

Temporally-aware dynamic network analysis: traversing nodegoat graphs

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Background

At the end of this year, nodegoat celebrates its 10 year anniversary.¹ This achievement makes for a unique temporality of research in graph and network technologies, as scholars are able to rely on a robust and innovative research infrastructure for more than a decade. nodegoat is used at over 160 institutes by over 2500 scholars for storing and analysing temporalities of historical subjects as well as creating complex temporalities of historical data.²

nodegoat is a research environment that allows scholars to define any amount of object types that can have any amount of spatially and temporally attributed properties and relationships.³ These contexts can be created by assigning an Object (e.g. 'Person') with Sub-Objects (e.g. 'Place of Residence', or 'Capacity'). Users can decide to implement an existing ontology or a custom data model. The flexible nature of nodegoat makes it difficult to define it as a type of database as it has elements of relational, graph, and document databases. This versatility has resulted in a large variety of research projects that use nodegoat to create historical datasets.⁴ The interface of nodegoat allows scholars to focus on complex methodological challenges in contrast to building prototypes that are boutique or inaccessible in terms of reproducibility.

Methods and data

The relational, spatial, and temporal core of nodegoat is continuously expanded to offer scholars enhanced modes of analysis. Users can perform temporally-aware filters and use

¹ <https://lab1100.com/onedecade>

² e.g. https://www.dh.unibe.ch/dienstleistungen/nodegoat_go/index_ger.html, <https://ictonderzoek.humanities.uva.nl/en/nodegoat-en/>, <https://www.ghentcdh.ugent.be/services/collaborative-databases>, <https://sites.coloradocollege.edu/dlaatcc/resources/>, and <https://nodegoat.net/usecases>.

³ Pim van Bree, Geert Kessels (2013). nodegoat: a web-based data management, network analysis & visualisation environment, <http://nodegoat.net> from LAB1100, <http://lab1100.com>. For an introduction see <https://nodegoat.net/guide.s/112/basicprinciples>.

⁴ e.g. Christophe Verbruggen, Florian Deroo, Hans Blomme, Thomas D'haeninck, Amandine Thiry, Lisa van Diem, Jan Vandersmissen, Eline Mestdagh, Bo Billiet, Judith Wolff, Sally Chambers, Pieterjan De Potter, Julie Carlier, Carmen Van Praet, Chris Leonards, and Nico Randerad, 'Social Reform International Congresses and Organizations (1846–1914): From Sources to Data', *Journal of Open Humanities Data*, 8 (2022), p. 13. Tobias Winnerling, *Das Entschwinden der Erinnerung: Vergessen-Werden im akademischen Metier zwischen 18. und 20. Jahrhundert* (2021). Greta Hawes, 'A half-dozen ways to die (in myth)', MYTHLAB, 17-03-2021, <https://www.manto-myth.org/blog/a-half-dozen-ways-to-die-mythically>. Ingeborg van Vugt (2017) "Using Multi-Layered Networks to Disclose Books in the Republic of Letters", *Journal of Historical Network Research*, 1, p. 25–51. More references can be found in this zotero library: <https://www.zotero.org/lab1100/tags/nodegoat/>.

graph navigation to generate custom paths throughout their datasets.⁵ nodegoat can dynamically generate a graph database based on these paths to perform a selected (social) analytical algorithm in a custom built C++ framework.⁶

The recently developed 'Chronology Statements' provide objects with a position in time by means of statements that combine operators, cyclic periodisation, relationality, and additional offsetting.⁷ The logical implementation of the system can compute actual dates while providing access to its underlying uncertainty or vagueness. A point in time can be described by one or two statements and would eventually result in a date range (vague) or a date time (exact). A period can be described by two, three, or four statements with varying levels of attribution that assemble the quantification of its vagueness.⁸

The newly developed extension to nodegoat's graph navigation adds temporally-aware dynamic network analysis. This allows users to traverse nodegoat's graphs while evaluating static and relative date statements where multi-modal definitions of time propagate from one node to the next. When analysing a network of cohabitation of artists at specific addresses, it is of vital importance that there is a temporal overlap or otherwise temporal relevancy. No software implementation of a generic algorithmic solution exists that incorporates a relative temporal evaluation when processing network data. The graph navigation in nodegoat allows researchers to interactively and reproducibly navigate these multi-modal and temporarily-aware networks. This proposed solution of dynamic traversal positions itself as a bridge between traditional statistical social network analysis and agent-based modeling.⁹

While unimodal datasets contain direct relationships between nodes ('friend of', 'roommate of'), historical datasets are oftentimes multimodal and contain many indirect relationships. These indirect relationships are established when various sources place multiple people at the same address, or the same educational institute. In order to generate a network of ties from these indirect relationships, a temporal evaluation needs to take place to establish if two or more people had the same link at roughly the same time. This newly built feature of nodegoat allows users to perform this kind of analysis in any kind of data model.

