration of female activists' biographies in twentieth-century China or Ceserani et al.'s study of British architects in eighteenth-century Italy.[10] Similarly, this paper focuses on people's participation in events or the relation of persons to events. Multi-mode networks have also found their way into historical network research, as in Ingeborg van Vugt's analysis of books in the Republic of Letters, which maps senders, receivers, letters, cited books, authors, subjects, and languages.[11]

While two-mode networks offer numerous possibilities for historical research, they also come with limitations. The calculation of the standard network metrics (statistical computations to measure social interaction) was developed for one-mode networks and cannot simply be adopted. Social network research is currently dealing with problems arising from two-mode networks, but network analysis software used by historians does not yet include the newest calculation methods. There is, however, a commonly used workaround: network projection. Thereby, a two-mode network is converted – «projected» – into (two) one-mode networks. While two-mode networks represent an indirect connection between nodes of the same type, one-mode networks draw models of direct connection. In our example: Instead of person A and person B being participants in the same event (two-mode network), they are now modeled as actually meeting at the event (one-mode network).

Although this projection is easy to accomplish with the help of adequate software, the interpretation of its outcome is complex. Can we presume direct contact between different people at an event? How do we interpret this uncertainty as historians? While two-mode networks are complex models of historical sources, projections of these networks represent a more simplified picture – but offer the whole range of network metrics. So is coding data for a two-mode network worthwhile when it needs to be projected for statistical analysis? Is there more to learn from the process of network projection? Why choose a two-mode

9 Maximilian Kaiser, Matthias Schlögl, Katalin Lejtovicz, Peter Alexander Rumpolt, Artist Migration through the Biographer's Lens. A Case Study Based on Biographical Data Retrieved from the Austrian Biographical Dictionary, in: Journal of Historical Network Research 2 (2018), pp. 76–108.

10 Henrike Rudolph, Structures of Empowerment. A Network Exploration of Women Activists' Collective Biographies in Twentieth-Century China, in: Cécile Armand, Christian Henriot, Huei-min Sun (eds.), Knowledge, Power, and Networks. Elites in Transition in Modern China, Leiden 2022 [forthcoming]; Giovanna Ceserani, Giorgio Caviglia, Nicole Coleman, Thea de Armond, Sara Murray, Molly Taylor-Polesky, British Travelers in Eighteenth-Century Italy. The Grand Tour and the Profession of Architecture, in: American Historical Forum 122/2 (2017), pp. 425–450.

11 Ingeborg van Vugt, The Structure and Dynamics of Scholarly Networks between the Dutch Republic and the Grand Duchy of Tuscany in the 17th Century, PhD thesis, University of Amsterdam 2019.

network for analysis? To put it simply: What are the possibilities and limitations of two-mode networks?

This paper discusses the comparison of both modes of networks as a heuristic tool for historians. We advocate that HNA benefits from the combined analysis of two-mode networks and their corresponding one-mode projections. Historians interested in both qualitative and quantitative methods must determine how these different modes of networks best complement each other with respect to their specific research interests. Our aim here is to share the insights we have gained during the research project «Issues with Europe: A Network Analysis of the German-Speaking Alpine Conservation Movement (1975–2005)». In the course of the project, we applied HNA not as an end to itself, but as a useful expansion of the historiographical methodological framework.[12] Our reflections may be useful to other researchers dealing with similar primary sources, namely participation records.

The structure of the article is as follows: The following part gives the historical context of the research object, the Swiss Alpine conservation movement. Drawing from an empirical analysis of this topic, the article discusses in the next section the possibilities and limitations of two-mode networks for historical network research. In the conclusion, the results are summarized and implications for further research are discussed.

Case Study: The Swiss Alpine Conservation Movement

The source material for our case study was based on archival material from the Swiss Alpine conservation movement, a social movement formed in the 1980s against traffic development in the Alps. The Alps represent a geographical boundary, but not an insurmountable border within the European continent.[13] Since the early modern period, warlords, travelers, and traders successfully conquered the natural mountain barrier.[14] At the end of the nineteenth-century efforts to ease transit across the Alps were accelerated, supported by technological progress, notably railways. The first important railway tunnel across

12 The project analyzes the disputes over European Alpine transit policy from the 1970s to the 2000s, with a comparative focus on Austria and Switzerland and a detailed analysis of the European level. For more information visit the project's website: https://www.uibk.ac.at/projects/issues-with-europe/index.html.en; For the Swiss case study, which provided the empirical base for this paper, see: Romed Aschwanden, Politisierung der Alpen. Umweltbewegungen in der Ära der Europäischen Integration (1970–2000), Köln 2021.

13 Jean-François Bergier, Des Alpes traversées aux Alpes vécues, in: Histoire des Alpes – Storia delle Alpi – Geschichte der Alpen 1 (1996), pp. 11–21.

