Embedded Humanities: The Khipu as a Situated Information System

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Abstract

This paper examines the ***khipu***, a pre-Columbian data-recording system composed of knotted cords, as a site for rethinking the epistemological and ideological assumptions underlying contemporary data infrastructures. Drawing on frameworks from feminist science and technology studies, postcolonial theory, and the history of computing, I argue that the ***khipu*** functions as a "situated storage" technology, an Indigenous, distributed system of information encoding that both parallels and contests the logic of modern Western databases. By placing the ***khipu*** in conversation with the CAP theorem, the rise of NoSQL architectures, and the ideological work performed by computational abstractions, this paper develops a comparative critique of data logics: one that foregrounds materiality, social relations, and political context over presumed universality and neutrality. Through close readings of theorists such as Wendy Hui Kyong Chun, Donna Haraway, and Jacques Derrida, I examine the khipu both as a material technology of Inca imperial administration and as a resource for contemporary counter-archival readings that challenge extractive and homogenizing assumptions in Western data regimes. The comparison developed here therefore concerns not simply different technologies of storage, but different practices of abstraction: the processes through which material, political, and social relations are converted into formal objects capable of circulating as data. By asking what those abstractions preserve and what they cause to disappear, the khipu makes visible assumptions about universality, labor, and representation that contemporary database systems can otherwise present as merely technical.

"When designing distributed web services, there are three properties that are commonly desired: consistency, availability, and partition tolerance. It is impossible to achieve all three."

The quotation above addresses an important challenge in contemporary computing. The paper in which it appears, *Brewer's Conjecture and the Feasibility of Consistent Available Partition-Tolerant Web Services* by Seth Gilbert and Nancy Lynch, explains and formalizes the fundamental problems involved in managing large-scale distributed data, such as social networks or search engines. One cannot expect a distributed database system to work as easily as it did for traditional smaller-scale projects. As Internet adoption and screen time increased in the early 2000s, the kinds of social and technical interactions online proliferated as well. The Internet evolved from a way to share static text, images, and links to other texts and images into a place for interactive content production and consumption, as well as commerce.

The role of the Internet expanded, and data challenges multiplied. One industry-focused perspective on the challenges of data management was to think about changes in terms of three key concepts: *variety, volume, and velocity*[2]. This period was marked by dramatic increases in all three measures with regard to the web. As Internet users created their own content in the form of social posts, chain emails, or images, the sheer *volume* of data presented new challenges, not least the question of where to store it all. To further complicate matters, user-created data could be far more diverse (increasing *variety*) than the simple inventory logs or lists of users that were more typical of data stored at the time. Finally, Internet applications were not bound by local

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[1] Gilbert, Seth & Lynch, Nancy. (2002). Brewer's Conjecture and the Feasibility of Consistent Available Partition-Tolerant Web Services. ACM SIGACT News. 33. 10.1145/564585.564601

[2] Laney, Douglas. 3D Data Management: Controlling Data Volume, Velocity, and Variety. META Group (2001).

business hours, and this diverse data was constantly being created and streamed to database systems, thus representing increased *velocity.*

As increases in the *three Vs* placed novel demands and strains on database systems, computer science researchers and industry programmers were desperate to understand and mitigate the challenges of what is now called data science. Assumptions that had previously been taken for granted in database systems, such as the ability of all database users to obtain the most up-to-date content from the database (*consistency*), were not true in this new ecosystem, in which data existed in different, distributed locales, often thousands of miles apart. In some cases, even the expectation that a database system would be accessible at all was thwarted by problems of distributed data (*availability*). Finally, *partition tolerance* refers to the ability of a distributed database system to keep working after a part of it fails or goes offline. Gilbert and Lynch's paper proves that there is a fundamental problem in handling data that is physically distributed: when working with distributed data, one cannot assume the same rules that apply when working with a single database and thus must give up sociotechnical expectations that have come to be treated as axiomatic (obtaining the latest data, having the system be available, *etc.*) in applied database systems. It is in this historical context that NoSQL databases emerged. These databases, to which I will return later, were designed to handle diverse data and had distributed data in mind. By introducing new sociotechnical expectations and mitigations, these databases represented a new context for data management, often invoking "practical compromise"[3] to deal with the impossibility of "commonly desired"[4] attributes.

