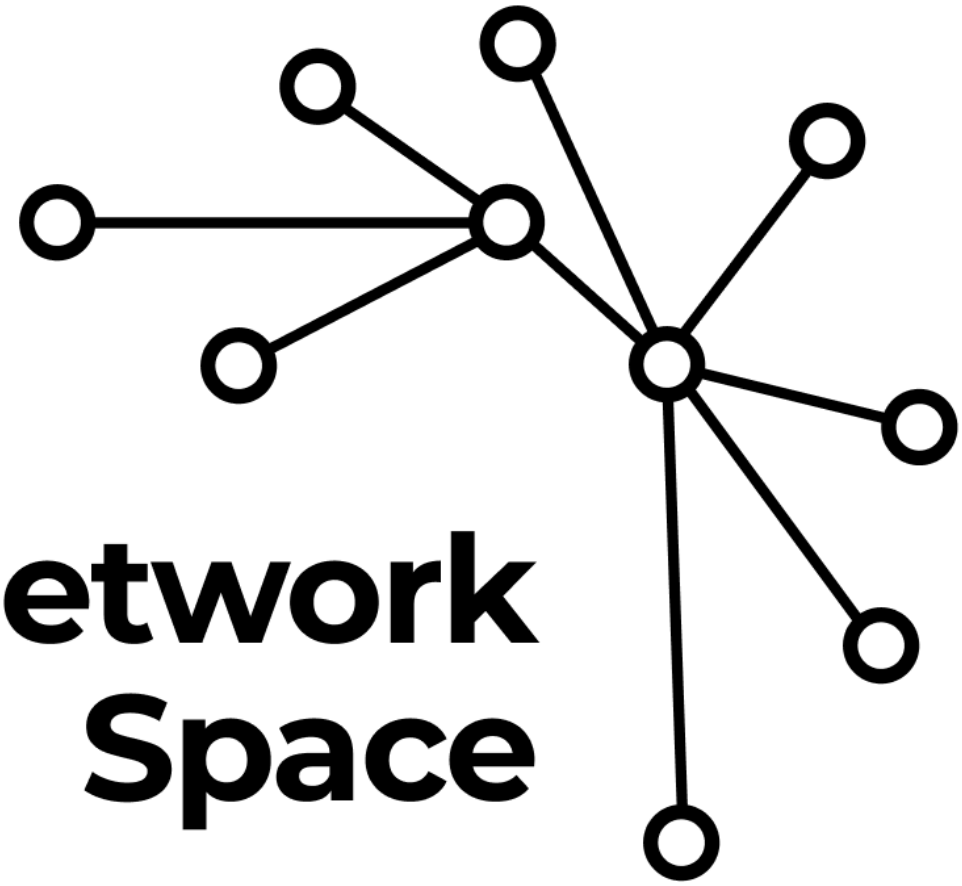

Network Space

From Node to Link: Applications of Network Science to Workspace

Josh Emig, Jorey Hurley, Nash Hurley
Research by Vital Architecture Studio

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Introduction - Framework for a New World

From Node to Link: Applications of Network Science to Workspace

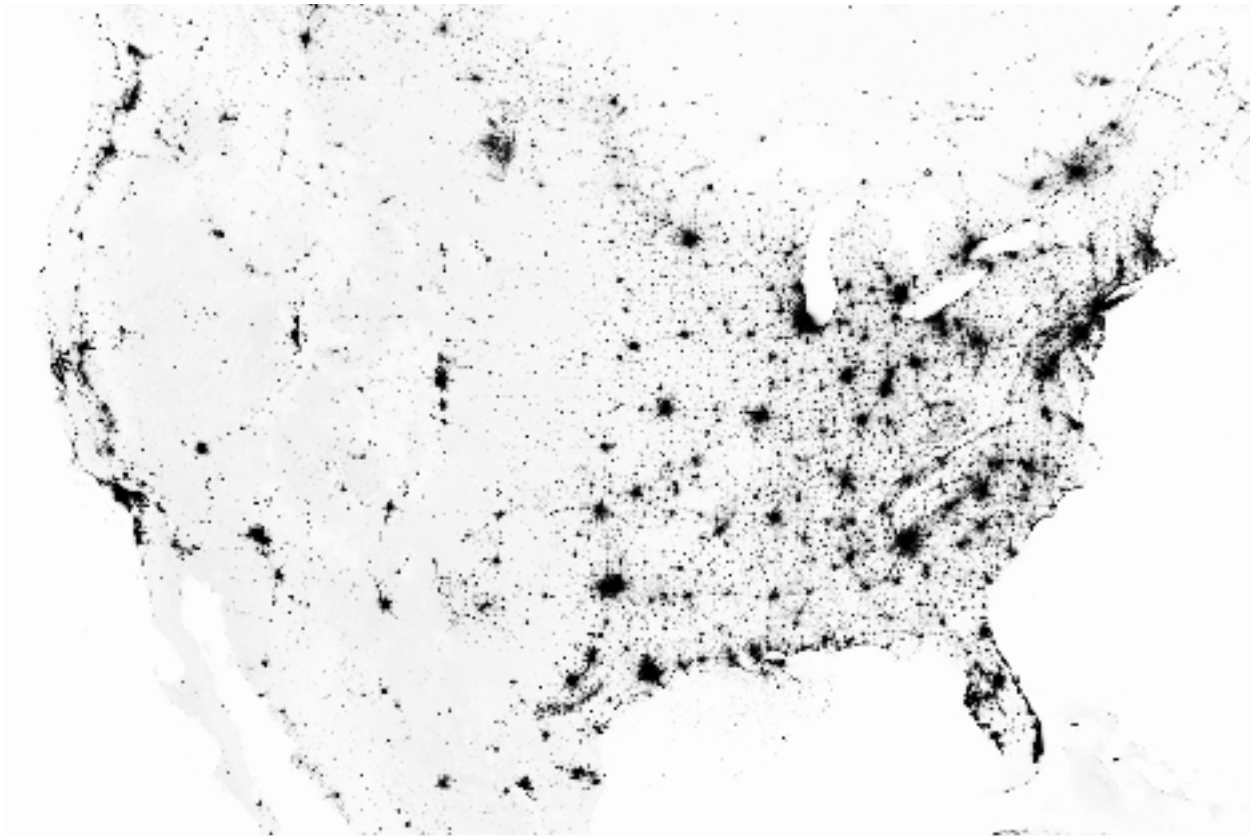

Image: NASA satellite negative of the United States at night[1] - boundaries between states vanish leaving a network of inhabitation and development

The intent of this piece of research is to contribute to the understanding of the role physical space plays in structuring the attitudes, relationships, and behaviors of people, specifically people who work together in firms (organizations or companies). It accomplishes its ends by taking an architect's or product designer's nuanced understanding of space and casting it within a borrowed framework.

Why borrow a framework? The nature of designing spaces for people requires that you understand those people, understand their motivations and expectations, their hopes and fears – in short it requires you to *know* them. In the commercial sector, it requires that you know their products - what their firm produces. Getting to know people and businesses also requires that one have a clear, repeatable, and communicable way of understanding and articulating this understanding. This is what we mean by a "framework," and frameworks developed in adjacent disciplines often serve the purpose very well by couching this understanding in a shared language. As such, architects and product designers are easily given over to other worlds:

[1] Original NASA composite image, 2012 https://www.nasa.gov/mission_pages/NPP/news/earth-at-night.html

philosophy, psychology, sociology, anthropology, management, organizational behavior, economics, and sometimes the hard sciences. This is an introduction to a networked world.

It is important to remember that these frameworks and theories are abstractions. Each in their own way, they present an idealized, structured way of seeing, of taming complexity by identifying underlying relationships and patterns that shed light on why things are the way they are. The measure of a good theory is the extent to which it accomplishes this illumination, offering a way of seeing things that transcends the observational and provides insight into how things relate and how they function. In this way, as the old saying goes, "There is nothing as practical as a good theory."[2]

As architects and product designers, we possessed no previous expertise on the formal study of networks. We started this research with a belief as much as a hypothesis: Companies were increasingly operating as networks of people, places and things, and these networks were adapting to ever-changing market conditions at a rate previously unseen on the scale of normal business cycles. From our professional experience, it appeared to us that workspace and the buildings that support workspace were creating an unproductive friction with the work that they were intended to support. Furthermore, the dynamics of these networks were increasingly at odds with the hierarchical, command-and-control structures of the past, *including* the way that workspace was designed and delivered. We witnessed a growing tension between what companies were asking for in their workspace and what the architecture, engineering and construction industry (the AEC industry) was prepared to deliver to them. Companies wanted flexible and adaptable spaces that helped keep them agile and competitive and their workers productive. The AEC industry wanted clear and consistent decision making that could drive multi-year, large-scale projects and long-term investments in space. We began to worry that our professional efforts, perhaps our whole careers, might be consumed by the unproductive friction between firms' need for networked space and a hierarchical design and construction process.

We hoped that a better understanding of networks could give us insight into the behavior of the modern workspace and begin to reveal the product design and architectural solutions that could better support this networked work. We saw the potential of the framework of network science to tell us something about the ways in which space, specifically workspace, impacts the relationships among individuals and groups within organizations, along with work that they pursue together.

In this realm of the application of network science to workspace, we have found the research of MIT's Sandy Pentland, Ben Waber and César Hidalgo to be particularly illuminating. We were fortunate enough to interview both Waber and Hidalgo for this research and have woven in their insights wherever possible. For Pentland, we have had to rely on written summaries of his work,

[2] Lewin, Kurt. "Psychology and the process of group living." *The Journal of Social Psychology* 17, no. 1 (1943): 113-131.

but it is no less informative. Pentland, Waber, and Hidalgo have conducted much of the primary research upon which we have built our hypotheses about networked workspace (and are listed as resources for follow-on work in Chapter 5). Suffice it to say that network science, now approaching a century old as a mathematical and scientific discipline, offers plenty of opportunities to go deep into technical analysis of organizations, but this is not our goal (a list of consultancies who perform this work can also be found in Chapter 5). It also offers plenty of opportunity to skirt the technicalities and operate purely by analogy, which risks lapsing into a kind of referential formalism that we'd like to avoid.

The aim of this work, then, is to balance the rigor and faithfulness to the mathematics of network science with an intuitive approach that allows an audience without that deep technical foundation to see firms as networks and to recognize how networks form and function. More specifically, we are interested in how the creation, arrangement, and inhabitation of physical space informs those networks. Our assumption here is that understanding networks and how they function will provide spatial practitioners – architects, interior designers, workplace strategists, operations experts, human resource professionals, and others – insight into the ways in which networks will impact their physical spaces and the people who inhabit them.

We would like to provide an open door to network science and to introduce a toolset that allows people to "tinker" with space and its relationship to the organization and digital communication in a way they might not have considered before or perhaps one that even offers new insight into their prior assumptions or conclusions. So this research is not about precise analysis and prediction, it's about experimentation, much in the way that Thomas Edison, a relentless tinkerer who lacked the technical depth of many of his famous contemporaries, brought the lightbulb to the world. Contrary to popular myth, he did not invent it. He merely perfected, through trial and error, a version of the lightbulb, and perhaps more importantly, he was successful in implementing a business model that brought it to the masses. A more recent example might be the way that CRISPR has unlocked a whole new world of genetic hacking and tinkering to people with a modicum of technical aptitude.

We're not the first architects or design professionals in this domain. "Network" models and theories have been circulating within the discipline for almost as long as "network science" has been a discipline. The success of these ideas, and interest in them, has varied over the years, and they existed quite comfortably alongside the myriad other ideas about workspace and organizations. The difference here may be the breadth of application. Network science can equally describe spaces for our industrial economy housed in factories as well as our knowledge economy operating in office towers.

But things have changed. We carried out this research in the latter half of 2020, during the global Covid-19 pandemic. If "network thinking" about physical spaces and organizations was interesting or promising prior to the pandemic, the abrupt, large-scale shift to remote work in

2020 has made it essential. If remote collaboration was but a component of the modern work experience prior to the pandemic, it has become perhaps the most critical consideration in the "future of work."

It turns out that seeing organizations as networks is a powerful and appropriate way of understanding the ways in which firms function in centralized or distributed ways. In the past, being in the same space served as an incredible accelerant of information flow in a way that actually hid or smoothed out many dysfunctions inside organizations. Atomizing organizations into individuals or even small teams functioning in a distributed way, using digital technologies as the "spaces" of communication and collaboration, amplifies the benefits of these arrangements (greater personal productivity, flexibility, freedom) as well as the costs (isolation, communication breakdown, tribalism, burnout). If there were some mild inefficiencies or dysfunction within an organization prior to this shift, they quickly become glaring obstacles in a remote-first environment. If the flow of clear, consistent communication was a challenge in a shared space, it will be like molasses in a distributed organization if unchanged. If a team lacked internal cohesion and relied on command and control leadership, there will be no team in a distributed organization. Conversely, teams with high cohesion, high trust, smooth and reliable information flow, and strong leadership can actually thrive in a decentralized environment.

At the outset of 2021, many professionals and commentators agree that the future of work will be some sort of "hybrid" between face to face collaboration and distributed remote work, with the balance tipped heavily toward the remote. This is intuitive enough, but we are all collectively figuring out, through this massive forced experiment, what exactly this means. This is where a Network Mindset (see Chapter 2) can shine. Through the lens of networks, we can start to identify what new levers (spatial, organizational and technological) companies can pull to foster success among their teams and individuals by tinkering with structuring elements like spaces, communication protocols, and rituals, or by experimenting with new cadences of convening, or by injecting new sources of knowledge/knowhow, or by establishing strategic bridges across organizational silos.

Two criteria need to be met in order to invest in workspace. The first is that the company has enough confidence that it can predict tomorrow with sufficient accuracy to make a meaningful investment in their workspace today. Second, the company believes that the investment in or improvements to the workspace will decrease the costs of making their product or they believe that the investment will increase their overall capacity to produce to the extent that it justifies the investment. Both of these conditions are harder to meet since the 2020 global health pandemic has disrupted historic workspace patterns of use. It is harder to predict the future today than it was a year ago. Our belief, as much as it is a hypothesis, is that a network mindset and seeing space as an integral part of a network of production will defuzz the future and improve our collective decision making around workspace design without asking you to predict the future.