14 Reto Furter, Transitverkehr in den Alpen. Einige Mengenangaben, in: Wege und Geschichte 2 (2007), pp. 18–23; Jon Mathieu, The Alps. An Environmental History, Medford 2019.

the Alps, the *Mont-Cenis* or *Fréjus Tunnel*, opened in 1871.[15] Other large-scale Alpine transit infrastructures, such as the *Gotthard Tunnel* (1882) or the *Lötschberg Bergstrecke* (1913), soon followed and trans-Alpine traffic, spurred by trade and tourism, continued to increase ever since.

In the second half of the twentieth-century, traffic additionally increased through the construction of automobile infrastructure, namely Alpine highways and their corresponding tunnels. After more than twenty years of economic growth since World War II, Switzerland completed its new highway route through the Alps. The *Gotthard* Road Tunnel between Göschenen and Airolo was opened in 1980. The new tunnel and highway were heralded as being of great European importance.[16] A similar development took place in Austria, where the *Brenner* Highway from Innsbruck (Austria) to Brixen (Italy) was finished in 1972. At the time it was presented as an infrastructure to overcome state borders, to expedite the integration of Europe, and to guarantee a peaceful and prosperous future.[17] Both highways transversing the Alps were of central importance to the European transport network and thus for the European economy.[18] The European Communities likewise embraced the new infrastructures, which eased the vital traffic and trade between the northern and southern parts of the continent.[19]

While these projects received international praise, the local population began to suffer from the effects of the highway system. Constant noise, air pollution, and the destruction of the pristine Alpine landscape were among the chief complaints. In Austria, Italy, and Switzerland citizen initiatives and coalitions for action were formed along the transit routes in opposition to the growing traffic and in order to protect public health and conserve Alpine nature.[20] These groups – among them the *ARGE Lebensraum Tirol* (1985), the *Dachverband für Natur- und Umweltschutz in Südtirol* (1982), and the *Alpen-Initiative in Switzerland* (1989) – strove for political participation, organized protest campaigns, attract-

15 Asciano Schneider, Gebirgsbahnen Europas, Zürich 1967.

16 Anon., Gotthard-Strassentunnel eröffnet. Würdigung eines Kommunikationsereignisses, in: Neue Zürcher Zeitung, 7. September 1980.

17 Magdalena Pernold, Die Brennerautobahn als Infrastruktur für Verkehr und Transit. Zur Entgrenzung geografischer Verkehrsräume im Zeitraum ihrer Realisierung, in: Geschichte und Region 25/2 (2016), pp. 64–81, here: p. 67.

18 Frank Schipper, Johan W. Schot, Infrastructural Europeanism, or the Project of Building Europe on Infrastructures. An Introduction, in: History and Technology 27/3 (2011), pp. 245–264; Per Högselius, Arne Kaijser, Erik van der Vleuten, Europe's Infrastructure Transition. Economy, War, Nature, Basingstoke 2015.

19 Christoph Stadel, The Brenner Freeway (Austria–Italy): Mountain Highway of Controversy, in: Mountain Research and Development 13/1 (1993), pp. 1–17, here: p. 2 f.

20 For the impact of transit and social resistance on Alpine conservation, see: Romed Aschwanden, Maria Buck, Patrick Kupper, Kira J. Schmidt, Moving Mountains. The Protection of the Alps, in: Anna-Katharina Wöbse, Patrick Kupper (eds.), Greening Europe. Environmental Protection in the Long Twentieth Century – A Handbook, Berlin, Boston 2021, pp. 217–242.

ed media attention, and collaborated transnationally.[21] The emergence of such movements in the Alps corresponded with the global rise of the environmental movement and debates about limited planetary resources since the 1970s.[22]

Focusing on the Swiss case, our research applied a bottom-up perspective to explore the citizen initiatives of what we call the Swiss Alpine conservation movement. Following Dieter Rucht's definition of social movements, we define the Swiss Alpine conservation movement as a network of individuals, groups, and organizations that, based on a collective identity, tried to bring about fundamental social change in the Alps through public protest.[23] The movement coalesces only after 1989. Before 1989 different local Alpine conservation movements are discernible, but with hardly any connections and exchanges between them.[24]

Historical network analysis has proven a promising method to analyze social movements in general.[25] In our study, we used HNA to examine the complex interplay between societal and political actors and to trace social and organizational ties across group boundaries and decision-making levels. As part of a mixed-methods approach that goes beyond traditional qualitative historical research, quantitative HNA was used as a tool to develop further research questions for qualitative historical analysis.[26] We started by developing a relational database based on extensive archival research.[27] The archives of the *Alpen-Initia-*

21 The scope and forms of resistance varied for each group, region, and political system.

22 John McCormick, Reclaiming Paradise. The Global Environmental Movement, Bloomington 1989.

23 Dieter Rucht, Modernisierung und neue soziale Bewegungen. Deutschland, Frankreich und USA im Vergleich, Frankfurt a. M., New York 1994, p. 76.