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[3] Gilbert, Seth & Lynch, Nancy. (2002). Brewer's Conjecture and the Feasibility of Consistent Available Partition-Tolerant Web Services. ACM SIGACT News. 33. 10.1145/564585.564601, 11

[4] Gilbert, Seth & Lynch, Nancy. (2002). Brewer's Conjecture and the Feasibility of Consistent Available Partition-Tolerant Web Services. ACM SIGACT News. 33. 10.1145/564585.564601, 1

Data management, however, is not unique to the computing age or to Western societies. The Inca Empire, through invasion and economic influence, expanded greatly in the 15th and 16th centuries. At its height, it spanned over 2,500 miles and comprised up to 10 million subjects[5]. Quechua was not represented by an alphabetic or syllabic script before Spanish colonization; whether khipus constituted a form of writing remains an open and contested question addressed later in this paper. However, like any large-scale organization, an empire needs to keep records to manage and administer activities across thousands of miles and millions of subjects. Additionally, Inca territory spanned diverse geographies: mountains, deserts, and rainforests. Mobility was a concern not only because of distance but also because of climate and terrain. The main data-management tool used by the Incas in this endeavor was the khipu. The khipu is a portable recording device made of cords, often of cotton or llama wool, with strategically placed knots. It has been shown to document numerical and simple categorical data. It is also thought that khipus encode more complex data, such as categorical information, narratives, and military plans; however, more advanced encodings have not yet been deciphered. Because of the diversity of khipu components, such as string color, ply direction, and color patterning, the potential for encoding complex and multidimensional data is high and motivates contemporary statistical and social-science research[6].

Some khipus likely represent credits, debits, and tax records of the official Inca state. Khipus were deployed across the Inca Empire, known to its inhabitants as Tawantinsuyu (translated as "the four parts together"). In several cases, copies of data were stored at remote

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[5] Ascher, Marcia, and Robert Ascher. Code of the Quipu: A Study in Media, Mathematics, and Culture. Ann Arbor: University of Michigan Press, 1981. Print., 4

[6] See: Medrano, Manuel. Khipu Transcription Typologies: A Corpus-Based Study of the Textos Andinos." Ethnohistory 68(2): 311-41. https://doi.org/10.1215/00141801-8801912.

locations, with *masters* located in the Inca capital of Cuzco[7]. Khipus used knots and their relative positions to one another to record numbers. All Inca khipus found to date are believed to use the decimal, or base-10, system; however, older, pre-Incan, khipus have been found that use base 5. Ashok Khosla finds this intriguing because there is little advantage to using a base-10 system over base 5 "unless you like to quarter and half things. Doing 25%, 50% and 75% in base 5 is difficult. It's easy in base 10, where you have that factor of two built-in..."[8] Indeed, as the name of their empire implies ("the four parts together"), the Incas were fond of halving and quartering things, from the capital city of Cuzco to granary buildings.

The transition from the use of base 5 to base 10 can be viewed as an example of how ideology can "interpellate subjects who internalize...logics." Drawing on Althusser's discussion of the *Ideological State Apparatus, Chun* uses software as a metaphor for ideology: "[software] interpellates a 'user': calls it and offers it a name or image with which to identify."[9] As a large-scale data-management tool used for "political arithmetic,"[10] the khipu does seem to occupy the same conceptual space as software does in Chun's account. Furthermore, mathematician Oliver Knill augments the case for viewing the khipu as database software: "If one would compare the Khipu with files of modern computing, the analog of the internet was realized by Chaskis, the Khipu runners."[11] The khipu enables a large-scale distributed data system, one often used to halve and

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[7] Ascher, Marcia, and Robert Ascher. Code of the Quipu: A Study in Media, Mathematics, and Culture. Ann Arbor: University of Michigan Press, 1981. Print., 42

[8] Khosla, Ashok. Introduction." *Www.khipufieldguide.com*, www.khipufieldguide.com/notebook/Introduction.html#Cloth-as-a-Writing-Medium. Accessed 01 Dec. 2021.