It will be tempting for some to look at the outcomes of this research and say, “we’ve tried that” or “we already know this.” We’re not necessarily looking for novelty, but sometimes novelty comes in the form of disruptions you didn’t anticipate. If 2020 showed us anything, it is how abruptly everything can change. And when the world has changed, every old experiment is new again. So we hope that we can offer some insight and some opportunities for you to try some things old or new by bringing another perspective to the future of work and workspace.

We are grateful to One Workplace for the grant that initiated this research. We hope it is just the beginning of a broader understanding of networks, architecture and distributed workspace. We’d also like to thank all of our Wikimedia interviewees and Lynette Logan (Wikimedia’s Director of Administration), as well as Ashley Lippitt, Ben Waber and Cesar Hidalgo for taking the time to talk with us, share insights and help our understanding of networks grow.

Image: photograph of networked plant structure outside our architecture studio

A Very Brief Intro

The history of formal Network Science, as it is known today, is relatively short. While the mathematics of "graph theory" has been around since 1735, interest in scientific and popular interest in networks "exploded" at the end of the 20th and beginning of the 21st century[1]. Major catalysts of this explosion include the development of electronic communications networks,

[1] Albert-László Barabási, *Network Science* (New York: Cambridge University Press, 2016), 25.

advances in biology and genomics, evolving theories of social networks and social interactions, new mathematical theories of networks and network behaviors, and, perhaps most obviously, the rise of the World Wide Web.

Over the past 50 years or so, the concept of a "network" has become an increasingly common and useful lens with which to understand the dynamics that emerge in complex systems involving many relationships among many entities. Aside from the fact that networks have become so visible to us in our information age, the science of networks has shown itself to be a remarkably powerful explanatory and analytical tool for understanding systems across a wide range of domains.

So what is a network, technically? Here is perhaps the simplest definition: "[...] a network is any collection of objects in which some pairs of these objects are connected by links"[2]. It is this simplicity that allows the network, as an abstraction, to be applied across so many different domains, and hence forms the basis for its flexibility.

These "objects" can be people, web-pages, movies and actors, scholarly publications, proteins, routers on the internet, or just about anything. Links can be any relationship among those objects. As such, a rigorous definition of those objects and links becomes an important variable in the application of network science to these domains. This will become clearer in the following sections and chapters, but by way of a quick example from a work environment, understanding the connections among co-workers as either a social and informal or hierarchical and formal – are two people friends or superior-subordinate? – would each tell you something different about that relationship and the broader network in which those two individuals are embedded.

While understanding network structure – which object or entity is linked to which others – in itself offers an illuminating view of networks, a critical insight offered by the network lens is an understanding of the behaviors and dynamics of the network as a whole, and how they emerge from the behaviors of individuals: "the fact that each individual's actions have implicit consequences for the outcomes of everyone in the system"[3]. This is perhaps the most alluring and important contribution of this way of thinking, not only that complex interdependencies exist, and that "everything is linked to everything else," but that these interdependencies have structure and behaviors that can be visualized and analyzed, that "complexity has a strict architecture"[4].

This is not to imply that networks are mechanistic. We should be careful not to confuse the complicated for the complex. Networks do not describe complex systems as connected cogs in a

[2] David Easley & Jon Kleinberg, *Networks, Crowds, and Markets: Reasoning about a Highly Connected World,*(New York: Cambridge University Press, 2017), 2.
[3] Easley and Kleinberg, *Networks, Crowds, and Markets,* 4.
[4] Albert-László Barabási, *Linked: How Everything is Connected to Everything Else and What It Means for Business, Science, and Everyday Life* (New York: Basic Books, 2014), 7.

machine, where "one cog turns, causing the next one to turn, and so on"[5]. So there are limits, but for the purposes of designers, both spatial and organizational, a network understanding can offer insight into aggregate behaviors and effects in ways that offer options for adjustment, or "tinkering" as was noted in the introduction.

The history of network science, though short, is rich and filled with the contributions of scientists, mathematicians, engineers, sociologists, diplomats, and more. While we will not cover this history in more detail here, it is worth delving into, and so we'll offer some suggestions from the references that informed this work. The book *Linked: How Everything is Connected to Everything Else and What It Means for Business, Science, and Everyday Life* and the textbook *Network Science,* both by Albert-László Barabási, a pioneer of network science, are both useful, with *Linked* being the more accessible, less technical of the two. The textbook *Networks, Crowds, and Markets: Reasoning about a Highly Connected World* by David Easley and Jon Kleinberg also offers a comprehensive education on the science of networks, with options for a broad introduction to the topic or deeper mathematical investigations of graph theory, game theory, and their applications. Two other titles that provided useful examples of the applications of network science in different domains, and which informed much of the "theory" contained in our research, are *Why Information Grows: The Evolution of Order, from Atoms to Economies* by César Hidalgo and *The Chessboard and the Web: Strategies of Connection in a Networked World* by Anne-Marie Slaughter. While not explicitly about network science, we found General Stanley's McChrystal's *Team of Teams* as a clear, concrete example of how network science can be applied to management structure as well as the design of physical space.

Key Concepts

As with any formalized theory or discipline, network science has a number of fundamental definitions and concepts that are more or less consistently shared among its proponents, and in this section we will outline a few of these. Admittedly, we're cherry picking the things that will lend themselves to our overall conclusions, and leaving out a huge amount. Our goal here is to provide a primer on a baseline set of terms that allow designers and strategists to understand and engage. For a deeper dive, consult the books noted in the above section.

Nodes & Links

As described in our simple definition, networks consist of objects and the connections between them. This is a general statement, however, and network science has specific terms it employs for these fundamental entities: *nodes* and *links*. Nodes are our objects, and links are our connections. It's worth noting that in Graph Theory, the mathematical component of network

[5] Stanley McChrystal with Tantum Collins, David Silverman, and Chris Fussell, *Team of Teams: New Rules of Engagement for a Complex World* (New York: Portfolio/Penguin, 2015), 57.

science that deals with the representation of networks, these terms are "vertex" and "edge." For our purposes, which are focused on the design of workspace, we will stick with node and link, as they refer more directly to "real" elements in real systems.[6]

These terms are perhaps most intuitive when seen in the conventional way of visualizing networks:

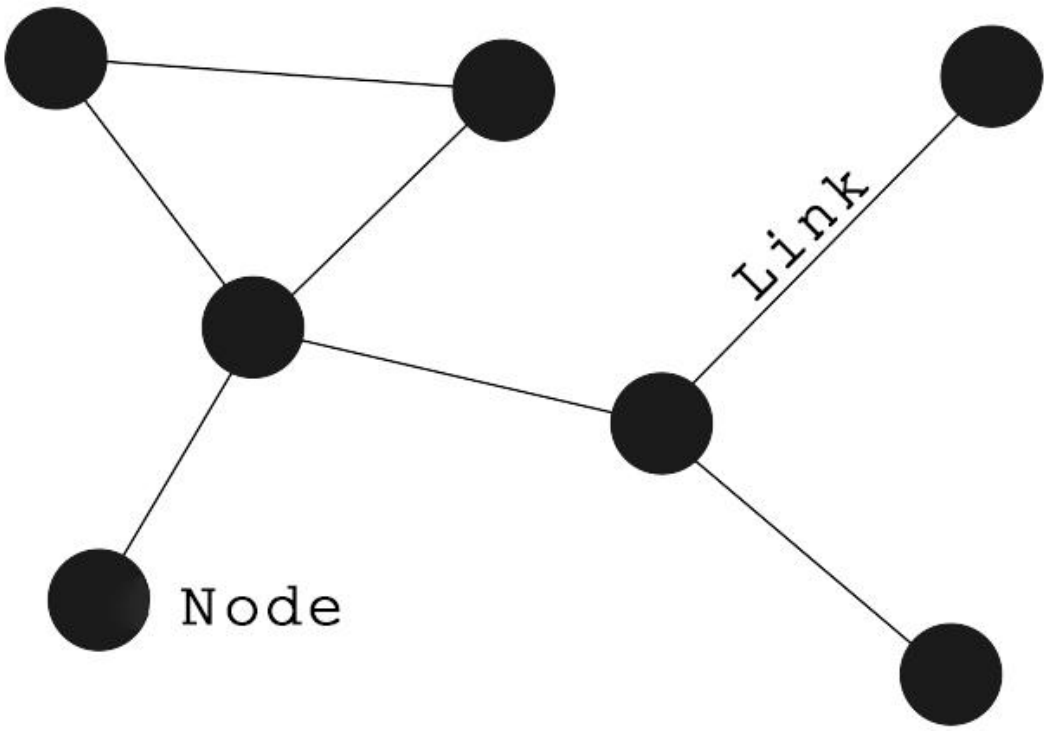

Image: Basic network graph with nodes and links annotated

A common application of this approach is the network mapping of social networks, where the nodes would represent individuals in the network and the links represent a relationship between those individuals. Online social networks, such as Facebook or LinkedIn, have allowed for the mapping of social relationships at a scale that was unthinkable before the existence of these internet-based applications. Prior to these applications, the network representation of social relationships would have to be constructed, typically by researchers asking people about the people with whom they are connected. Online social networks allow users to curate their personal connections, which are then aggregated with those of other users and stored.

[6] Barabási, *Network Science,* 45.

As of 2020, Facebook has the largest number of users in the world, at 2.8 billion monthly active users, each of which would be represented as a node in Facebook's massive network[7]. Facebook and other social networks also offer ways of analyzing not just whether people are connected but the *strength* of that connection. For instance, you may have a connection on Facebook that is an old acquaintance and with whom you rarely, if ever, correspond. You may also be connected to your sibling or best friend with whom you exchange daily messages, comment on or "like" posts, etc. The frequency of this communication, along with its directedness (one-way or two-way), then, is a reliable proxy for how strongly or weakly you are connected to another person.[8] We will discuss the implications of link strength in a later section, but this example serves to illustrate two things: 1. That not all connections are equal, and 2. That the definition of what constitutes a link is variable and will tell you different things about the relationship between two nodes.

This example also maps well to our domain of study, which is workspace. It has become common in organizational network analysis to look at the electronic communications, email primarily, among employees to develop a network map of an organization.[9] It is worth noting here that the organizational charts, or org-charts, that visualize the reporting hierarchy within a firm, are also a form of network map, one that treats the superior-subordinate relationship as the fundamental definition of a link.

In our research and our thinking about workspace and networks, we occasionally associate nodes to individual people, which is an almost standard assumption in social network analysis, but more often, for our purposes, we define our base unit or node as the "team." For the purposes of this research on workspace, we have defined a team as consisting of 5 to 15 individuals. Some would place team size more narrowly at 5 to 8 individuals[10] while others more broadly at 20 to 30.[11] For the design and layout of workspace, we have found 5 to 15 to be a reliable range for defining the size of a team. You might think of a team as a self-sufficient grouping of people who share an objective in a specific productive contribution (or task), which could be a standalone product output or a component of a larger product. A team might also be viewed as the next largest organizational grouping above the individual contributor. Over time, teams engaged in specific tasks in specific organizations will develop attributes that come to inform their functional behaviors, such as optimal size, leadership, structure, division of labor, and standard processes and procedures. The relationship between these attributes, the performance of teams, and the

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[7] https://www.statista.com/statistics/264810/number-of-monthly-active-facebook-users-worldwide/ It's even more remarkable to note that this is a count of *monthly active users* – the number of users who visit the site in a 30 day period. The total number of Facebook members would be larger than this.

[8] Easley and Kleinberg, *Networks, Crowds, and Markets,* 54.

[9] For those who would like to learn more about this topic, we have provided the names of a few social network analysis firms in the resource section Chapter 5.

[10] Gershoni, Guy, "Perfect Team Size for Successful Agile Software Development," Strategic and Heuristic IT Management, July 24, 2019

[11] McChrystal, Team of Teams, 126

overall organizational network is also a dynamic one, in which each will inform the other and change over time.

Our links are comprised of relationships defined inclusively[12] by either informational or material exchanges between nodes. As we are focused on the development of products, these exchanges consist of flows of information or material through a product development process. In this way, networks are not static. Instead, they rely on these flows and they can also grow and change over time. As Anne Marie-Slaughter has written: "The network itself exists only as long as exchanges are happening across it."[13] Furthermore, maintaining these flows requires inputs of energy, effort, or capital, and in this way, they have a cost associated with them. A key aspect of our conclusions relate to the relative costs (or investments) in both proximity and connectivity across these links.

Structure & Connectedness

A network in which every node is connected to every other node is called "complete," but complete networks, outside of theory, are rare. Most real networks are sparse, meaning that they have far fewer links than are possible mathematically.[14] A recognition of the general sparseness of real networks is effectively what opens them up to interrogation and analysis, as many of the measures of network characteristics refer, in some way, to how and to what extent a node is linked to its neighbors or connected to other nodes in the broader network. Because we know that not all nodes are connected, we can study this connection or lack thereof and use it as an analytical variable.

Many of the characteristics of networks that are measurable start with the node but are extended to aggregate measures at the level of the whole network. For instance, the most basic measure of network connection is *degree*, which is simply the number of links a node has (Barabasi 2016, 147) or how many other nodes it is connected to. The *average degree* of the whole network, then, would be the degree of each of its nodes averaged over all of the nodes.

Nodes do not have to be directly linked (neighbors) to be connected, however. Two nodes are connected if there is a *path* between them. A path refers to following links in order to reach a particular node from another node. A network is said to be connected if there is a connection between all nodes in the network. It is possible that a network is *disconnected*, that is it is made up of distinct *components,* or sub-networks, that have no path between them.

In our setting, looking at organizations and workplaces, these measures become important because connections play a role in allowing information to flow across an organization, which in turn creates the conditions for production. In addition, connection can be seen as a requirement

[12] "Inclusively" meaning either one, the other, or both.
[13] Anne-Marie Slaughter, *The Chessboard and the Web: Strategies of Connection in a Networked World (New Haven: Yale University Press, 2017), 57.*
[14] Barabasi, *Network Science,* 53.

for and correlated with *cohesion*, which in turn has ramifications for trust and belonging and the ability for groups of people to coordinate toward a common goal.[15]

"Siloing" is another organizational concept that would be related to network connection, albeit one that network science does not itself use.[16] Instead, a "disconnected" organizational network would be one in which two groups in which there is not at least one connection between them. This might be a form of strict silo, but organizational siloing can happen even when connections exist, because of other communication or power dynamics that emerge in networks. However, in order for siloing to happen, there must exist a condition where more densely connected groupings of nodes are less connected to each other across the boundaries of those groupings. The most common example would be the creation of formal departments that separate groups according to disciplinary or operational assignments.