24 Romed Aschwanden, «Für eine Opposition in den Alpen». Transnationale Dimensionen des Widerstands gegen den Transitverkehr durch die Alpen in den 1990er Jahren, in: Histoire des Alpes – Storia delle Alpi – Geschichte der Alpen 23 (2018), pp. 259–273, here: p. 260 f.

25 Jens Aderhold, Soziale Bewegungen und die Bedeutung sozialer Netzwerke, in: Christian Stegbauer, Roger Häussling (eds.), Handbuch Netzwerkforschung, Wiesbaden 2010, pp. 739–753, here: p. 739. For a similar approach, see: Rachel Stevenson, Nick Crossley, Change in Covert Social Movement Networks. The 'Inner Circle' of the Provisional Irish Republican Army, in: Social Movement Studies 13/1 (2014), pp. 70–91.

26 Marten Düring, Verdeckte soziale Netzwerke im Nationalsozialismus. Die Entstehung und Arbeitsweise von Berliner Hilfsnetzwerken für verfolgte Juden, Berlin 2015, pp. 66–73. Ulrich Eumann points out the different viewpoint that HNA offers on the primary sources and the confusion («*Wahrnehmungsirritation*») that is sometimes caused by the visualized network: Ulrich Eumann, Heuristik. Hypothesenentwicklung und Hypothesentest, in: Marten Düring, Ulrich Eumann, Martin Stark, Linda von Keyserlingk (eds.), Handbuch Historische Netzwerkforschung. Grundlagen und Anwendungen, Münster 2016, pp. 123–138, here: p. 129.

27 Various database and visualization software was tested during this research project. Eventually, the tool Nodegoat was chosen for managing the database and Gephi for visualizations and network metrics. On Nodegoat, see: Pim van Bree, Geert Kessels, nodegoat. a web-based data management, network analysis & visualisation environment, http://nodegoat.net from LAB1100 http://lab1100.com, 2013 (07.09.2021); on Gephi, see: Mathieu Bastian, Sebastian Heymann, Mathieu Jacomy, Gephi. An

tive, *Initiative Transport Europe*, *Mountain Wilderness Switzerland*, and the *Oberwalliser Gruppe Umwelt und Verkehr* all hold vast records of meetings over a time span of about twenty years.[28] These serial sources lend themselves well to network analysis as they provide high consistency of data over a long period and thus allow for quantitative analysis.[29] For the qualitative part of the analysis, the research corpus was supplemented by additional sources, for example from the Swiss federal government.[30]

The basis of the relational database (on which the HNA is built) was an entity-relationship model (ERM). This first conceptual step of data modeling specifies how the (historical) facts and processes are to be encoded: it defines entities, the relations between the entities, and possible entity attributes.[31] In our ERM, the defined entities were persons and events. Constructing the network, persons and events became nodes, and the edges *ipso facto* represented the participation of persons in these events. As edges exist only between different types of nodes, no direct relations between persons were established. A broad definition of «event» encompassed regular meetings, small gatherings, or one-off conferences. Following the project's research interests, all event-nodes were provided with the following attributes: date (start, end), location (street/place), and social field (field).[32] The social field («social movement», «science», «politics») was assigned based on the field in which the organizers worked. For example, conferences organized by the CIPRA were categorized as expert events, meetings of the *Alpen-Initiative* as social-movement events (*Figure 2*).[33] Person-nodes were not

Open Source Software for Exploring and Manipulating Networks, in: International AAAI Conference on Weblogs and Social Media, 2009.

28 These five organizations were selected as representative examples of Alpine conservation in Switzerland.

29 André Mach, Thomas David, Stéphanie Ginalski, Felix Bühlmann (übers. Adrian Zimmermann), Schweizer Wirtschaftseliten 1910–2010, Baden 2017. On the difficulties of historical network research and all quantitative methods in history, see: Claire Lemercier, Claire Zalc, Méthodes quantitatives pour l'historien, Paris 2008, pp. 19–47.

30 It was necessary to expand from a realist definition of the network to a nominalist one. For «nominalist» and «realist» definitions of networks, see: Mario Diani, Green Networks. A Structural Analysis of the Italian Environmental Movement, Edinburgh 1995, p. 7.

31 Fotis Jannidis, Grundlagen der Datenmodellierung, in: Jannidis, Kohle, Rehbein, Digital Humanities, pp. 99–108, here: p. 103.