When running a shortest path analysis on a network of people and addresses, connected by temporally attributed 'has residence' relationships, the temporally-aware dynamic network analysis functionality allows a user to establish a range in which a certain overlap needs to occur, see fig. 1. A tie will only be considered if '[date 1]' and '[date 2]' fall within the defined overlap.

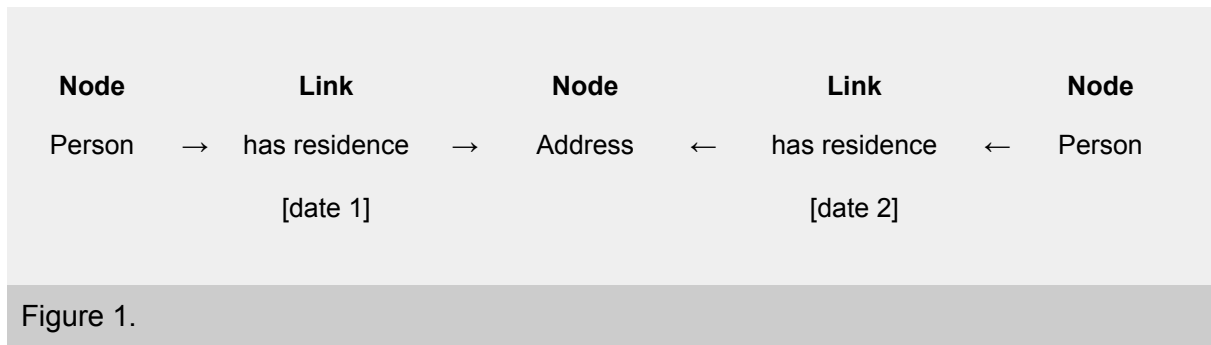
⁵ <https://nodegoat.net/documentation.s/86/create-graph>,
<https://nodegoat.net/documentation.s/81/scope>

⁶ Pim van Bree, Geert Kessels, 'New Analytical Features in nodegoat', 13th Workshop on Historical Network Analysis 'Networks Across Time and Space', 27-5-2019, <https://nats.hypotheses.org/>.

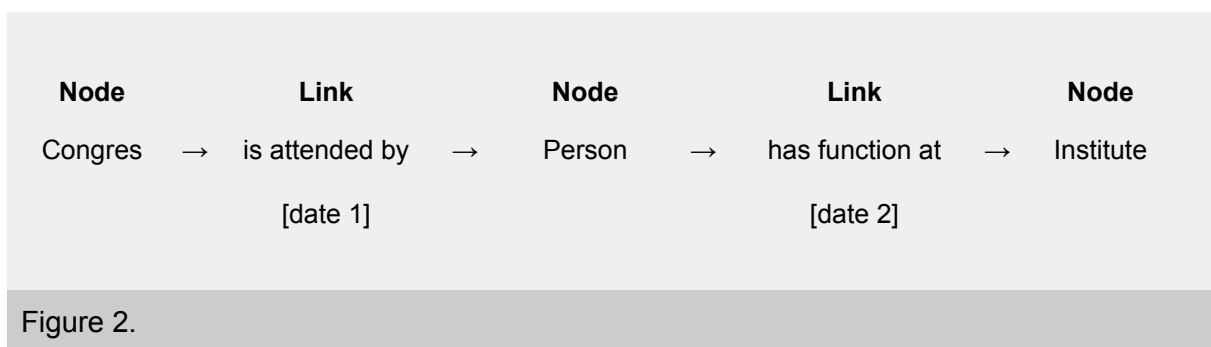
⁷ Pim van Bree, Geert Kessels, 'Chronology Statements for nodegoat: a temporal topology to interface with vague, relational, and actionable dates', Data for History 2021: Modelling Time, Places, Agents, [sciencesconf.org:d4h2020:322525](https://sciencesconf.org/d4h2020:322525).

⁸ <https://nodegoat.net/guides/chronologystatements>.

⁹ e.g. Wendy H. Cegielski, J. Daniel Rogers, 'Rethinking the role of Agent-Based Modeling in archaeology', *Journal of Anthropological Archaeology*, vol. 41, 2016, pp. 283-298, <https://doi.org/10.1016/j.jaa.2016.01.009>.



This functionality can also be used to analyse institutional influences at conferences based on temporal overlaps between an 'attendance' relationship and a 'function' relationship, see fig. 2.



Findings

Temporally-aware multimodal traversal offers another layer of complexity to the forms of graph-based historical network analysis that is now available to a large variety of research projects that use nodegoat. As each of these projects differ in subject of study, source dynamics, and the applicability of time, the resulting findings will cover a highly heterogeneous body of research.