[9] Wendy Hui Kyong Chun; On Software, or the Persistence of Visual Knowledge. *Grey Room* 2005; (18): 26–51. doi: https://doi.org/10.1162/1526381043320741, 43

[10] Urton, Gary. 2012. Mathematics and Accounting in the Andes Before and After the Spanish Conquest. In Alternative Forms of Knowing (in) Mathematics, ed. Swapna Mukhopadhyay and Wolff-Michael Roth, 17-32. Rotterdam: Sense Publishers. 19

[11] Knill, Oliver. The Inka Khipu Enigma. *https://people.math.harvard.edu/~knill/history/khipu/khipu.pdf* 22 Dec. 2018.

quarter land, labor, and resources and one that required specialized labor to keep the recording and administrative system going. This labor is made easier by the use of a base-10, or decimal, system. Thus, the switch from base 5 to base 10, although expressed as a formal change in a number system, represents a sociotechnical decision aimed at consolidating political power across a distributed empire. As Donna Haraway notes, "it follows that politics and ethics ground struggles and contests over what counts as rational knowledge...in the exact, natural, social, and human sciences."[12] Mathematician Marcia Ascher and anthropologist Robert Ascher describe the inevitability of bureaucrats and appear to strengthen Chun's argument that data technologies create subjects: "Hand in hand with massive construction, standing armies, and all the other attributes of the state, there is always a bureaucracy to administers its affairs."[13] The Aschers' observation also supports Haraway's conjecture that "knowledge projects" ultimately owe their guiding structure to politics and ethics. Thus, khipu makers, known as Khipu-Kamayuqs[14], and those in charge of transporting khipus, Chaskis, became necessary political actors in the Inca Empire. The identities of these knowledge workers, or *data engineers*, were motivated by technologies of political administration.

Khipu-Kamayuqs, always male, were trained in Cuzco and then sent throughout the empire as political need dictated. Despite being subject to relocation, the Khipu-Kamayuq was entrusted to "conceive and execute a recording [of data] in three dimensions with color... [and] worked with

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[12] Haraway, Donna (1988). Situated Knowledges: The Science Question in Feminism and the Privilege of Partial Perspective. *Feminist Studies* 14 (3):575-599, 587

[13] Ascher, Marcia, and Robert Ascher. Code of the Quipu: A Study in Media, Mathematics, and Culture. Ann Arbor: University of Michigan Press, 1981. Print., 63

[14] Khosla, Ashok. Introduction." *Www.khipufieldguide.com*, www.khipufieldguide.com/notebook/Introduction.html#Cloth-as-a-Writing-Medium. Accessed 01 Dec. 2021.

privileged information, so he was privileged."[15] The Khipu-Kamayuq was, then, a numerate, highly educated person who was privileged but not among the elite who governed the Inca Empire and dictated which khipus would be built. Furthermore, among the Khipu-Kamayuqs, there was a hierarchy, with some working on large khipus representing "larger units of organization within the Inca state" and others working on small khipus of local concern[16].

In contemporary society, there also exists a privileged, though not necessarily bourgeois, type of information worker: the software engineer. Although the role is not state-mandated, software engineers today tend to be men, and many work on web applications that perform some form of *political arithmetic.* From financial technology to bidding on government contracts, software engineers, like the Khipu-Kamayuqs, are important but not elite.

By the time Gilbert and Lynch's *Brewer's Conjecture* paper came out in 2002, software engineers, despite the profession's origins in its association with menial and feminized labor, were now important and male[17]. Here, Chun's discussion of software's interpellation helps underscore that technologies, from khipus to web-scale databases, are created with users in mind and that, without these users, the data is inaccessible. As social and financial trends increased the amount and variety of data being created (think of the *three Vs* mentioned above), software engineers struggled with complex distributed data and began to seek more flexible options that also corresponded with how data was being created and used in ways different from those of the past.

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[15] Ascher, Marcia, and Robert Ascher. Code of the Quipu: A Study in Media, Mathematics, and Culture. Ann Arbor: University of Michigan Press, 1981. Print., 62

[16] Ascher, Marcia, and Robert Ascher. Code of the Quipu: A Study in Media, Mathematics, and Culture. Ann Arbor: University of Michigan Press, 1981. Print., 73

[17] Wendy Hui Kyong Chun; On Software, or the Persistence of Visual Knowledge. *Grey Room* 2005; (18): 26–51. doi: https://doi.org/10.1162/1526381043320741, 33

The traditional way of storing data in computers is focused on the relational database model and Structured Query Language, or SQL. In the relational model, software engineers must know how data will be structured ahead of time. Software engineers design tables with specific schemas, or templates, that predetermine the data stored and searched (queried) in the table. Furthermore, to make relational database systems efficient, it is often necessary to break up data in unintuitive ways, a process called normalization. Because relational databases were designed for applications in which all data could fit in one location, working with distributed data caused unexpected problems in accessing data efficiently, or at all[18].