32 Date stamping also makes it possible to construct a temporal network and explore development over time.

33 The *Commission Internationale pour la Protection des Régions Alpines* (CIPRA) was founded in 1952 in St. Gallen (Switzerland) by members of the International Union for the Protection of Nature (IUPN, today IUCN). The CIPRA started as a transnational expert organization mainly concerned with traditional conservation issues such as the protection of iconic landscapes. During the 1980s, it underwent a transition into a highly recognized organization on a European level, calling for a more encompassing view of the Alpine environment that included economic activity and the specific cultural heritage of the region. See: CIPRA International (eds.), 50 Jahre CIPRA, in: CIPRA info 64 (2002). The *Alpen-Initiative* was a Swiss group of left and green activists from the Alpine regions

Name	Start	End	Street_Place	Field
CIPRA Jahresfachtagung	1991	1991	Château-d'Oex (CH)	ExpertInnen
"Schwimmen gegen Europas Strom"	1991	1991	Maloja (CH)	Bewegung
3. Informationssitzung AG Alpenkonvention CH	23-11-1990	23-11-1990	Bern (CH)	Politik
2. Tagung Arbeitsgruppe Hoher Beamter für die Alpenkonvention	05-09-1990	05-09-1990	Vienna (AT)	Politik
2. Informationssitzung AG Alpenkonvention CH	10-08-1990	10-08-1990	Bern (CH)	Politik
OGUV Vorstand	11-06-1990	11-06-1990	Brig (CH)	Bewegung
1. Tagung Arbeitsgruppe Hoher Beamter für die Alpenkonvention	31-05-1990	31-05-1990	Vienna (AT)	Politik

Figure 2: Screenshot taken from the nodegoat database showing the «event» nodes.

provided with any attributes, as the sources provided only little personal information about the participants.

Based on this dataset, we constructed an undirected, unweighted, two-mode network.[34] The network of the Swiss Alpine conservation movement from 1980 to 2005 consists of 2'360 nodes (2'035 persons and 325 events) and 5'104 edges (*Figure 3*).

Two-Mode Networks: Possibilities and Limitations in Historical Research

In general, «events» offer extensive opportunities for historical network research. Most events produce primary sources which may find their way into archives.[35] Even correspondence about invitations and cancellations or media

Grison, Uri, and Valais formed in 1989. It launched a popular initiative to protect the Swiss Alpine regions from the growing trans-Alpine transport of goods, which – against all predictions – was passed by Swiss voters in February 1994. See: Aschwanden, «Opposition».

34 We deliberately chose «constructed» instead of the commonly used «reconstructed». The network(s) generated from data collection cannot claim to reconstruct a past reality. Due to the level of abstraction, the incompleteness of the data, and presuppositions made e. g. about the boundaries of the network, the network works more like a model – a tool for the historian. For the use of networks as models, see: Fotis Jannidis, Netzwerke, in: Jannidis, Kohle, Rehbein, Digital Humanities, pp. 147–161, here: p. 160. For how historical theory deals with (re-)constructing the past, see: Chris Lorenz, Konstruktion der Vergangenheit. Eine Einführung in die Geschichtstheorie, Köln 1997; Horst Walter Blanke, Historik, in: Stefan Jordan (eds.), Grundbegriffe der Geschichtswissenschaft, Stuttgart 2001, pp. 148–151.

35 On the difference between HNA and SNA and the role of the archive, see: Claire Lemercier, Formale Methoden der Netzwerkanalyse in den Geschichtswissenschaften. Warum und Wie?, in: Österreichische Zeitschrift für Geschichtswissenschaft 23/1 (2012), pp. 16–41; Daniel Reupke, Claudia Volk, Von der Akte zum Netzwerk. Erfahrungsbericht aus der Werkstatt des Historikers, in: Michael Schönhuth et al. (eds.), Visuelle Netzwerkforschung. Qualitative, quantitative und partizipative Zugänge, Bielefeld 2013, pp. 297–316.

Figure 3: The Swiss Alpine conservation movement, 1980–2005. Visualization made with Gephi (version 0.9.2); grey: person, light grey: event; algorithm: ForceAtlas 2.

reporting can provide insights. In our case study, the analyzed events such as board meetings and academic conferences were recorded on attendance sheets or meeting minutes. In discussing the possibilities and limitations of two-mode networks in historical research, we will refer to our research on the Swiss Alpine conservation movement. Our observations on the application of two-mode networks can be divided into three main points.