Clustering

The term that network science uses to describe the density of links or connection is "clustering." Clustering is measured by a "coefficient" and is essentially a measure of the connectedness of a particular node in a network. The clustering coefficient of a node is defined as the probability that two randomly selected friends of it are friends with each other.[17] The clustering coefficient is also the fraction of a node's total neighbors that are also neighbors with each other. This is known as the "local" clustering coefficient, as it pertains to a single node and its neighbors.

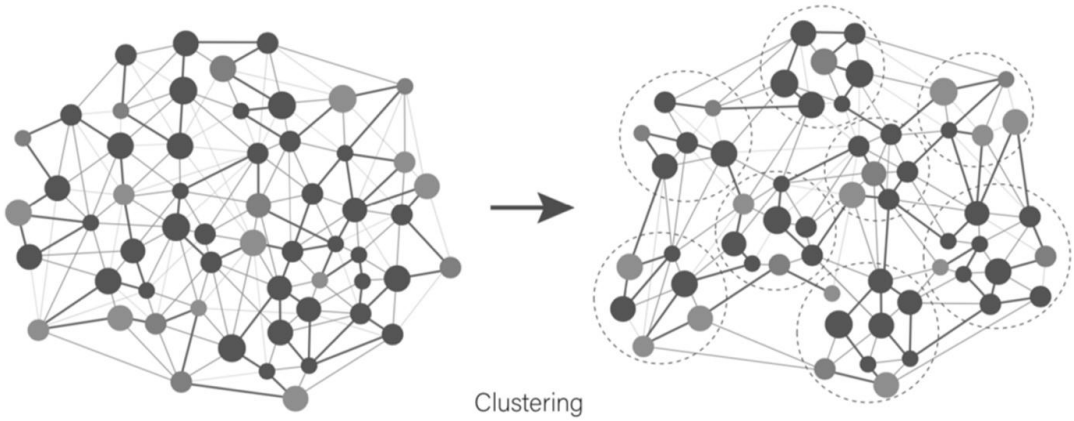

Image: Random network and random network with clustering[18]

[15] https://en.wikipedia.org/wiki/Group_cohesiveness
[16] "Silo" has become a common term in management. ***The Silo Effect*** by Gillian Tett (New York: Simon and Schuster, 2016) is a good treatise on the causes and impacts of organizational siloing.
[17] Easley and Kleinberg, ***Networks, Crowds, and Markets,*** 45.
[18] Meisner, Dennis. "AB-Testing Challenges in Social Networks," Towards Data Science, July 14, 2020

Another way of looking at the clustering coefficient is to see it as a measure of the "closure" within a localized area of a network. The term *triadic closure* refers to the propensity for triangles to "close," especially in social networks, and workspaces would be no exception. For example, if you are friends with two people who are not friends, there is a higher likelihood that, over time, those two friends will become friends.[19]

Bringing these concepts together then, clusters occur in networks where there is a higher density of connections. The key contributors to this density are degree, the number of connections nodes have to other nodes, and clustering, which measures how likely it is that neighbors of a node are also connected forming closed triangles in the network. This is important because highly connected clusters in networks are likely to have stronger links (relationships), higher cohesion, trust, and the ability to act in a coordinated fashion. It is no mistake, then, that clusters where all the nodes are connected to each other are called "cliques."

Centrality

If clustering is a measure of the density of connection, and serves as an indicator of cohesion and strength of connections, then "centrality" is a measure of the importance of an individual node within a network.

There are four types of centrality that offer different angles on the importance of a node. The simplest, and perhaps the most obvious is "degree" centrality, which is simply the number of links or neighbors a node has. Intuitively, the more connected a mode is, the more important it is to the network. Social network analysis in organizations has shown that, often, a network can be fragmented into multiple disconnected components just by removing a few highly connected individuals.

"Betweenness" centrality is a measure not just of how connected a node is but how much of a role it plays as a conduit in the broader network. Mathematically, this is measured by the number of "shortest paths"passing through a given node. Slaughter points out in *The Chessboard and the Web* that this measure can be seen as an "opportunity for brokering" because "a node with high betweenness centrality [...] sits at the crossroads of information money, or goods and is thus able to exert control over the interactions of other nodes in the network."[20]

"Eigenvector" centrality is also related to this "brokering" function in that it is a measure not only of a node's connections, but also the connections of its connections. A powerful, highly connected node in a network will tend to be connected to other powerful, highly connected nodes. Slaughter compares these nodes with Manuel Castells' "switchers," such as "politically wired media moguls,

[19] Unless they are active enemies, which creates a different network dynamic which has also been studied, but that we will not pursue further here. For a good overview of this topic see Easley and Kleinberg, ***Networks, Crowds, and Markets,*** chapter 5 on "Positive and Negative Relationships."
[20] Slaughter, *The Chessboard and the Web,* 169.

Wall Street executives who fund political campaigns, and university trustees who sit on corporate boards."[21] In terms of the workspace, eigenvector centrality may be thought of as an indicator of "bridging capital" that individuals or firms accumulate over time and may be very valuable to other nodes in the network.[22]

The last type of centrality is called "closeness"centrality . Closeness centrality is a bit less intuitive to explain in real world terms, but it is the average distance between a node and all of the other nodes in a network.[23] A good way of understanding this is through the lens of the so-called "six degrees of separation" made famous by Stanley Milgram through his experiments in 1967. Milgram sought to find the "distance between any two people in the United States," and discovered that on average, any two randomly chosen people are 5. 5 (rounded up to six) people away from each other.[24] Now imagine a similar experiment inside a company where you find that you, yourself, are on average three people away from anybody in the company – this is your closeness centrality. For another less connected friend, this number could be higher. Perhaps for your boss or for a person in HR who onboards all new employees, it could be much lower.

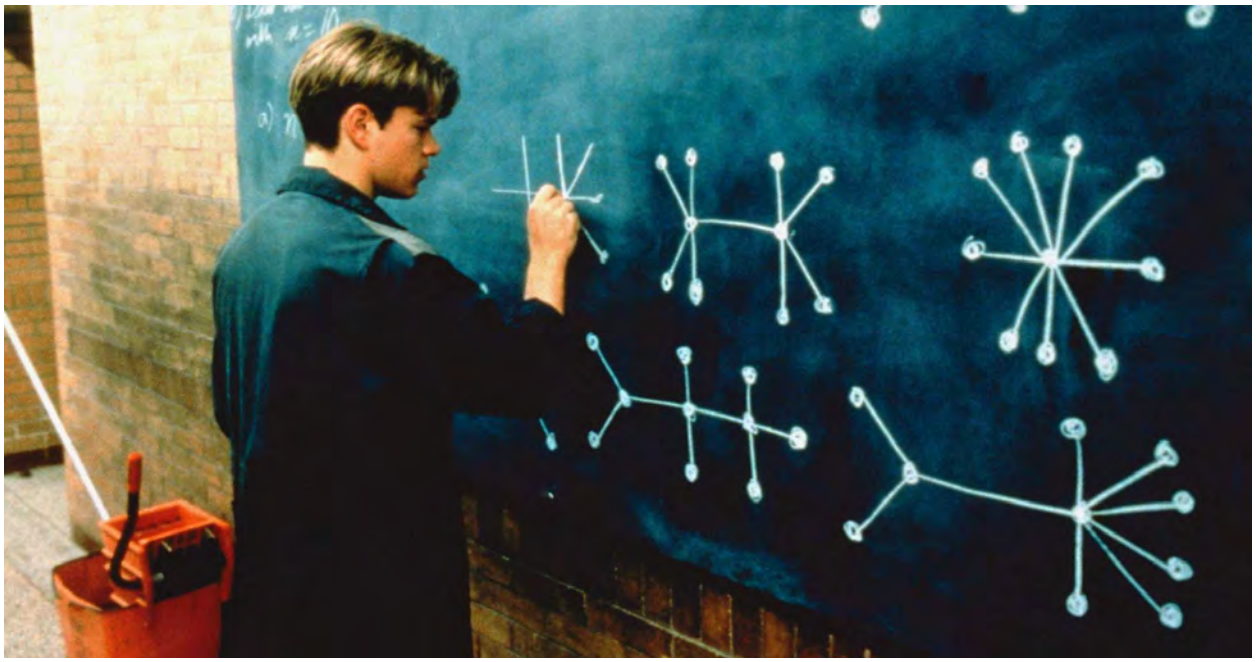

Image: Graph theory and network structure in Good Will Hunting. Matt Damon's math problem was to draw all homeomorphically irreducible trees of size n=10.

[21] Ibid, 170.
[22] https://link.springer.com/article/10.1186/s40649-020-00079-4
[23] Ibid, 48.
[24] Barabasi, *Linked,* 28-30.

Strong & Weak Ties

Links themselves can possess qualities that provide additional nuance to the relationships described in networks. One of these qualities would be the connection's valence, either positive or negative. In social networks, positive links would indicate friendship, whereas negative links would indicate antagonism. The concept of "structural balance" provides a framework with which to analyze relationships across a network and anticipate network dynamics as the network seeks to balance these positive and negative relationships.[25]

Another of these qualities would be the weight of the connection, which would indicate the relative strength of the link or, possibly, the volume of whatever flows the link describes (information, bytes, scholarly citations, money, etc.).[26] A more specific form of weight, and perhaps one of the most well-known aspects of networks, would be the link's "strength" as it relates to the duration, intensity, intimacy, and reciprocity of the relationship between two nodes in a social network.[27] The concept of "strong" and "weak" ties originates in the work of Mark Granovetter, who discovered that job-seekers were most often connected to opportunities through more distant personal contacts, or acquaintances, rather than close friends. This illuminated the so-called "Strength of Weak Ties," which is the observation that acquaintances play a critical role in connecting disparate clusters and components within networks, and facilitate information flow that would otherwise be trapped in more highly connected clusters.[28]

A link between otherwise disconnected clusters in a network is called a bridge, intuitively named for this role. Network clusters, characterized by high average degree of connection, high clustering, high closure within the network (see section on Connectivity and Clustering), would contain a relatively high number of strong ties, and relatively few weak ties (though not necessarily none). Bridges, on the other hand, are weak by definition. The definition of a bridge is a link that joins two nodes in a graph that have no other friends in common.[29] Because of the unlikelihood that two nodes are close friends, yet share no common friends, it can be shown that "all bridges are weak ties."[30,31]

The role that bridges and weak ties play in the overall network is as conduits that enable the high speed diffusion of new information through a network. This role is critical in introducing new ideas (or opportunities) into areas of the network that would otherwise be cutoff. It is worth noting, however, that the introduction of an idea does not guarantee its adoption. "Behaviors that are in some way risky or costly to adopt – behaviors where you need to see a higher threshold of neighbors doing it before you do it as well, " do not spread well through weak ties, though

[25] Easley and Kleinberg, *Networks, Crowds, and Markets*, 107-135.
[26] Barabasi, *Network Science*, 65.
[27] Mark S. Granovetter, "The Strength of Weak Ties," *American Journal of Sociology,* Volume 78, Issue 6 (May, 1973), 1361.
[28] Easley and Kleinberg, *Networks, Crowds, and Markets*, 43-75.
[29] Ibid, 47.
[30] Granovetter, "The Strength of Weak Ties," 1364.
[31] Easley and Kleinberg, *Networks, Crowds, and Markets, 50.*

awareness of them does. Diffusion in networks is a specific area of study and common feature of diffusion models is that awareness happens in waves preceding adoption. Actual adoption of a new idea or behavior by the majority of people depends on the adoption of that idea by neighbors with stronger ties. Simply put, most people will need to observe their friends adopting a new behavior before they will adopt it. The higher the perceived "risk," the more people that are required before the behavior can be said to "cascade" through the network. Ironically, clusters, which are in many ways indicative of trust and cohesion, can also present a barrier to adoption of new ideas. Easley and Kleinberg give this intuitive, real-world example:[32]

> Although a world-spanning system of weak ties in the global friendship network is able to spread awareness of a joke or an online video with remarkable speed, political mobilization moves more sluggishly, needing to gain momentum within neighborhoods and small communities.[33]

The intuition is not hard to follow for organizations: weak ties allow information to move rapidly through the network but both cohesion and behavioral change happen through close relationships over a longer period of time. We would argue that it is at the level of teams or smaller departments (a few teams closely linked) that the latter needs to happen.

In our case-study interviews it was not uncommon for interviewees to describe themselves as "connectors" and to see it as part of their formal role to create bridges.[34] In addition, the significant investment that companies make in large events is justified, in part, by the informal connections that are made at these events. These events are quite literally incubators of weak ties. But such events also contain programming devoted to cultivating a broad shared vision and to fostering stronger, more cohesive teams. Done correctly, they can check both boxes and become a critical tool in the distributed work toolbox.

In this section, we introduced some key concepts that will allow practitioners to think and reason about networks in their organizations. These included the fundamental building blocks of nodes and links, as well as how to look at and think about various types and measures of connectedness in networks. The discipline of network science goes far deeper analytically on these subjects, and offers mathematically rigorous approaches to their evaluation. For our purpose, an understanding of the intuition behind the math and an ability to use these models to see an organization as a network will suffice. We will refer back to these concepts repeatedly in other chapters.

[32] Ibid, Chapter 19, 497-536.
[33] Ibid, 511.
[34] See Chapter 03

Types of Networks

Aside from the localized structure of nodes, links, and clusters, there are a few common types of macro network structures, each exhibiting certain behaviors, strengths and weaknesses.