While many relational databases evolved, with varying success, to meet the new challenges, the desire for fundamentally new ways of working with data also emerged. Thus, the image of the engineer who used relational databases by default was losing its dominance. As Chun writes, one is not "aware of software s constant constriction and interpellation (also known as its user-friendliness'), unless you find yourself frustrated with its defaults."[19] As data became more complex and distributed, software engineers found themselves at odds with these defaults, which directly affected how they performed their labor. Relational databases proved not to be user-friendly for a large number of real-world data-management challenges, and alternatives began to emerge. These databases, now collectively known as NoSQL databases, are built with contemporary issues, such as distribution and complex data forms, in mind. MongoDB, the most widely used NoSQL database, describes itself as a modern database that "supports a variety of workloads...programming languages, and cloud [environments]"[20]. MongoDB is based on an

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[18] Harrison, Guy. Next Generation Databases: NoSQL, NewSQL, and Big Data. Apress. 2015. 22

[19] Wendy Hui Kyong Chun; On Software, or the Persistence of Visual Knowledge. *Grey Room* 2005; (18): 26–51. doi: https://doi.org/10.1162/1526381043320741, 43

[20] Why Non-Relational? Why MongoDB? https://docs.google.com/presentation/d/1eFGXUWjvW7CDJhdiUdFMjEJiNOuKzVVusfvpS3nNmJo/edit

already popular web programming language, JavaScript. By using the existing, popular JavaScript, MongoDB also aimed to eliminate the need to hire software engineers specifically to work on databases. With the promise of requiring less specialized labor, it is perhaps no surprise that, at the time of this writing, MongoDB has the largest market share of any NoSQL database, as high-level technological decisions, such as which database to use, are often based on fiscal concerns[21].

Complex data analysis and highly networked data also spurred the development and use of new databases based on mathematical models different from those of relational databases. Graph-based databases, such as Neo4j, were developed to store and analyze data as a network of objects and their relationships. Graph databases are based on graph theory, a branch of mathematics that studies relationships between objects. They are also highly scalable and more performant than relational databases "if data structures are complicated."[22]

NoSQL databases emerged as a series of techniques for dealing with complex and distributed data on the Internet. The khipu was developed and iterated on to address the complexities of managing a civilization at scale. Although these technologies serve a general sociopolitical administrative purpose in vastly different contexts, comparing each system's "semiotic technologies"[23] can provide insight into the "politics and ethics" of each culture. Anthropologist Gary Urton, a khipu scholar, investigates the Quechua number system, which was the basis for the khipu's numerical representation:

> *Numbers are not conceived of in Quechua ideology as abstractions whose nature and relations to each other rely on the predictions of pure logic, as in the West, Rather, numbers are conceptualized in terms of social—*

[21] https://yalantis.com/blog/how-to-choose-a-database/

[22] Knill, Oliver. The Inka Khipu Enigma. *https://people.math.harvard.edu/~knill/history/khipu/khipu.pdf* 22 Dec. 2018.

[23] Haraway, Donna (1988). Situated Knowledges: The Science Question in Feminism and the Privilege of Partial Perspective. *Feminist Studies* 14 (3):575-599, 579

> *especially family and kinship…One consequence of their participation in social life is that all of the linguistic formulations and grammatical constructions that are used to talk about inheritance, succession, dependence, and interdependence within a kin group…can be applied as well to number identities and numerical relations.*[24]

So, despite sharing the decimal system, Western and pre-Columbian Quechua mathematics are based on fundamentally different understandings of what numbers can be. A familiar post-Enlightenment position would celebrate Western abstraction, the reduction of numbers to the results of first-order logic. Quechua's association of numbers with social relations would be seen as a burden of specificity, while numbers in Western mathematics are universal and "promise transcendence."[25] However, like Urton, I ask if this burden of social relations is also a productive source of cultural insight into how a community thinks? Urton wonders whether the cultural specificity of numbers in Quechua implies that the "Cartesian split between the real and ideal…represents an unnecessary sacrifice in our pursuit of the truth of mathematics." Certainly, Cartesian dualism brings about as many problems as it solves, so must our mathematics and data systems depend on it as a given? Haraway would not only find value in the Quechua number system's social ontology but could also recognize it as an example of *situated knowledge*, insofar as it "does not pretend to disengagement: to be from everywhere and nowhere, to be free from interpretation."[26] Quechua numbers are meaningful partly through the social relations they can represent. It is precisely this "partial view" that enables the kinds of connections Haraway

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[24] Nina Llanos, Primitivo, and Urton, Gary. The Social Life of Numbers: A Quechua Ontology of Numbers and Philosophy of Arithmetic. United States, University of Texas Press, 1997. 13