Firstly, the two-mode network approach made it possible for us to include an adequate amount of historical information during the coding process.[36] Compared to one-mode networks more details get preserved: We can track each person's participation in the events. The primary source, in our case the attendance list, is virtually reproduced in the database. This makes data coding easier, i.e. less abstract and more comprehensible. Due to the nature of our sources – the two-column attendance list lends itself well to a two-mode network (*Figure 4*) – we did not opt for a more complex multi-mode network. Consistency of data increases when the amount of information to code decreases. The two-mode

36 A prerequisite was of course the availability of suitable source material.

Figure 4: CIPRA annual conference in 1992: original attendance record (left) – database entry (right).

network is as simplified as useful and as complex as necessary for our purposes: It aims at balancing between the advantages of keeping the analysis simple but still appropriate for understanding complex phenomena.

The origin of a connection is visually traceable in the two-mode network: In a one-mode network, this information is lost. Establishing clear coding guidelines also makes it possible to share the task of data coding. Of course, this is not meant to suggest that the usual problems of historical network analysis, or rather historical research in general, are diminished. On the contrary, the abstraction of source material through coding brought essential source criticism concerns to the foreground. In our case study, we encountered illegible handwriting, poor-quality copies, missing pages, people with the same or similar name, inconsistent spelling of names, etc. Participants could have left a meeting earlier, joined later, forgotten to, or intentionally not signed their names on the attendance list. All in all, no definitive statement can be made on who actually attended an «event» – a challenge that also applies to historiography in general.

As a by-product of network analysis, insights into the membership of an organization are given. None of the organizations investigated in our case study had a membership record which would have given conclusions about their structure. This aspect could only be uncovered with the help of the foundational work

for the network analysis. HNA was thus helpful for establishing a quantitative picture of the Alpine conservation movement in Switzerland from 1980 to 2000. Thanks to the two-mode approach, the generation of this membership list can be reproduced: Each member can be tied to the events they attended. This also offers the possibility of re-using the collected data for future research.

Secondly, the indirect connection established by two-mode networks is often considered a limitation, but we argue that this does not prevent the analysis of two-mode networks from being useful. On the contrary, this can be regarded as an advantage: The indirect connection is more accurate to the source material and cautions against simplified interpretation. For the analysis of the Swiss Alpine conservation movement, the two-mode network only maps joint participation. Attendance at the same «event» does not automatically imply interaction, exchange of information, or future reciprocal support. The extent to which any kind of relation – from friendly to hostile – between the participants can be established also depends on several factors, among them the size of the «event». Then again, repeated attendance of the same people at several events makes an interaction between them more likely.

Thus, the network graph does not depict the actual interaction of participants, but rather their potential to interact.[37] In our opinion, the fact that the network does not assume any direct relations can be seen as an advantage. Graphical visualizations of networks tend to claim an objective ontological state, which means one runs the risk of seeing them as a reconstruction of (past) reality.[38] This applies to one-, two-, and multi-mode networks alike. When conducting research, it is essential to remember that a network graph and its underlying dataset represent nothing more than a model of social relations. In our case, the two-mode network perhaps makes this model character more explicit than a one- or multi-mode network, as the origins of the network connection are visible and the reduction to only two factors makes the simplification of «historical reality» obvious.

Thirdly, although the calculation of the standard metrics is more difficult for two-mode networks than for one-mode networks, this limitation can be overcome and offers the possibility of engaging more closely with the underlying dataset.[39] In the following, we will discuss the meaning of network metrics, show

37 Rausch, Bimodale Netzwerke, p. 421. For the differentiation between interaction and relationship, see: Emily Erikson, Formalist and Relationalist Theory in Social Network Analysis, in: Sociological Theory 31/3 (2013), pp. 219–242, here: p. 227.

38 Markus Gamper, Michael Schönhuth, Ansätze und Verfahren der visuellen Netzwerkforschung, in: Katharina Lobinger (eds.), Handbuch visuelle Kommunikationsforschung, Wiesbaden 2016, pp. 1–27.

39 Networks can be explored visually or using statistical analysis; on the latter, see: Marten Düring, Florian Kerschbaumer, Quantifizierung und Visualisierung. Anknüpfungspunkte in den Geschichtswissenschaften, in: Düring et al. (eds.), Handbuch Historische Netzwerkforschung, Münster 2016, pp. 31–43, here: p. 40.

the deviation in the calculation results, and present the implications for our interpretation of the network.

One of the most important metrics for examining a network's internal structure is centrality. Centrality is a node attribute and gives information on the position of a node within the network.[40] Calculating centrality values helps to identify central or, in other words, important nodes. This invites us as historians to study the historical actors represented by these nodes more closely. In our analysis, we focused on degree centrality and betweenness centrality.