Structural Types

In 1964, a young researcher named Paul Baran was asked to come up with the best structure for a communications network that could survive a nuclear attack. Baran showed three graphs, which he called centralized, decentralized, and distributed. The more common terminology used today would be star, hub, and mesh.[35]

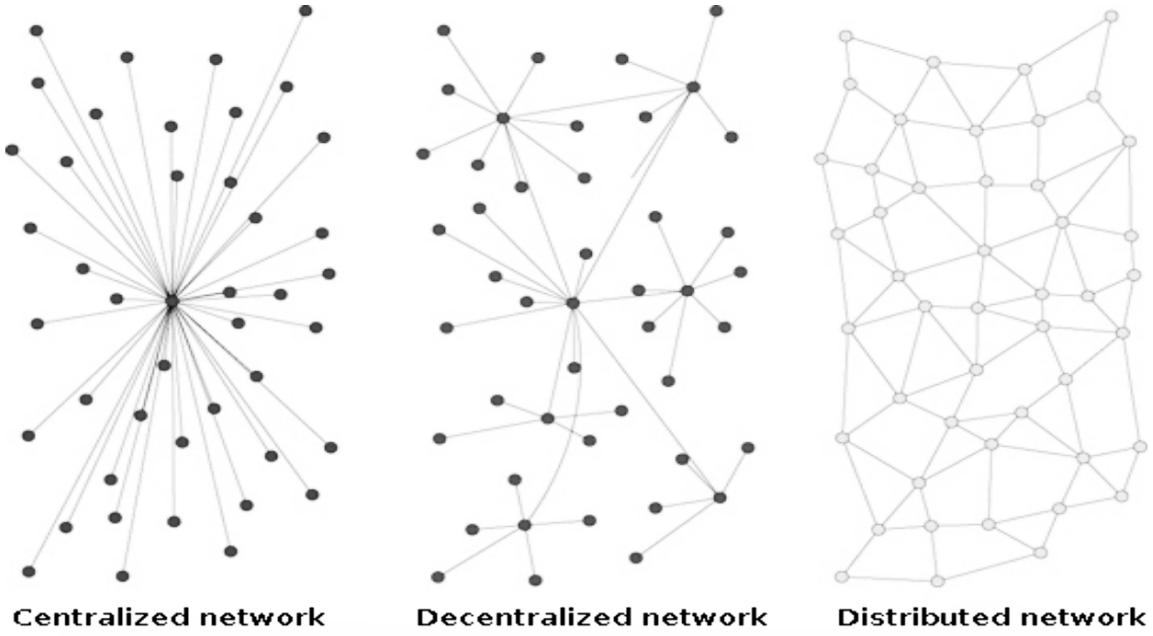

Image: Paul Baran's three types of networks In 1964, Paul Baran began thinking about the optimal structure of the Internet. He suggested that there were three possible architectures for such a network – centralized, decentralized, and distributed – and warned that both the centralized and decentralized structures that dominated communications systems of the time were too vulnerable to attack. Instead, he proposed that the Internet should be designed to have distributed, mesh-like architecture.[36]

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[35] Barabási, *Linked,* 143-146; Slaughter, *The Chessboard and the Web,* 82.
[36] Barabási, Linked, 145

Star (Baran's Centralized network)

A star network is a simple structure where all nodes are connected back to a single, central node, with no connections among the outer nodes. In the star, all communications would originate from or pass through the central node. This structure has a unique form of efficiency, in that no node is more than two degrees removed from any other, and is ideal for centralized control, as all nodes are one link away from a coordinating center. However, the star is extremely vulnerable to attack because eliminating the hub would shatter the network into individual nodes.

Hub (Baran's Decentralized network)

The hub network contains a series of stars, the central nodes of which are connected forming regionalized centers. Most hierarchical organization structures can be represented as a hub network, with team leaders, managers, department heads being the centers of distributed hubs. In this way, the hub is more resilient than the star, but still vulnerable to the attack of any of these multiple center points.

In real social networks the likelihood is low of finding an actual star or strict hub structure, where peripheral nodes are not also connected in some way or there is not some branching that would create a hybrid, such as a hub network with a single center. In this way they are more indicative of abstract or idealized structures, such as corporate organization charts.

Mesh (Baran's Distributed network)

The mesh network was Baran's suggestion for the most resilient network structure. A mesh is characterized by a distribution of nodes such that there are no "hubs" – no single point of failure locally or globally. Mesh networks are so-named because they display a net- or mesh-like structure with a relatively even distribution of nodes, equally connected, with no obvious central nodes or clustering. The structure of routers on the internet does, in fact, form a mesh network.

While they are not synonymous, mesh networks would be closely related to random networks, the graph structure elaborated by mathematicians Paul Erdős and Alfréd Rényi. In a random network the probability distribution if degrees of connection follow a normal, or bell curve, distribution. What this means practically, is that most nodes have around the same relatively small number of connections, with fewer nodes having either very many or very few connections, and none having an extremely large number of connections relative to the average. Albert-László Barabási in his book *Linked* uses the analogy of average height to illustrate a bell-curve:

> If you measure the height of all your adult male acquaintances and prepare a histogram counting how many of them are four, five, six, or seven feet tall, you will find that most people in your sample are between five and six feet tall. Your histogram will have a peak around these values. [...] you will have very few seven- or eight-foot people in your sample. The same is true for shorter people: Three- or four- feet-tall people will be rather rare.[37]

[37] Barabási, *Linked,* 67

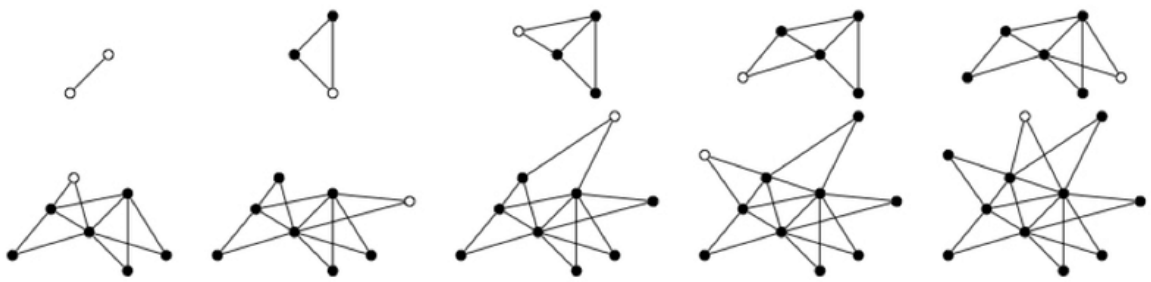

Image: The Birth of a Scale-Free Network. The scale-free topology is a natural consequence of the ever-expanding nature of real networks. Starting from two connected nodes (top left), in each panel a new node (shown as an empty circle) is added to the network. When deciding where to link, new nodes prefer to attach to the more connected nodes. Thanks to growth and preferential attachment, a few highly connected hubs emerge.[38]

Scale-free

In the late 20th century, as the availability of data on real networks and the overall interest in networks grew, new understandings of network structures began to emerge. By studying real networks that "had evolved organically,"[39] Barabasi discovered that many large networks, including sites on the world wide web, have the same degree distribution, which does not follow the random network's bell curve, and that they exhibit a few key behaviors and characteristics. These networks, called "scale-free" are marked by the presence of large, strongly connected clusters, connected by fewer bridges, recalling Mark Granovetter's work on strong and weak ties in sociology. They also roughly echo the 80/20 rule illustrated by Italian economist Vilfredo Pareto (but later named by others), which is that a very small number of nodes account for most of the links and most nodes have relatively few links. This distribution follows what is called a "power-law," which is characterized by few exceedingly large events and very many small ones (as well as mathematically undefined maximums and minimums and poorly defined averages, unless intentionally bounded in a set domain).[40]

[38] Barabási, Linked, 87
[39] Slaughter, *The Chessboard and the Web,* 55.
[40] Ibid.

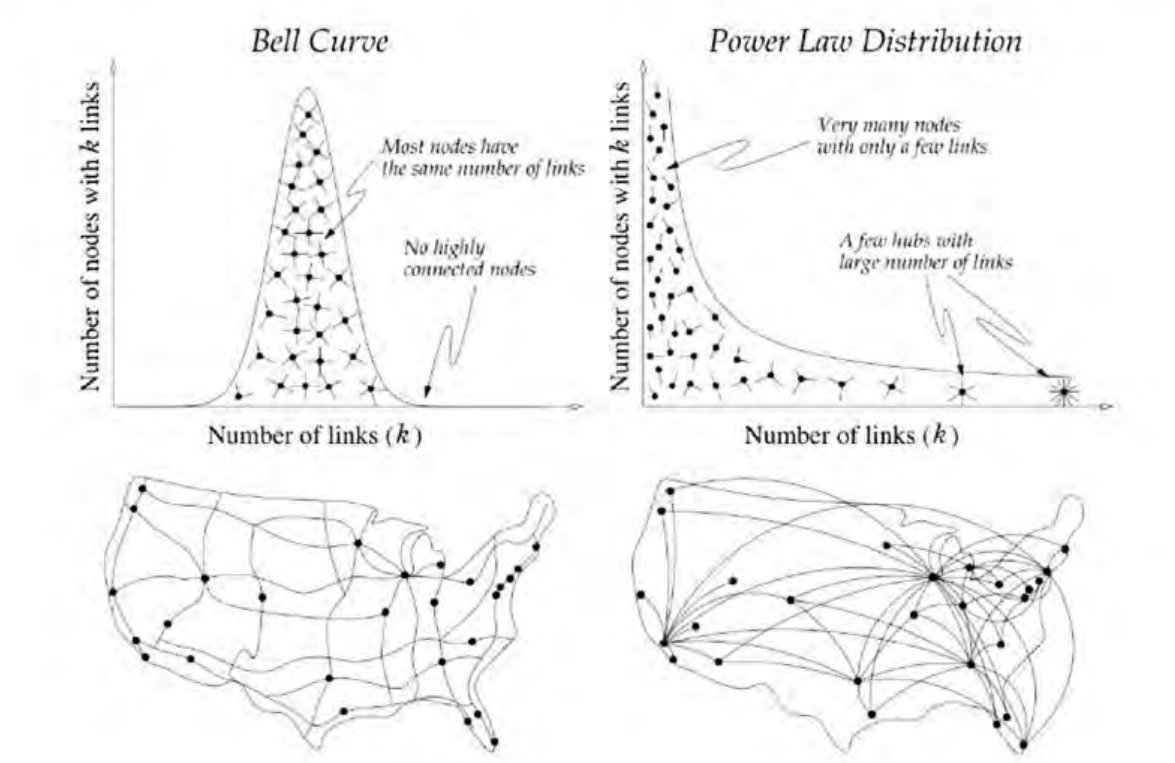

Image: Random and Scale-Free Networks. The degree distribution of a random network follows a bell curve, telling us that most nodes have the same number of links, and nodes with a very large number of links don't exit (top left). Thus a random network is similar to a national highway network, in which the nodes are the cities, and the links are the major highways connecting them. Indeed most cities are served by roughly the same number of highways (bottom left). In contrast, the power law degree distribution of a scale-free network predicts that most nodes have only a few links, held together by a few highly connected hubs (top right). Visually this is very similar to the air traffic system, in which a large number of small airports are connected to each other via a few major hubs. (bottom right).[41]

Following his explanation using height, Barabasi offers the following:

> If the height of an imaginary planet's creatures followed a power-law distribution, most creatures would be really short. But nobody would be surprised to see occasionally a hundred-feet-tall monster walking down the street. In fact, among six billion inhabitants, there would be at least one over 8,000 feet tall.[42]

[41] Barabási, *Linked*, 71
[42] Ibid.

This structure also gives rise to the so-called "small-world" effect, in which it is fairly easy to get to any node in a network by traversing just a few links. This is illustrated in the principle of "six degrees of separation" and also in the popular game "Six Degrees of Kevin Bacon," whereby you try to connect any randomly selected actor back to Kevin Bacon through the network of actors sharing the screen in films.[43]

Barabasi also notes that modeling scale-free networks requires two things. Firstly, they require growth, adding one node at a time over a period of time. Secondly, this growth must display a behavior called "preferential attachment," wherein the probability of a node receiving an attachment to a new node is proportional to the links the receiving node already has. "Given the choice between two nodes, one with twice as many links as the other, it is twice as likely that the new node will connect to the more connected node."[44]

This growth and preferential attachment is what creates the power-law distribution, the presence of a few extraordinarily highly connected nodes. The result of this is "richer get richer" or "winner take all" dynamics, where a node's number of connections, be they social or economic, become self-reinforcing – highly connected nodes are destined to become even more highly connected, which can result in massive inequalities in the network.

This is also related to what might be seen as the scale-free network's biggest liability: its vulnerability to attack. These networks are very tolerant of random failures, because of the overall number of connections, low average distance in the network, and the fact that any randomly selected node is likely to have very few connections. On the other hand, a coordinated attack on a known hub – one of the rare nodes with an extraordinarily high number of connections – would be disastrous. "The targeted destruction of a few of the biggest nodes can bring down the entire network."[45]

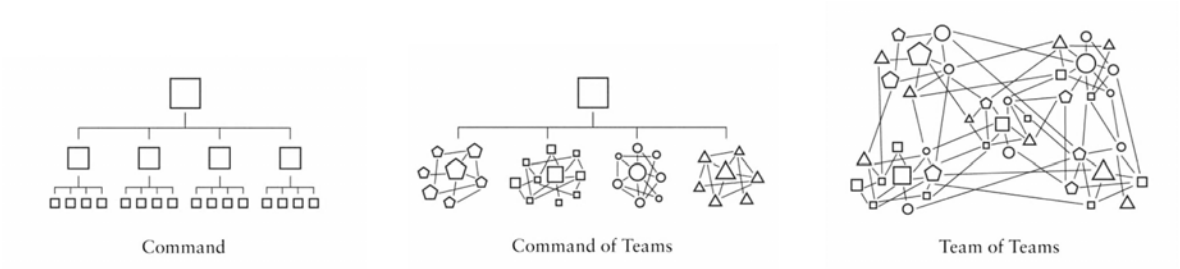

Image: McChrystal's Team of Teams concept is a scale-free organizational model that leverages the trust and reciprocity born of small groups but avoids the scalar problem of becoming strangers to one another, which is symptomatic of large organizations.[46]

[43] Barabási, *Linked,* 58-62.
[44] Barabási, *Linked*, 86.
[45] Slaughter, *The Chessboard and the Web, 55.*
[46] McChrystal, Team of Teams, 129

Functional Types

Whereas the structural types outlined above are analytically and practically useful, they remain abstractions removed from any notion of purpose or intent in a network. In her book, *The Chessboard and the Web,* Anne-Marie Slaughter builds upon the fundamentals of network science to offer a "starting point, a framework for analysis, and a set of tools"[47] that begin to build a "playbook for strategies of connection"[48] in the realms of foreign policy and business. One aspect of building Slaughter's playbook involves moving from the mathematical abstractions of network science into the realm of the practical and functional and of tying those abstractions to real world strategies "to solve public problems, much as an engineer applies physics, chemistry, and mathematics to solve engineering problems."[49] Our research has a similar goal for the application of network science to workspace, and so we rely heavily on the frameworks set up by Slaughter.