[25] Haraway, Donna (1988). Situated Knowledges: The Science Question in Feminism and the Privilege of Partial Perspective. *Feminist Studies* 14 (3):575-599, 582

[26] Haraway, Donna (1988). Situated Knowledges: The Science Question in Feminism and the Privilege of Partial Perspective. *Feminist Studies* 14 (3):575-599, 582

considers productive: "Situated knowledges are about communities, not about isolated individuals. The only way to find larger vision is to be somewhere in particular."[27]

The contrast has consequences beyond the philosophy of mathematics. Western forms of abstraction often make information portable by separating formal objects from the circumstances of their production. In Marx's account of commodity fetishism, relations among people acquire the appearance of autonomous relations among things;[28] an analogous process can occur in information systems when historically and socially produced categories appear instead as inherent properties of data. The Quechua ontology described by Urton suggests another possibility. If numerical identities can themselves encode dependence, succession, kinship, and other social relations, abstraction does not necessarily require those relations to disappear. Situatedness is therefore not simply an impurity that must be removed in order to produce knowledge. It may itself be part of what the information means.

A topic of great interest in the study of the khipu, aside from deciphering it completely, is whether the khipu counts as a writing system[29]. The khipu is distinct from speech, serves to preserve information, and fulfills many definitions of writing proper, but lacks the focus on inscription associated with written language. However, in *Of Grammatology*, philosopher Jacques Derrida uses writing as a tool to deconstruct linguistic meaning and uses the term to "designate not only the physical gestures of pictographic or ideographic inscription but also the totality of what makes it possible...all that gives rise to inscription in general, whether literal or

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[27] Haraway, Donna (1988). Situated Knowledges: The Science Question in Feminism and the Privilege of Partial Perspective. *Feminist Studies* 14 (3):575-599, 590

[28] Marx, Karl. *Capital: A Critique of Political Economy, Vol. 1* (1867), ch. 1, sec. 4, "The Fetishism of the Commodity and Its Secret." https://www.marxists.org/archive/marx/works/1867-c1/ch01.htm

[29] Cossins, Daniel. https://www.newscientist.com/article/mg23931972-600-we-thought-the-incas-couldnt-write-these-knots-change-everything/

not."[30] Derrida references Jean-Jacques Rousseau and Ferdinand de Saussure, a pioneer of semiotic linguistics, as proponents of the supremacy of speech over writing. Both Rousseau and Saussure view speech as more authentic than writing. Derrida cites Rousseau from an unedited essay on languages: "Writing is nothing but mere representation of speech."[31] Saussure pioneered the semiotic model in which a sign and its meaning are constituted by the relationship between the signified and the signifier. Saussure viewed writing as derivative because it is a *re*presentation (emphasis mine) of speech, which has a more direct connection to true meaning.

While Derrida's characteristic method is to expose tensions internal to Western texts, the khipu provides a material case through which the hierarchy between speech and writing can itself be questioned. Quechua numerical ontology did not require a spoken lexical term corresponding to zero, yet the khipu could represent zero through the meaningful absence of a knot at a particular positional value. The important distinction is therefore not that zero lacked a signifier altogether, but that its material signifier in the khipu did not depend upon an equivalent spoken word.

The khipu consequently cannot be understood simply as the transcription of a prior and complete spoken numerical language. Here the supposedly secondary term in the speech/writing hierarchy performs representational work that speech does not. Read through Derrida, the khipu therefore complicates the claim that writing is merely a derivative representation of speech: material inscription can participate in producing distinctions that speech itself does not lexicalize. The recording system is not simply a passive container into which already constituted meanings are deposited. Its material structure participates in determining what can be represented and how.

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[30] Derrida, Jacques. Of Grammatology. Baltimore: Johns Hopkins University Press, 1998. 13

[31] Derrida, Jacques. Of Grammatology. Baltimore: Johns Hopkins University Press, 1998. 27

A contemporary example demonstrates what can be lost as socially situated knowledge passes through successive levels of abstraction. A central concept in network science is homophily, commonly summarized by the proposition that similarity breeds connection. Homophily is now used in the analysis of social networks and can be operationalized computationally in recommendation systems, link prediction, graph embeddings, and other forms of network analysis. Yet the historical genealogy of the concept complicates its apparent universality. An influential 1954 study used racially segregated housing communities as an empirical setting while analyzing only white residents' responses.[32] What was observed within a highly specific political environment, one structured by racial segregation, housing policy, and unequal access to space, could subsequently be formalized as a general property of social networks.