As mentioned in the introduction, network metrics can be calculated for two-mode by converting the network into a one-mode network – the type of network for which these computations were developed. Therefore, network researchers suggest a combined method of analysis. One should analyze the two-mode network as well as the one-mode projections and subsequently compare both networks.[41] According to Aline Deicke, «contextualizing» the different types of networks assists with interpretation, for example by indicating whether certain nodes are overrepresented in the one-mode network.[42] As the projection is easily made using the software, we suggest collecting and coding the data for a two-mode network, and then converting it into one-mode networks.[43]

In the case of the Swiss Alpine conservation movement, the one-mode networks depicted in *Figure 5* resulted from the projection. In the following, we will focus on the person-to-person network, as it is the people involved that we are interested in.[44]

Calculating certain centrality measures for the one-mode network reveals a source of error in gathering this information from the two-mode network: The two-mode network was unweighted, but the one-mode network has weighted

40 On centrality measures, see: Linton C. Freeman, The Development of Social Network Analysis with an Emphasis on Recent Events, in: John Scott, Peter J. Carrington (eds.), The Sage Handbook of Social Network Analysis, London, Thousand Oaks 2011, pp. 26–39; Martin Stark, Netzwerkberechnungen. Anmerkungen zur Verwendung formaler Methoden, in: Düring et al. (eds.), Handbuch Historische Netzwerkforschung, Münster 2016, pp. 155–171.

41 Working with projections is still common in SNA, but some research has also been done on the problems arising from projection and dealing with bipartite networks on their own. See: Michele Coscia, Luca Rossi, The Impact of Projection and Backboning on Network Topologies, in: Proceedings of the 2019 IEEE/ACM International Conference on Advances in Social Networks Analysis and Mining (ASONAM), New York 2019, pp. 286–293; Filip Agneessens, Martin G. Everett, Introduction to the Special Issue on Advances in Two-Mode Social Networks, in: Social Networks 35 (2013), pp. 145–147; Matthieu Latapy, Clémence Magnien, Nathalie Del Vecchio, Basic Notions for the Analysis of Large Two-Mode Networks, in: Social Networks 30/1 (2008), pp. 31–48, here: p. 35.

42 Deicke, Networks of Conflict, p. 79.

43 For this projection the multimode networks transformation plugin in gephi was used, which uses a matrix multiplication approach. See: https://github.com/jaroslav-kuchar/Multimode-Networks (07.09.2021).

44 Two one-mode networks result from the projection as there were two types of nodes in the two-mode network. One could also analyze the event-to-event network to find the events with the most participants in common or track the potential flow of information between events.

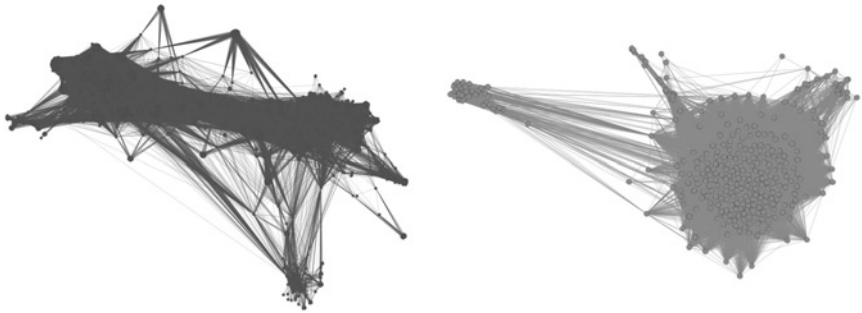

Figure 5: The (two) one-mode networks resulting from the projection: left: person-to-person network (2,035 nodes, 13,3723 edges); and right: event-to-event network (325 nodes, 2,8776 edges). Visualization made with Gephi (version 0.9.2); algorithm: ForceAtlas 2.

edges. Edge weight is a means for adding value («weight»), respectively meaning, to the otherwise unweighted connection between the nodes. In our case, the weight these edges carry is directly proportional to the number of events the people attended together. The more events people attended together, the higher the weight of the edge between them – the closer the connection between these nodes, respectively people.

The influence of a weighted network becomes apparent when looking at degree centrality, that is the centrality based on the number of edges to other nodes (*Figure 6*). Degree centrality measures the number of relationships of a node by adding its edges. Following degree centrality, a node is important, when it has a high number of connections to other nodes. In our case study that means: A person is important if they have many connections to other people, meaning they attended many events with other people.

person-event network → type: person	label	degree
	Weissen, Andreas	209
	Arnold, Alf	207
	Pedrina, Fabio	126
	Hämmerle, Andera	122
	Roulin, Denys	98
	Huwiler, Rita	86
	Eyer, German	76
	Perrett-Gentil, Willy	68
	Zauner, Renate	63
	Mutter, Christa	58

person-person network	label	weighted degree
	Weissen, Andreas	2631.0
	Arnold, Alf	2337.0
	Broggi, Mario F.	1475.0
	Pedrina, Fabio	1465.0
	Danz, Walter	1340.0
	Kahler, Otto	1312.0
	Perrett-Gentil, Willy	1261.0
	Huwiler, Rita	1232.0
	Mutter, Christa	1097.0
	Hämmerle, Andrea	1080.0

Figure 6: Nodes with the highest degree centrality: two-mode network and one-mode network in comparison.