Slaughter outlines three major strategic categories of networks which are based on what she sees as the categories containing the most difficult problems that foreign-policy-makers face: "resilience problems, execution problems, and scale problems." For each of these, Slaughter outlines three network typologies addressing these problem sets: Resilience Networks, Task Networks, and Scale Networks.[50]

While organizations certainly need to be resilient, most of the work that happens within an organization fits fairly neatly into the realm of execution or Task Networks, and this is the lens with which we approach much of our research. In addition, larger organizations producing complex products also need to operate within Scale Networks, and as medium or small organizations become more distributed, the lessons of Scale Networks apply to them as well.

Resilience Networks

Resilience problems involve avoiding and responding to crises, whether man-made, natural, or both, ranging from direct military attack to an earthquake to a famine.[51]

Resilience networks must take on the characteristics of natural systems – diversity, modularity, and redundancy – in order to create networks that are resistant to shocks. Slaughter describes three sub-types of resilience networks, each adopting a somewhat different network structure in order to achieve specific capacities. Defense networks need to be resistant to attack, and as noted above, the mesh network offers the best solution because of the parallelism and redundancy of the type.[52] Response networks, which kick into gear after the initial shock of the crisis, need to bias the rapid dissemination of reliable information to a likely fragmented and

[47] Ibid, 26.
[48] Ibid, 13.
[49] Ibid, 78.
[50] Ibid, 77.
[51] Ibid, 77.
[52] Ibid, 84-90.

atomized community. For this purpose, a modified hub network, called a "modular hierarchical network" is recommended.[53] Modular hierarchical networks, like their name suggests, offer both hierarchy, which allows for centralization and multiple distributed command centers, and modularity, which creates redundancy in connection and allows each module to function autonomously, while maintaining connection to other modules up through the hierarchy to the center.[54] Lastly, stabilization networks are required to recover and regain stability after the initial response to a crisis. For this purpose, another modified hub is recommended. In this case, however, it is a hub network where the clusters of nodes around each hub are highly connected with each other. This offers the distribution and redundancy of the hub, but also allows for high levels of peer-to-peer trust and cohesion required to stabilize a community.[55]

Task Networks

Execution problems require the implementation of a specific task or set of tasks by identifiable individuals or organizations to accomplish a concrete goal such as addressing a financial crisis, implementing a peace treaty, or finding new ways to reduce carbon emissions.[56]

As the name implies, Task Networks are focused on execution toward a "concrete goal" comprising "specific, time-bound tasks." In some way, every organization is a task network, regardless of the scale of the task or the ambition of the goals it sets out to achieve. There is work to be done, and in organizations that work is carried by people working together. Of course, there are myriad reasons that some people and some organizations work better than others, and the network lens offers a way of seeing where problems may arise because of lack of information flow, lack of trust or cohesion, organizational siloing or disconnection, etc. Thinking about organizations as specific strategic network types also offers insight by clarifying the nature of the problem or task the organization is addressing. Slaughter offers, again, three types of Task Networks:

- A cooperation network is a linked group of individuals working together to carry out a prescribed task in a prescribed way.
- A collaboration network is a linked group of individuals figuring out together the best ways to carry out a prescribed task that itself may evolve
- An innovation network is a linked group of individuals tasked with generating new ideas, processes, and/or products in the service of a prescribed general goal.[57]

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[53] Ibid, 91-96.
[54] Perhaps the most interesting feature of modular hierarchical structures is that they are not only modular and hierarchical, but they are also scale-free. In fact, it has also been shown that most real-world, scale-free networks have some identifiable degree of hierarchy. See Erzsébet Ravasz and Albert-László Barabási. "Hierarchical organization in complex networks." *Physical review E* 67, no. 2 (2003): 026112.
[55] Slaughter, *The Chessboard and the Web, 97-108.*
[56] Ibid, 77.
[57] Ibid, 112.

Put another way, for cooperation networks, the task is clear and the execution is clear. In Collaboration Networks, the task is clear, the execution is unclear. And in Innovation Networks, a shared, but sometimes fuzzy high level goal is present, but neither tasks nor execution is clear.

The strategies for Task Networks all hinge on managing connectedness. In the case of Cooperation Networks, connecting disconnected clusters via their central node and getting those central nodes aligned on a task will foster additional connections across the clusters and contribute to behavior change within the clusters. For Collaboration Networks, Slaughter references Stanley McChrystal's "Team of Teams," where the command structure of the military was turned into a star network, where each peripheral cluster can act autonomously (like the Al Qaeda network) and is tied informationally to other clusters as well as to a central command. It's worth noting that this is similar to the Resilience-Response Networks noted above and the Scale-Coordination Networks discussed in the next section. Lastly, Innovation Networks benefit from the connection and alignment of multiple larger networks and organizations, each bringing a high-degree of capability and specialization to bear on the goal. These networks are characterized by open-boundaries for information flow and shared incentives that cross these boundaries. What these "open innovation"[58] networks allow is the creation of links to high-value knowledge or capability that frees organizations from the costs of internalizing that knowledge or capability. "Aggregating knowledge and linking multiple problem solvers with different areas of expertise fosters a far more complex division of labor in the innovation process." [59] As we will see in later sections, both the costs of knowledge and information flow, as well as the complexity of the division of labor, play a role in organizations' choices about team centralization and distribution.

Scale Networks

Scale problems arise when challenges are being overcome at the micro-level but not at the macro-level.[60]

Scale Networks are fundamentally geared toward wide-scale dissemination and adoption of policies or practices. Scale problems arise because solutions to problems are often manageably sorted out in small experiments and pilots, but scaling those solutions to large populations and geographies can be "frustratingly resistant to small-scale approaches."[61] Like Resilience and Task Networks, they come in three flavors, each with a slightly different operation: replication, gathering-in, or parcelling-out. These three operations are aligned with three categories of "scale" problems.

Replication Networks, and the operation of replication, addresses problems where a discrete solution is well-understood, but requires wide scale adoption. This is called replication because

[58] See also Henry Chesbrough, *Open Innovation: The New Imperative for Creating and Profiting from Technology* (Boston: Harvard Business School Publishing), 2006.
[59] Slaughter, *The Chessboard and the Web,* 128-133.
[60] Ibid, 77.
[61] Ibid, 136.

these solutions can be carried out by a relatively small number of people, and so it is really a problem of information diffusion and adoption. Examples given for this kind of solution are the "playbooks" or guidelines built by organizations like Alcoholics Anonymous, Tedx, and Team Rubicon that create low barriers to adoption and a lot of local autonomy. For these organizations, network replication requires only motivated individuals who can adopt the playbook and mobilize a modicum of local participation. The network strategy, then, is borrowed from viral marketers, who target small, interconnected clusters where there is enough openness to the adoption of new ideas but enough cohesion to quickly meet the thresholds for adoption across the cluster. Individuals who span multiples of these small clusters are key targets, because they have both the bridging capital to connect clusters but also the bonding capital to reinforce behavior within those clusters.[62]

Coordination Networks, which both "gather-in" expertise and "parcel-out" solutions, represent a slightly different problem where there is a general consensus on a policy or solution but it requires larger amounts of coordination across differing organizations, disciplines, or geographies to implement. The strategy here is the creation of "'interfirm networks' composed of various small and large companies that collaborate to perform different components of the research and development and production processes." Examples of coordination networks include the Global Alliance for Vaccination and Immunization and the Global Covenant of Mayors for Climate and Energy. One important aspect of coordination networks is that they are fundamentally star-shaped (with the nodes being organizations not individuals), and require a strong central node to manage the coordination (though not in a "command and control" way).[63]

Cumulation Networks also "gather-in" and "parcel-out." In this case, however, they are aligned with problems requiring the distribution of effort across wider networks with more diffuse specialization and a more granular disaggregation of work into smaller units. Slaughter notes that Cumulation networks can also be any of the three types of Task Network. Examples of this type of network are Amazon Mechanical Turk, Wikipedia, and the Linux open source software development project. In Coordination Networks, each contributing organization contributes specialized knowledge or capability to a large-scale coordinated effort, whereas in Cumulation Networks each contributor is taking a small chunk of the larger problem or goal, and providing the solution back to the network which will then recompile the parts into a whole. Similar to Coordination Networks, which require a centralized coordination node, Cumulation Networks require enough hierarchy to ensure quality in the final re-aggregated product.

Hierarchies in Networks

In our initial literature review, we found that there was a tendency to frame hierarchies as something other than a network. While we found this distinction to be a particularly useful framework for understanding workspace today, we will also show that depending on the

[62] Ibid, 137-148.
[63] Ibid, 149-153.

transaction costs and risks associated with any given network, a hierarchy may viewed as just a specific instance of a network.

In order to illustrate our view, we should look at a few common definitions of the term 'hierarchy,' which can cause some confusion if they are intermingled with each other uncritically. On the one hand, hierarchy can be viewed as an organizational structure built upon assigned relationships of authority and compartmentalization of functions. Commonly associated with top-down, "command and control" management, which emphasizes centralized direction passed down, level by level, from superior to subordinates,from the highest level of the hierarchy to the lowest. A "hierarchy" would be typified by either military style command or a "Fordist/Taylorist" industrial model of production, which emphasizes high degrees of standardization, specialization, and central coordination aimed at maximizing the overall efficiency of production. The hallmark of the hierarchy is the optimization of the system through centralized, top-down management, assigned authority, and management of the efforts of individuals at a high level granularity, even down to the movements of individuals in the case of Taylorist "Scientific Management." [64]

A more technical view of hierarchy is as a structural model that shows nesting relationships between parent and child entities, where one category contains the other, as in a subset and a superset relationship. This definition refers to abstract relationships, and does not necessarily mean the presence of relationships of authority, rank, or value, though there can be a part-whole relationship.

In more modern collaborative or "networked" models of organization and management, these nested entities exhibit a high degree of autonomy to achieve objectives. This autonomy follows a continuum from so-called "decentralized command"[65] where high level goals and objectives are set centrally, but teams are given the latitude to execute as they sit fit to achieve them, to even more decentralized models such as "holocracy"[66] or Stanley McChrystals "Team of Teams" approach, where teams are free to set objectives and execute against them as they see fit in alignment with the overall purpose of the organization. It is important to note that these hierarchical relationships have been shown to be "a fundamental characteristic of many complex systems."[67]

We propose a definition of hierarchy that blends these two definitions into one that works for thinking about both the structure and characteristics of organizational hierarchies in network terms. In framing hierarchy as a type of network, we are leveraging the ideas of Walter Powell,

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[64] https://en.wikipedia.org/wiki/Scientific_management

[65] A term actually borrowed from the organizational structure of the Marines and the Navy, and made popular more recently by ex-Navy Seal turned media personality and business consultant, Jocko Willink. https://en.wikipedia.org/wiki/Jocko_Willink

[66] https://www.holacracy.org/

[67] Erzsebet Ravasz and Albert-László Barabási, "Hierarchical organization in complex networks." Physical Review E, 67. See also Barabási, *Network Science,* chaper 9.

Ronald Coase, César Hidalgo and synthesizing it with what we have learned about centralized, star networks from Anne-Marie Slaughter and Albert-László Barabási. We define it as a stable, multi-level star network arising from high-transaction costs and evidenced by efficient outputs. In this way, we capture the structural relationship, while retaining the ability to also inject the authority function as a characteristic of the links and flows within the network.

Chapter 03 of this research contains a case study on the Wikimedia Foundation, which we approached as both a Task and a Scale Network organization. Slaughter also uses the foundation as an example of the hierarchy required in Cumulation Scale Networks:

> Even Wikipedia – a nearly pure coordination network with volunteer content production, editing, and policing – is centrally managed by the Wikimedia Foundation, whose paid staff designs the platform's software, vets contributions, and mediates disputes, and whose board sets standards and complex administrators around the world to accept updates.[68]

We will discuss topics of standards, trust, and network relationships at Wikimedia and beyond in more detail in Chapters 03 and 04.

In this chapter, we introduced a brief history and key concepts of Network Science, along with some examples of Network Structures. Having a basic understanding of these concepts will help with the chapters that follow and may also spark an interest in diving deeper into the more technical, mathematical side of networks. In the next chapters we will build on these basics to help develop a "Network Mindset," apply these concepts to a case study of the Wikimedia Foundation and the production of Wikipedia, as well as develop a more general set of suggestions for organizations grappling with the tradeoffs between centralized versus distributed work and workspace.

[68] Slaughter, *The Chessboard and the Web*, 156.