Each stage of this formalization makes the concept more portable. People become nodes, relationships become edges, and historically constituted forms of similarity become variables that can be mathematically compared. Once homophily is implemented computationally, a programmer need not encounter the political history from which the abstraction emerged at all. Graph systems such as Neo4j can provide algorithms capable of identifying similarity or structural equivalence directly from a network.[33] The problem is not that Neo4j therefore causes segregation or political polarization. Rather, the software demonstrates how completely a situated social concept can be transformed into reusable technical functionality while leaving the conditions of its production outside the computational representation.

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[32] Kurgan, Laura, et al. "Homophily: The Urban History of an Algorithm." *e-flux Architecture*, https://www.e-flux.com/architecture/are-friends-electric/289193/homophily-the-urban-history-of-an-algorithm/

[33] "Graph Embeddings - Developer Guides." *Neo4j Graph Database Platform*, https://neo4j.com/developer/graph-data-science/graph-embeddings/.

Read alongside the Quechua ontology described by Urton, this transformation becomes especially striking. In the contemporary computational example, abstraction progressively separates numerical and relational structures from the social worlds in which they were produced. In the Quechua account, by contrast, social relations such as dependence, inheritance, and kinship participate in constituting numerical identity itself. The comparison therefore raises a question more fundamental than whether one information system is technically superior to another: what forms of knowledge become available, and what histories disappear, when an information system requires social relations to be abstracted away from the objects it represents?

While I position the logic of the khipu as a means of critiquing the West's universalist project, I do not seek to depict pre-Columbian peoples as noble savages or human blank slates. Many *privileged* Khipu-Kamayuqs were conscripted from defeated tribes, and while Inca governance allowed for some form of multiculturalism within the empire, for example, local deities could still be worshipped as long as Inca gods were also worshipped and local governance structures were retained if they did not interfere with Inca state affairs, the Inca Empire expanded primarily through military conquest. Thus, some of the political arithmetic performed using khipus must have been in the service of colonizing neighboring communities[34]. I mention this not to imply that the West and colonized Indigenous empires are on the same footing because both have a history of colonization, but to avoid the trap of cultural relativism, which, as Haraway states, promises "vision from everywhere and nowhere equally and fully."[35] I choose to compare two data

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[34] Ascher, Marcia, and Robert Ascher. Code of the Quipu: A Study in Media, Mathematics, and Culture. Ann Arbor: University of Michigan Press, 1981. Print., 54

[35] Haraway, Donna (1988). Situated Knowledges: The Science Question in Feminism and the Privilege of Partial Perspective. *Feminist Studies* 14 (3):575-599, 584

systems to investigate the ideological assumptions behind contemporary data systems currently in use in the West and to examine alternative data practices and their ideological implications.

While theories of difference may be productive and exciting, discovering fundamentally different models of computing may not be the only source of insight, as Urton writes: "even if we do find a philosophy that does not disturb mathematical truths on our (Western) theorems, but does allow us to link mathematics, cultural values, and social organization...why not pursue that philosophy...to discover what we can learn."[36] While khipu studies is a growing field, it is important not to allow an uncritical contemporary celebration of technology to validate the khipu merely because it resembles important computing and software technologies. While both the khipu and NoSQL databases are used in similar contexts, identity-blind "technoliberalism," which is a dominant ideology of contemporary society, threatens to erase the specific social and material relations that shape pre-Columbian and contemporary globalized data-management logics.

Conclusion

The adoption and deployment of the khipu as a means of managing the growing Inca Empire draw interesting parallels with the emergence of modern, multipurpose NoSQL databases. By comparing the internal structuring schemas of the khipu and of NoSQL databases, we can gain insight into ideological assumptions made in the deployment of each technology. Using the khipu to frame a conversation around non-Western or Indigenous computing enables us to critically examine our sociotechnical data environment from Haraway's "objective" standpoint. Because the khipu provides a privileged vantage point from which to analyze our own Western data-

[36] Nina Llanos, Primitivo, and Urton, Gary. The Social Life of Numbers: A Quechua Ontology of Numbers and Philosophy of Arithmetic. United States, University of Texas Press, 1997. 19

management systems, khipu studies cannot be one-sided. Discussion of Indigenous technologies must not be used only to benchmark Western ideologies but must also serve to draw insight from Indigenous frameworks and knowledge systems.