Edge weight also influences betweenness centrality (*Figure 7*).[45] Betweenness centrality is defined as «the fraction of the number of geodesics [shortest paths, author's *note*] passing through this node over the number of geodesics between all pairs of nodes in the network».[46] That is to say: Betweenness centrality measures how many edge paths (that is, indirect relationships across several nodes) run across a particular node. A node's betweenness centrality increases if it lies on many shortest paths between nodes. In visualizations, nodes with high betweenness centrality connect different parts of the network which would otherwise be unconnected. This network metric thus identifies nodes connecting «cutpoints» between different parts of the network.[47] Central nodes – by this definition – are related in interpretations to brokering and exerting control within the network.[48]

45 Gephi uses Ulrik Brandes' algorithm to calculate betweenness centrality: Ulrik Brandes, A Faster Algorithm for Betweenness Centrality, in: Journal of Mathematical Sociology 25/2 (2001), pp. 163–177.

46 Glossary in Collar et al., Networks in Archaeology, p. 17.

47 Peter Mutschke, Zentralitäts- und Prestigemaße, in: Christian Stegbauer, Roger Häußling (eds.), Handbuch Netzwerkforschung, Wiesbaden 2010, pp. 365–378, here: p. 370.

48 For the significance of intermediary positions and «weak ties» in networks, see the canonical paper by Mark S. Granovetter, The Strength of Weak Ties, in: American Journal of Sociology 78/6 (1973), pp. 1360–1380.

person-event network → type: person	label	betweenness centrality (normalized)
	Weissen, Andreas	0.236722
	Arnold, Alf	0.165181
	Speer, Franz	0.035789
	Moroder, Helmut	0.031174
	Ehringhaus, Barbara	0.031130
	Broggi, Mario F.	0.028528
	Gürke, Jan	0.027483
	Antonietti, Aldo	0.023495
	Schraffl, Kuno	0.021462
	Danz, Walter	0.018454

person-person network	label	betweenness centrality (normalized)
	Weissen, Andreas	0.170215
	Arnold, Alf	0.112608
	Speer, Franz	0.039258
	Moroder, Helmut	0.033150
	Broggi, Mario F.	0.026486
	Antonietti, Aldo	0.023433
	Ehringhaus, Barbara	0.023189
	Schraffl, Kuno	0.019394
	Danz, Walter	0.018637
	Gürke, Jan	0.018363

Figure 7: Nodes with the highest betweenness centrality: two-mode network and one-mode network in comparison.

Looking at degree centrality and betweenness centrality in both types of networks, the results are fairly similar and the same two people come out on top: Andreas Weissen, followed by Alf Arnold. Andreas Weissen, a Swiss environmentalist from Brig (Valais), was elected as CIPRA president in 1995. He was the first non-professional (i.e. not a trained natural scientist) to hold this position. Alf Arnold co-founded the *Alpen-Initiative* and served as its executive director from 1995 to 2014. Both have a high degree centrality in both types of networks. Weissen and Arnold were present at a considerable number of events. Their high betweenness centrality in the one-mode network indicates that they may have held a position of brokerage. This finding is backed by a qualitative analysis. In the case of Andreas Weissen, the qualitative analysis shows that he was consistently an actor of importance on the local and international levels for

more than twenty years, bringing together Swiss and European groups as well as activists and experts on Alpine conservation. Alf Arnold was a key actor in national activism and an influential spokesperson, but his activities focused more on the national level.[49]

The person with the third-highest weighted degree centrality in the person-to-person network, Mario F. Broggi (president of CIPRA from 1983 to 1992), does not appear in the top 5 of the two-mode network (there he has a degree of 12). His low degree in the two-mode network, combined with a higher weighted degree in the one-mode network, suggests that he was present mainly at widely attended events. Traditional source analysis reveals that Mario F. Broggi was a productive and effective publicist and an important figure in the transformation of the CIPRA into a much-respected expert organization and thus an actor of great influence. Broggi was a prominent reformer of CIPRA and trenchant spokesman of international Alpine conservation experts during the 1980s. As the publisher of *CIPRA Info*, he criticized politicians as well as society as a whole and called for humans to treat Alpine nature with care and restraint. Quantitative analysis, by contrast, doesn't put him among the highest ranks (see also his betweenness rank). Taking these findings duly into account, the qualitative argument must be modified to reflect that Broggi was an important voice but less present in a physical way compared to Weissen and Arnold.