Chapter 2 - The Network Mindset

From Node to Link, Applications of Network Science to Workspace

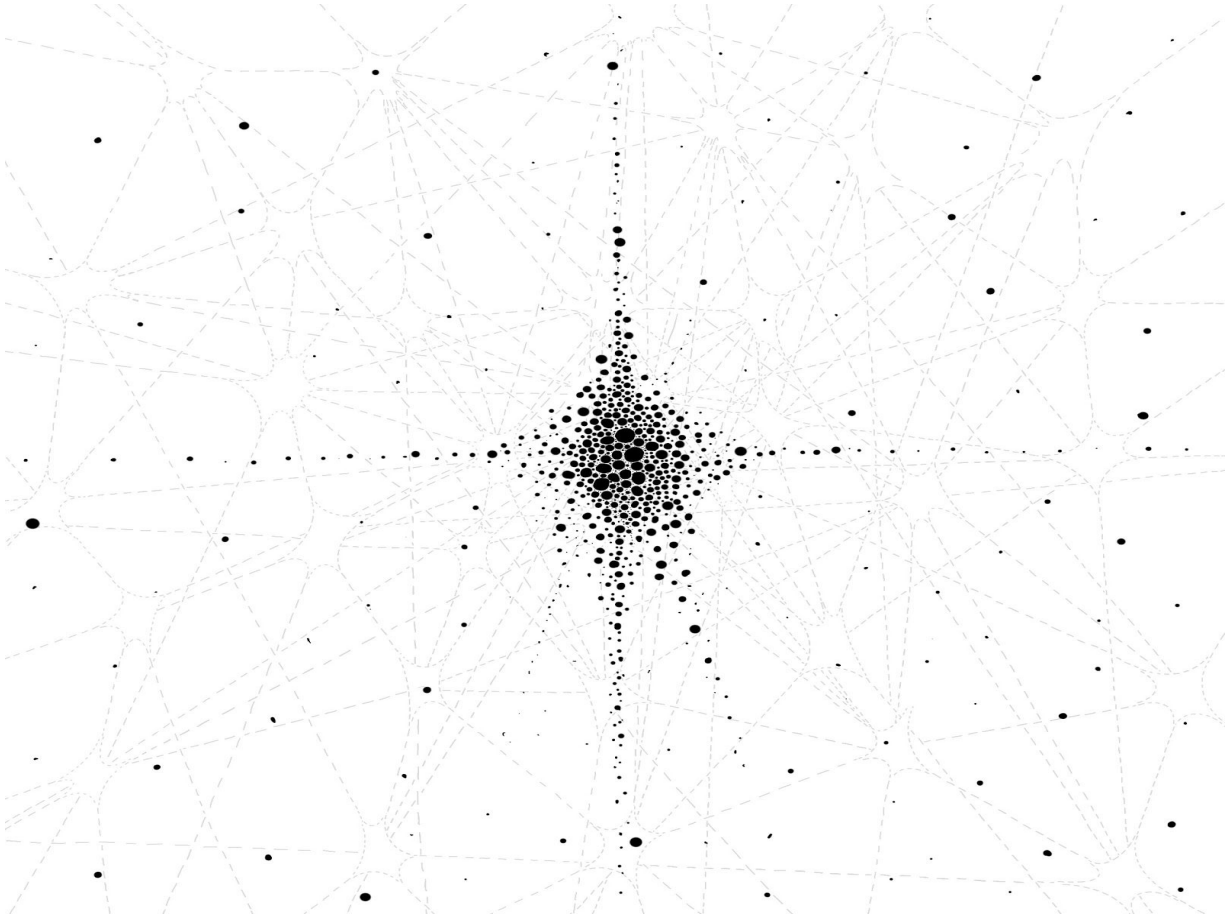

Image: our concept drawing of a network

In this chapter, we will take you through various applications of the concepts presented in the previous chapter, along with some examples from other fields, that help to illustrate the Network Mindset and how this view can add a new dimension to the understanding of workspace. We will proceed through four understandings that will also help to frame our overall hypotheses and recommendations about Network Spaces.

1. **Flows define a network**. Without flows a network is not a network it is a collection of parts. Understanding the flows of a company's internal and external network is foundational towards understanding their workspace needs. Flows can be dominated by the movement of physical information embodied in the material to make a physical product; or dominated by the transmission of pure information in the case of a digital product. But in all cases it is the flow of energy, matter and information that ultimately defines a network – this is equally true for cellular biology and workspace design.

2. **Links run on trust.** The various aspects of what has become to be known as “social capital” is a critical ingredient to ensuring that networks grow, through the addition of new nodes and communities, and that networks are cohesive through the addition of connections among groups of nodes. Trust also ensures that flows are efficient across those links. Increasingly, reinforcing organizational identity with “purpose” is a key building block of social capital and is a necessary complement to proximity in a distributed organization.

3. **Links have costs**. The costs of making or links, whether they are a click on your phone, commuting to the office or constructing a new railway will inform the structure of the network, the efficiency of its flows, and its capacity for both knowledge and growth.

4. **Nodes have capacity**, and an organization’s capacity to make both physical and digital products can be measured by the amount of capacity embedded in their network. This network capacity always has two dimensions, one internal to the company and the other external to the company with transaction costs sitting at the edge in between.

Image: Keck, Jakob, 2017 Rahpaädno River - Creative Commons

The Importance of Flows

Say the word “network” you will almost certainly see recognition in the faces of your colleagues, perhaps even a knowing smile or a head nod, but these knowing nods often disguise a misunderstanding or at the very least some level of misalignment. Network to someone in a campus facilities department might refer to their IT department, the IDF room and their proximity to the internet fiber in the street outside their campus. Network to someone in people operations or HR might refer to the informal and formal communication patterns within your company, patterns that infer who has influence and who has power within the organization. If we look to those who sit on the edge of our companies, perhaps someone in supply chain management, network may mean their host of individual contractors or whole external companies who expand their capacity to develop and deliver products or services. While we would agree with all of these working definitions of network as reasonable, we found ourselves needing something more grounded and less mutable based on the context of its usage. For terra firma, we turned to biology.

In biological terms, network theory has been used to describe the flows of information, energy and matter that move among cells and clusters of cells in order to allow an organism to function.

This network of life cannot be defined by simply adding up all the cells, the connections between cells and the clusters of cells within any given organism – it requires something more. It requires understanding the flows between cells. It is these flows of energy, matter and information that ultimately determine the network performance for living organisms, and it is through this lens of flows that we will explore how network science can inform the workspace design.

As we noted in the last chapter, Anne-Marie Slaughter drives this biological definition home with the work of physicists Fritjof Capra, pointing out that, "the network itself exists only as long as exchanges are happening across it [...] the network is a network only as long as those communications are actually flowing. Dead organisms have DNA, genes, proteins and molecules just as live ones do; what makes a living organism a network is the flow of energy and matter within it."[1] We have found this stark comparison of a network to be most reliable when applying network science to workspace: All networks are alive. All networks require active flows across their links. If you cannot name the flows, you do not understand the network.

Networks, seen through this lens of flows, can be defined not only by the nodes, links, and overall structure, but also by what is flowing across those links and stored in those nodes. The flows of physical material and creative ideas that make physical products may be very different from the flows of digital bits and bytes that make a digital product. A change in flows means a change in network behaviors, which could require a different workspace. For instance, the social capital, the bonding and bridging capacities that reside within our people and within communities, may become asymmetrically depleted from the spatial isolation imposed by the current Covid health crisis. As Ben Waber described in our interview with him, "[i]f you look at the effect of the pandemic, the number of strong ties have gone up. Strong relationships got stronger. Weaker relationships got weaker."[2] If this pattern holds true, it would mean that we would become more efficient at team-level tasks that rely on close relationships, but over the long run, we could expect to see problems of innovation and network growth due to the lack the infusion of new ideas, which relies on loose connections to adjacent networks or communities.

Looking back to our original examples of divergent network definitions based on our divergent, hypothetical personae, we can see how the logic of flows can bring clarity to what is and what is not a network. An IT department becomes a network when energy and information flow across its fiber; without these flows there is just a collection of wires and hardware. The staff for people operations or HR becomes a network when they are communicating with each other; without talking, emailing, Slacking, or texting they are just a group of people who happen to be collecting a paycheck from the same bank account. Lastly, for our supply chain manager, her supply chain becomes a network when money, goods and services flow between companies, creating a quantifiable stream of value.

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[1] Slaughter, Anne-Marie. 2017. *The Chessboard & The Web: strategies of connection in a networked world*. New Haven: Yale University Press. Page 57

[2] Waber, Ben. 2020. "Interview of Ben Waber by Josh Emig and Nash Hurley" Google Meet, November 18, 2020

Links of Trust

Our built environment is composed largely of buildings that were designed to support hierarchical production. Hierarchies proved to be excellent structures for increasing efficiency, and in terms of workspace, the efficiency and centralization is well understood as a byproduct of the industrial revolution and the industrial economy that followed. Our shared language of rust belt, factory town, and brownfield site conjures shared imagery of a time when workspace was defined by large-scale factories devoted to the production of physical products. This is most prominently on display in the physical plants of mega factories like Ford's 1920s River Rouge complex.

Later, in the 1950s, as the knowledge economy became the driver of economic growth, efficiency and centralization once again showed up in the increasing density of our cities' commercial business districts. Here, in these downtowns, paper and face-to-face meetings replaced iron ore as the medium flowing within the network of production, but the results were the same. Centralization of workspace and consolidation of control in order to drive down the cost of production – internal, transaction and external production costs. With respect to knowledge workers and downtown commercial districts, we have largely inherited the building typologies that were better suited to our parents' and grandparents' workstyle, dependent on centralization and clear boundaries and better suited for hierarchical models of production. Our workspace and the workspace of our children will need to leverage our cooperative, collaborative, and innovative networks of production.

In *The Rise of Network Society*, Manuel Castells noted that "networks are the fundamental stuff of which new organizations are and will be made, "just as hierarchies were the fundamental building blocks of Industrial Age organizations."[3] Anne Marie Slaughter offers a succinct description of the relative benefits of networks via a summary of Walter Powell's 1990 paper "Neither Market Nor Hierarchy:

> Powell identified networks as an organizational form distinct from markets and hierarchies. Markets [...] are characterized by "discrete" (one-off) transactions among independent, "disinterested" actors (who don't know each other.) Hierarchies arise when transactions recur and require substantial investment. The transactions become routinized, governed by a central authority and dictated by rules. Networks, however, defy both categories: they are based on mutually beneficial, recurrent exchanges among flexible yet interdependent actors. Unlike markets, they enable long-term relationships, but they are also nimble enough to adapt to environmental ambiguity in a way that hierarchies cannot.[4]

[3] Castells, Manuel. 2010. *The Rise of Network Society*. Wiley-Blackwell. Page 180

[4] Slaughter, Anne-Marie. 2017. *The Chessboard & The Web: strategies of connection in a networked world*. New Haven: Yale University Press. Page 49

If hierarchies are marked by centralization, control, and clear stable boundaries, networks are decentralized and dynamic with amorphous boundaries. Whereas hierarchies rely on stable, authority based control structure, networks require something different. For those of us who crave direct comparison of characteristics, Slaughter provides a table dissecting the various characteristics of hierarchies and networks:

Characteristics of Hierarchical versus Networked Organizations	
Hierarchies	**Networks**
Centralized	Distributed
Fordism: workers perform specialized tasks over and over as part of a defined sequence	Flexible specialization: small-scale production teams simultaneously work on complementary projects
Employee traits: deference to authority, obedience, conformity	Employee traits: autonomy, adaptability, problem solving, collaboration
Ties are strong but few	Ties are loose by many
Tasks, managers, and departments are organized by function	Tasks, managers, and departments are organized by project
Communication is vertical command through defined channels	Communication is lateral as well as vertical consultation
Management derives from authority from title rank, and seniority	Management derives authority from expertise and contribution
Job descriptions and areas of control are narrowly defined	Job descriptions are broad and boundaries are permeable
Transaction and payment are the glue of relationships	Trust and reputation sustain relationships
Slow to adapt, difficult to change	Quick to adapt, easier to change
Key decisions are centralized so coordination costs are low	Decentralized decision making, so higher employee satisfaction and loyalty
Performs well in stable, predictable environments	Performs well in ambiguous environments that require efficiency and flexibility

Table: Chessboard and the Web[5]

[5] Slaughter, Anne-Marie. 2017. *The Chessboard & The Web: strategies of connection in a networked world*. New Haven: Yale University Press. Page 52

Slaughter continues to explain that networks depend on the trust born of reciprocity – pointing to corporate anthropologist, Karen Stephenson's, argument that although trust is the natural glue of human connections since prehistoric times, it is mostly absent in modern hierarchies.[6]

In a hierarchy, you are much more likely to view the relationship as successful based on your status or how you are compensated for a specific transaction. This was clear even a hundred years ago. Ford's five-dollar-day was enough to attract workers from all across the United States and beyond.[7] With a network, it is the relationship itself and contextual awareness of the health of the network that comes into the foreground to evaluate success. We believe this shift from market transactions and hierarchical relationships to relationships in networks is evidenced by the intense amount of focus that organizations today are paying today to their purpose. In a network economy, purpose pays. Rather than citing a number of references here that will be quickly outdated, we suggest Googling "purpose-driven business" to better understand how purpose is becoming a cornerstone of an economically viable modern place of work.

Unlike the office tower of the 1950s or the factory of the 1920s, network businesses do not end at the edge of their buildings. Their work permeates out into a world of partners, collaborators and co-producers of your work product. Bringing this point home, in a recent talk with Michael Bush of Great Place to Work and Gary Pinkus at the global consulting firm McKinsey, Pinkus pointed out that companies need to view their partners as an extension of their business. Pinkus went on to say that people working for that company need to define themselves by what they are trying to accomplish, not to whom they report. Pinkus believes that affiliation, purpose, social cohesion and meaning are the drivers of success for future companies.[8] We have outgrown our parents' office space.

The Cost of Links

If the knowledge and knowhow embedded in networks is what allows our world to make increasingly complex products[9] and thereby grow our economics then why did hierarchies become so dominant for so long? The answer, as we discussed in the previous chapter, is that hierarchies are really just a specific kind of network: one where high transaction costs and other external production costs incentivize vertical integration market transactions or over inter-firm contracts. We have found this network definition of organizational hierarchy useful in understanding how current firms can evolve to embrace networks and network thinking, and can evolve their workspace as well.

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[6] Slaughter, Anne-Marie. 2017. *The Chessboard & The Web: strategies of connection in a networked world*. New Haven: Yale University Press. Page 53

[7] Anderson, Matt. 2014. "Ford's Five-Dollar Day," January 3, 2014 https://www.thehenryford.org/explore/blog/fords-five-dollar-day/

[8] Pinkus, Gary. 2021. Webcast "Workplace culture, and what great companies will look like in the future." February 10, 2021, Walker and Dunlop.

[9] For a full development of this assertion see César Hidalgo, *Why Information Grows: The Evolution of Order from Atoms to Economies (New York: Basic Books), 2016.*

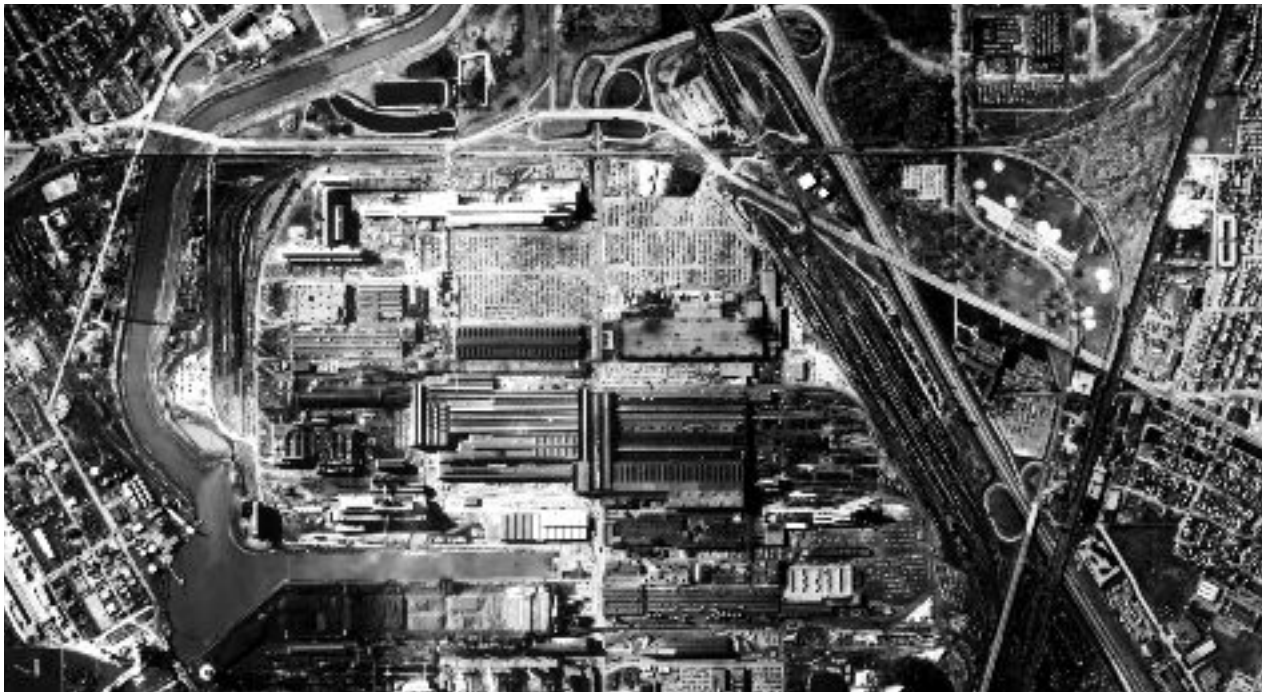

Image: Ford's River Rouge, 1975[10]

In his seminal 1937 essay, "The Nature of the Firm," the economist and eventual Nobel laureate Ronald Coase argued that firms exist to avoid the transaction costs of the free market.[11] More specifically, Coase also argued that there was a cost to the internal coordination of resources in a firm, and that these costs rose in relation to the spatial distribution of the firm. To the extent that firms could centralize resources and minimize these organizational costs, the firm would integrate functions internally, versus purchasing them on the open market, and would grow.[12] To see what this means for workspace, we can look to one of the most cited examples of hierarchical production – again the Ford Motor Company. When Ford's River Rouge plant was completed in 1927, it had ninety-three buildings totaling sixteen million square feet of factory space.[13] Ford drove efficiency through centralization and created a production process that existed almost entirely unto itself. It was an aggregation of the productive capacity of thousands of people – thousands of *personbytes*, as César Hidalgo would later label it – made even more efficient by the investment in capital-intensive equipment like metal forges, metal stamping machines and metal-moving assembly lines. It was a network defined by the flows of metal,

[10] Ford River Rouge Plant Aerial Picture. 1975 http://www.fordmotorhistory.com/factories/river_rouge/photos_1.php

[11] De Smet, Aaron; Gagnon, Chris; Mygatt, Elizabeth. 2021. "Organizing for the future: Nine keys to becoming a future-ready company." McKinsey Insights. January 11, 2021

[12] R.H. Coase, "The Nature of the Firm," Economica, 4: 386-405. https://doi.org/10.1111/j.1468-0335.1937.tb00002.x

[13] Hidalgo, César. 2016. Why Information Grows: the evolution of order, from atoms to economics. New York. Basic Books. Page 87

people and energy – organized in a very specific way for a very specific outcome, to make a Ford Model-T.

Hidalgo acknowledges, however, that the theory of the personbyte explains that

> larger networks are needed to accumulate larger volumes of knowledge and knowhow, but it does not explicitly tell us why our world is not filled with megafactories that are ten or twenty times larger than River Rouge. [...] The limited proliferation of megafactories like the Rouge implies that there must be mechanisms that limit the size of the networks we call firms and make it preferable to disaggregate production into networks of firms."[14]

Hidalgo calls this limit the *firmbyte*, the maximum amount of knowledge and know-how that can be contained within a firm. When this limit is approached, as Coase recognized in a different way, the costs to manage the internal coordination of resources in a firm will rise. At this point, Hidalgo adds, "when the external transactions become less costly than the internal transactions, firms stop growing, since it is better for them to buy things from the market than to produce these internally."[15]

Hidalgo's framework and Coase's theory help us to see the centralized, hierarchical production of Ford's 1920s River Rouge Plant as an example of a network of production. A task network entirely within the boundaries of one organization because of high transaction costs and high external production costs and/or risks.

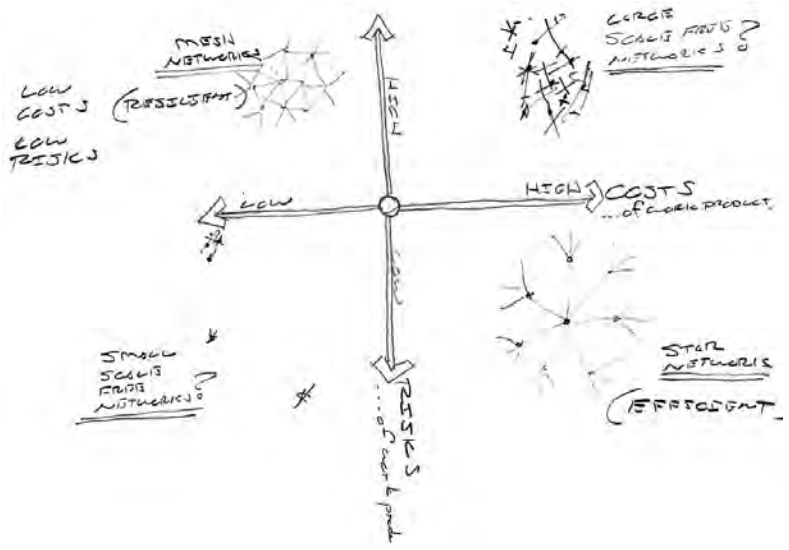

Image: our concept diagram hypothesizing how costs and risk of network production may influence network structure, 2021.

[14] Hidalgo, César. *Why Information Grows: The Evolution of Order from Atoms to Economies* (New York. Basic Books),2016. 89
[15] Ibid, 91.

As transaction costs and external production costs dropped through the second half of the 20th century theory, Ford's production began to take a new shape – a distributed shape. It became more efficient to produce parts and pieces through the network of relationships than trying to make everything under one roof. This trend toward distributed production continued to the extent that by 2009 at the height of the great recession, Ford's CEO "worked with rivals GM and Chrysler to make sure the suppliers they all depended on – many of which were struggling – stayed in business. [Ford's CEO] recognized that the interdependence of the market meant that keeping these suppliers alive would benefit Ford."[16] Ford and its network of suppliers had a shared purpose and therefore it benefitted Ford to invest in the health of its network. Ford had evolved from a self-contained network of production to become a part of a broader network of production.

As a recent McKinsey report points out "with transaction costs plummeting (spurred by rising connectivity) [Ronald Coase's 1937] rationale no longer holds up."[17] Our hierarchies are turning into distributed networks because the transaction costs associated with making products is "plummeting." Seen through this lens, hierarchies are not something other than a network, rather they are a network internalized to reduce transaction costs. Factoring in advances in communication technology, especially for knowledge work, many services, and in the preproduction phases of manufacturing, what we are experiencing today is a dramatic disentanglement of transaction costs and physical proximity. Coase's statement in 1937 that "the costs of organising and the losses through mistakes will increase with an increase in the spatial distribution of the transactions organised" does not hold the in the way that it once did. Amassing staff in the same space, Monday through Friday from 9am to 5pm, is no longer a requirement for building an organization's capacity. As we will explore in the next section, communications networks have allowed organizations to far exceed their physical boundaries, radically changing their ability to aggregate knowledge and know-how. As Hidalgo states: "The cheaper the link, the larger the network."[18]

[16] McChrystal, General Stanely. 2015. *Team of Teams*. New York: Penguin Publishing Group. Page 195
[17] De Smet, Aaron; Gagnon, Chris; Mygatt, Elizabeth. 2021. "Organizing for the future: Nine keys to becoming a future-ready company." McKinsey Insights. January 11, 2021
[18] Hidalgo, *Why Information Grows,* 91.

[19] Image: NASA Control Command Central

The Capacity of Nodes

In 1963, NASA brought in the executive George Mueller, an electrical engineer by training, to build an emergent intelligence, an interconnected mind of scientists to get America's space program back on track. This nerve center was a confluence of people, data, knowledge and know-how.

> All data were on display in a central [NASA] control room that had links with automated displays to Apollo field centers. These rooms buzzed with activity, constantly receiving updates from contractors and teams and in turn providing information to them. It was the Internet before the Internet: information was updated and shared widely and instantly. As the utility of this information became evident, more and more engineers who were initially opposed started to come around. It was the organizational manifestation of this insight

[19] NASA Control Room
https://www.nasa.gov/centers/kennedy/history/LCC/Gallery-index.html

> [of systems thinking] that imbued NASA with the adaptive, emergent intelligence it needed to put a man on the moon."[20]

NASA's workspace drove the flow of ideas and the accumulation of the complex information necessary to land a man on the moon. Command Central remains one of the most appealing and clear examples of workspace facilitating idea flow between people.

Today's relationship of workspace to the performance of the network of work is not nearly as clear as NASA's command central. According to a recent McKinsey article, even before the Covid-19 pandemic, many leaders had realized that "their companies were organized for [a disappearing] era of standardization and predictability that's being overwritten by [...] heightened connectivity, lower transaction costs, unprecedented automation and shifting demographics."[21]

The McKinsey article goes on to claim that future-ready companies will share three characteristics:

- They will know who they are and what they stand for, and their purpose will be built into their culture
- They will operate with a fixation on speed by prioritizing people, flattening organizational structure, and accelerating decision making
- They will grow by scaling up their ability to learn, innovate, and seek good ideas regardless of their origin

Restated through our network lens, we can say that McKinsey's future-ready companies will use purpose to build trust and create links; they will replace unnecessary hierarchy and create bridges in order to speed information flow and decision making; and they will look to build their capacity by linking to knowledge beyond the boundaries of their company. In short, the companies of the future will be networked. The reliance on stability and predictability that underpinned their previous hierarchical cultures will dissolve and be replaced by adaptable sets of productive, mutually beneficial relationships much more attuned to the pace and dynamics of today's environment.

The question that organizations are now faced with is "What is the workspace of network work?" In today's age of uncertainty, we have seen two trends from leading organizations: First, do nothing because workspace is costly and its future is unclear. Or second, move to a "hybrid" model as an acknowledgement of change in the marketplace while also keeping one foot rooted in the past. What is the framework to evaluate these dramatically different approaches to workspace? As Ben Waber pointed out in his interview with us "some of these companies are

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[20] McChrystal, General Stanley. 2015. *Team of Teams*. New York: Penguin Publishing Group. Page 149

[21] De Smet, Aaron; Gagnon, Chris; Mygatt, Elizabeth. 2021. "Organizing for the future: Nine keys to becoming a future-ready company." McKinsey Insights. January 11, 2021

making some long term commitments based on very little information. In four years we'll see a number of wins, and a number of companies crumbling."[22] If they understood how their networks worked, they might be able to make more informed decisions around their workspace.

Here, we return to capacity as a north star for aligning workspace and the networked model. As an abstraction, the principles of network science often offer the ability to shift scales while retaining the principles. As Ben Waber said in an interview: "Networks of neurons become nodes when we abstract them as people, and networks of people become nodes when we abstract them as networks of firms."[23] As we stated in the prior chapter, occasionally we are looking at individuals as nodes, but more often than not, we are thinking about teams, and – again occasionally – we are talking about firms as nodes in much larger economic networks. Each node and each network has a capacity associated with it, and it is the accumulation of knowledge and know-how in the network that is associated with the potential of the network to continue to grow and produce more complex products. Continuing to draw directly from Hidalgo, "these networks are important because they are the only structures that we have available to accumulate large volumes of knowledge and knowhow [required to grow our economy]. The evolution of these networks of firms is constrained by historical and institutional factors, from a society's level of trust to the relative importance we give to family relationships."[24]

To understand how networks structures can hold knowledge, we must understand that:

- There is a relationship between the size of a productive network and the volume of knowledge and knowhow it can embody, with larger networks being able to embody larger volume of knowledge and knowhow.
- Knowledge involves relationships or linkages between entities to predict the outcomes of events without having to act them out.[25] Knowhow is the tacit computational capacity that allows us to perform actions, and it is accumulated at both the individual and collective levels.[26]
- Larger networks depend on the costs of establishing links, with cheaper links favoring the creation of large networks needed to amass large volumes of capacity.
- There are fundamental breaks, or transition points, in the structures of the networks that we use to accumulate knowledge and knowhow at the collective level.