Overall, there is quite a significant drop after the two highest-ranking nodes for degree and betweenness centrality in the one-mode network (the betweenness values aren't high: 0.17 and 0.11). Thereafter, the values lie very closely together, only differing in the third decimal place (averaging 0.03). For the persons below the fourth position in the tables, the numbers are too close together to allow for significant statements. But the comparison between the two-mode network and its one-mode projection sheds light on Franz Speer and Helmuth Moroder, who do not change their position. Moroder, a prominent CIPRA member from South Tyrol, often appears in the sources and attracts the attention of the qualitatively working historian. But the position of Speer, speaker for nature and environmental conservation of the *Deutscher Alpenverein*, surprises, as he is rarely mentioned in other sources. Thus, the comparison between the different types of networks suggests that it is worthwhile to take a second look at Speer.

These findings illustrate once more that network metrics are not the final result of historical network analysis but need further interpretation. Network statistics are tools to help interpret the underlying historical sources.[50] By using numerical results in this way, it is not only the absolute values that are relevant

49 For more insights into the Swiss Alpine conservation movement gained using HNA, see: Aschwanden, Politisierung, pp. 56–67.

50 «Sie [Netzwerkberechnungen] sind kein Ergebnis, sondern Werkzeuge, die bei der Interpretation historischer Begebenheiten helfen.» Stark, Netzwerkberechnungen, p. 171.

but also their relations to one another. Often missing links and surprising or even inconclusive results offer insights into the biases of one's own research, here for example the emphasis on physical presence. Coming back to Franz Speer this methodology suggests that it would be worthwhile to take a closer look at the role of the *Deutscher Alpenverein* in the context of Alpine conservation. HNA once more shows itself to be a sophisticated tool to expand the historian's toolbox and to question established viewpoints.[51]

Conclusion

The two-mode network offers several possibilities for historical network analysis. Coding historical sources into data suitable for network analysis inevitably entails a loss of information and accuracy. However, in the two-mode approach, more information from the historical source material can be preserved compared to the one-mode approach, and the establishment of the node-edge relations is highly visible, while still retaining clarity in the visualization. The two-mode network also more accurately represents the source material (attendance records) in our participation network, as no direct relations are assumed. The projection into one-mode networks expands the heuristic potential: The projected networks can be explored visually, but they also allow for the use of network metrics. The extra step of coding sources in a two-mode network is justified by the possibility of afterward creating a one-mode projection.[52]

In the particular case examined here, HNA helped to reveal the structural conditions of the Swiss Alpine conservation movement. We used the two-mode network to investigate connections between local environmental activists and members of social-democratic parties acting transnationally. This enabled us to understand the patterns of exchange between these different levels of political activities, which would otherwise be difficult to capture. The results of HNA delivered important insights to understand and explain the success of Alpine conservationists in the early 1990s. The Swiss Alpine conservation movement succeeded in anchoring the protection of the Alps on a national (adoption of the Swiss citizens' initiative in 1994) as well as on an international level (adoption of the Alpine Convention in 1991). Today, Switzerland's «green» transport infrastructure – for example the opening of the Gotthard Base Tunnel in 2016 as part of the NEAT (short for *Neue Alpentransversale*, German for the *New Railway Link through the Alps*) project – is a testimony to the work done by the movement. HNA opened up a new perspective for understanding the social networks of the activists, experts, and politicians behind this political success.

51 Eumann, Heuristik, p. 127.

52 The dataset will be published in an open-access data repository.

At the same time, the process of HNA enhanced our understanding of the primary sources and sensitized us to the underlying assumptions in the construction of our model of «reality». Therefore, we recommend coding the information for a two-mode network (if possible) as part of a complementary and iterative research process that alternates between quantitative network analysis and qualitative empirical research. Digital tools and «traditional» research should not be seen as mutually exclusive but as reciprocal complements. When working with digital tools, methodological reflections become even more important than they already are: while exploring visualizations, «thinkering»[53] with the projections of two-mode networks into one-mode networks, applying different algorithms, or analyzing metrics. In this process, the need for new, digital source criticism as part of new digital hermeneutics becomes obvious.[54]

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53 «Thinkering» is a combination of «thinking» and «tinkering». In digital history research, it has been used by the Centre for Contemporary and Digital History at the University of Luxemburg to describe the «playful experimentation with technological and digital tools» that characterizes their approach to history; see: https://www.c2dh.uni.lu/thinkering (07.09.2021).

54 On digital hermeneutics, see: Andreas Fickers, Update für die klassische Hermeneutik. Geschichtswissenschaft auf dem Weg zur digitalen Forensik?, in: Zeithistorische Forschungen/Studies in Contemporary History 17/1 (2020), pp. 157–168.