George Mueller's approach at NASA was about consolidating this capacity – knowledge and know-how – in a single, connected space. Getting the capacity into one room is no longer a goal. The workspace strategy of the future will be about capacity, connection, and flow. The question to ask is "How can I use physical workspace to build capacity in my nodes, to proliferate links, and to

[22] Waber, Ben. 2020. "Interview of Ben Waber by Josh Emig and Nash Hurley" Google Meet, November 18, 2020

[23] Hidalgo, *Why Information Grows*, 107

[24] Ibid, 179

[25] Ibid, 6

[26] Ibid, 7

supercharge flows?" What we will see is a world in which workspace becomes less of a fixed container for the body and identity of the firm, and more of a dynamic tool to program the network by bringing people together when necessary, to build bonds and bridges, to create shared purpose and foster trust, to allow for learning, and to welcome new members and partners. But it need not persist all of the time, or for everyone. This will allow people to return to other places, perhaps distant, perhaps previously beyond the reach of the network, where they will remain connected through purpose and commitment, but not bound by the walls of a headquarters. This sounds intuitive enough, but the impacts will be radical for the design and planning of workspaces, for real estate more broadly, and for cities, urban areas, and the economy broadly.

In this chapter, we discussed the importance of flows, the role of trust, the cost of links, and the capacity of nodes in order to build on the basics of network science and to develop an understanding of the Network Mindset, a way of looking at and thinking about workspace and organizations. In the following chapters, we will proceed through a case study, where these concepts will be elaborated in a real-world context, and we will close by building on this notion of workspace as a network component and a network tool.

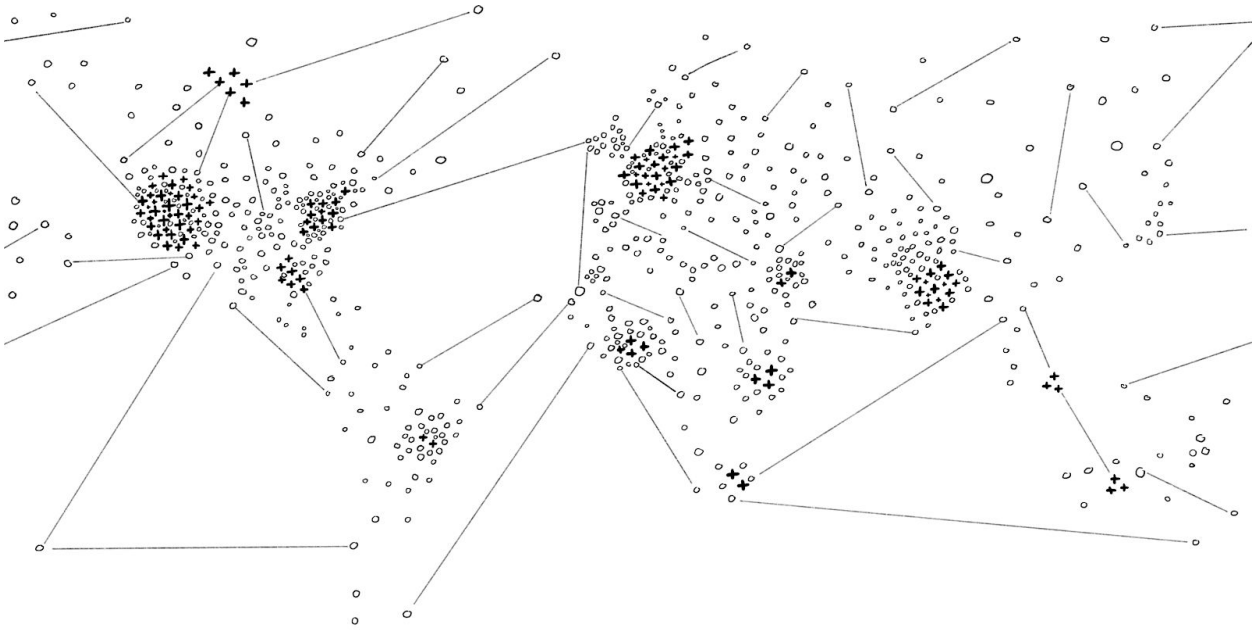

Image: our concept diagram of the Task Network of Wikipedia
(~280,000 active editors; ~500 staff & contractors; ~200 secure servers)

Wikipedia and the Wikimedia Foundation

One of the most trusted and most popular sites on the internet worldwide, Wikipedia was founded 20 years ago with a vision described by founder Jimmy Wales as “building the sum of all knowledge for all people.” Wikipedia is open for editing by everyone, and every month more than 280,000 volunteer contributors edit the site. The legal, institutional and technical infrastructure for the website is run by the Wikimedia Foundation, the nonprofit organization that operates Wikipedia and other free knowledge projects to advance the goal of a world in which every single human can freely share in the sum of all knowledge. The Foundation, founded over two years after the launch of Wikipedia, does this by providing critical technical infrastructure to Wikipedia and its other wiki projects, building software experiences for reading, contributing to, and sharing content from Wikipedia; supporting Wikipedia’s volunteer editor communities through grantmaking and other programmatic support; and advocating for policies that protect and advance privacy, free expression, and digital freedoms. The Foundation does not edit, create, or otherwise determine what content exists on Wikipedia, volunteer editors do.

The Wikimedia Foundation works in partnership with affiliate groups and individual Wikipedia volunteer contributors around the world; together, this global movement works to advance the Wikimedia free knowledge mission and ensure Wikipedia’s future sustainability for generations to come. Collaboration is at the heart of Wikipedia’s open contributor model, and thus is also a

critical part of the Wikimedia Foundation's relationship with this global movement. Staff and contractors often work side by side with volunteers on new programs, tools, and projects. An example of this is their recent Movement Strategy[1] process, a global consultation to define the future of Wikipedia and the free knowledge movement. The Wikimedia Foundation initiated this strategy conversation, and worked with volunteers to create a decentralized, collaborative process to build a 10-year strategy for the movement. This consultation drew participation from volunteers, affiliates, partners, and experts across the globe.

Significantly, Wikipedia is the only top 10 website that is run as a not-for-profit with the primary goal of furthering its mission, as opposed to generating value for shareholders. Operating as a United States 501(c)(3) nonprofit, the Foundation anticipates raising $140,000,000 in donations in 2021, with an average gift size of around $15. It will use these funds to pay for its ongoing operations and aims to distribute approximately $10,000,000 in grants to communities around the globe. One Foundation staffer noted that the not-for-profit status is core to the organization's success, saying "People donate to [Wikipedia] because of its utility and then they trust it because there's no external influence on content."

Our Methodology

For our case study on network space we conducted one-hour-long interviews with 13 Wikimedia staffers and contractors from across the Foundation from December 2020 to February 2021. A list of participants is included at the end of this chapter. One of our research team led the interview and one served as a scribe to document the interviewee's responses. All quotes in this case study are drawn from those notes. We intentionally do not not to call out the specific staffer or contractor speaking - relying on the quotes to illustrate a general Wikimedia point-of-view. All interviewees were working remotely, due to the global pandemic. At the time of the interviews, 4 were in the San Francisco Bay Area, 6 were in other US locations, and 3 were in other countries. Prior to the pandemic, 4 of them worked primarily in the Foundation's San Francisco headquarters (though not necessarily coming in 5 days per week), 3 had started in the headquarters and switched to fully remote work prior to the pandemic, and the remaining 6 had always worked remotely for the Foundation since they were hired. Said another way, 45% of the people we talked to have always worked remote, and that number had risen to 70% before the pandemic hit. At the time of the interviews 100% were remote.

A Distributed Workspace

We first got to know the Wikimedia Foundation and Wikipedia in 2012. We designed their old San Francisco spaces at 149 New Montgomery Street (though not their current space at 1 Montgomery) and worked with them to develop prototype workstations for Foundation staff and contractors prior to that. Having spent time with them at the midpoint of their history, we knew a

[1] Wikimedia 2030 Movement Strategy https://meta.wikimedia.org/wiki/Wikimedia_2030

bit about their preferences and culture, had been watching their growth and development, and saw the Wikimedia Foundation and one of its core products, Wikipedia, as a particularly interesting organization to view from the perspective of networks for three main reasons.

First, because the Wikimedia Foundation has a long history of relying on geographically distributed staff and contractors, with more than half of its people working remotely even before the pandemic. Repeatedly voted one of the top remote employers,[2] the Foundation currently has staff and contractors in 40 countries, including upwards of 500 people. It is growing across the globe, having added over a hundred new staff and contractors in the past year. At the same time, Wikipedia's volunteer editor base has grown too. The number of monthly active editors grew by 38 percent since 2016, and by 8 percent in the last quarter of 2020 alone. Certain functions of the organization traditionally had been more distributed than others. We heard in our interviews that the "majority of product and technology people are remote" while departments such as legal, accounting, and HR have tended to be more headquarters-centered and "you could always find a lawyer or an accountant in the office."

Second, we wanted to focus our first case study on an organization that makes a digital product because we thought this would maximize the potential for distributed work. (We would expect to see somewhat different patterns in an organization that produces a more physical product.) For Wikipedia, the production of encyclopedia articles is done by a globally dispersed population of volunteer editors who are tied together by a digital communication network stewarded by the Foundation and a shared sense of common purpose nurtured by the Foundation. An interviewee described their workflow as "our product is a communication tool so we can use the software itself to connect with people. . . the tool is something we produce and something we use to organize the production." In effect, the Foundation's core work is the creation of a network of connections. Another interviewee described the work as "We have given people a global ability to share in the sum of all human knowledge. We're not experts in any one area, but we give the ability for people to share in it through conversation."

Lastly, the production of Wikipedia is accomplished through distributed network effects. Unlike a traditional top down firm that produces a traditional digital product, Wikipedia relies on a massive Community of volunteers that has a relationship to, but is independent of, the Wikimedia Foundation itself. The Community and the Foundation have a relationship, they share links, that make the process for producing Wikipedia particularly interesting when considering Network Space.

What is Wikipedia and How is it Produced?

[2] Laura Begley Bloom, "Work From Home Or Anywhere: Top 20 Companies For Remote Jobs In 2020," *Forbes*, February 11, 2020 https://www.forbes.com/sites/laurabegleybloom/2020/02/11/work-from-home-top-20-companies-remote-jobs/?sh=54a56b5b157d

So, what exactly is Wikipedia? The site's own entry about itself describes it as "a free, multilingual open-collaborative online encyclopedia created and maintained by a community of volunteer editors using a wiki-based editing system." The Foundation's staff and contractors tended to describe it in relation to its broader mission, for example, "We have given people a global ability to share in the sum of all human knowledge."

On a mechanical level, Wikipedia is made entirely by volunteer editors (Foundation staff and contractors do not write, edit, or otherwise maintain content on Wikipedia in their official capacity) using the software tools created by the Foundation working with the editor community. In the words of an interviewee, it is "Written entirely by volunteers who have created a hierarchy and process for checking facts and solving problems amongst themselves. The Foundation provides a technical backbone that allows 80,000 people to come together on any given day and write an encyclopedia." There is no top-down editorial control and no particular person tasked with deciding whether any article or parts of its content are suitable for publication on Wikipedia. Everyone can edit the site. With that said, volunteers do have to abide by certain rules when editing. That is, subjects of articles have to meet certain notability requirements, and from there, facts in an article have to be backed up by reliable sources and presented from a neutral point of view. Other volunteer contributors regularly review new content "often quite savagely"[3] against the core policies to decide what to keep, what to improve, and what to delete. An interviewee elaborated, "if you take a regular Wikipedia page most content has been contributed and edited by well under 100, maybe a couple dozen editors and some bots. There have been studies about how a good article comes to life - it takes one person with domain expertise and one person with Wikipedia expertise usually. You need both and they can overlap. . . Most articles will have a few editors, but some will have a thousand - for example the article about Barack Obama." These editors communicate using the Talk Pages on every Wikipedia article (where editors discuss changes to articles). .

Describing the process of creating Wikipedia articles, more than one interviewee noted that "It shouldn't work but it does." and "Looking back to the contributors there is a whole aspect of how a product can be made by just a bunch of people talking. They're just talking. And that contributes to the evolution of a product." An interviewee elaborated, "One of the reasons Wikipedia works as a knowledge production machine - the power is much more distributed than in other entities. Moderation happens lower, so the Foundation can operate a top 10 website with [〜500] people. Private companies have trouble scaling the moderation because they want to keep that power higher up. Especially when there aren't enough people on HQ staff who speak the language."

[3] Ayers, Matthews, and Yates "How Wikipedia Works," 12

Wikipedia as a Task Network

We have been particularly interested in task networks as a lens to understand workspace. Anne-Marie Slaughter frames all task networks as versions of a hub and spoke networks that feature small, tightly connected groups, pods or teams that are connected to other groups, pods, or teams in various ways. She notes that this type of network performs best when these small groups are diverse but cohesive. A diversity of team members provides multiple talents and perspectives, while small size builds sufficient trust and team spirit for the group to act as one and to adapt seamlessly to changing circumstances.[4] While we are newer to the subject of network science, we could think of task networks with a range of structure, not only hub and spoke referenced by Slaughter but also task networks could take the shape of a mesh or star network depending on the internal production costs of the task at hand for the product being produced. For instance, a customer service call center may be more mesh-like if the problems are relatively simple and therefore have low internal production costs per task. However, if the task were to build a second version of a bridge that had already been built, in other words, a task with high internal production costs and relatively low risk associated with the task (because you've already built one), that task network may take the form of a star because that is the most efficient. For the modern knowledge worker, where both the diversity of new ideas and the quality of trust within and between teams is a driver of success, the hub and spoke in Slaughter's frameworks, what others refer to as scale-free networks, appears to hold, because its balancing the relatively high internal production costs with the relatively high risk of working on the wrong thing. This is all a long way of saying that much of the literature on task networks that we encountered had a hidden assumption that they were talking about high cost / high value complex products - and we wanted to take a moment and clarify that this makes sense for GE's or Facebook's products but may be less applicable to the work of call centers or repetitive bridge building.

While we believe the shape of a task network is informed by inherent product risks and the amount of the internal production costs for that product, there is also a dimension of the boundedness to the task itself which is a helpful dimension for understanding the behavior of task networks. Again leveraging Slaughter's research, this varying level of boundedness can be broken out into three different types of task networks:

- cooperation networks (defined input and output)
- collaboration network (defined output and undefined input)
- innovation networks (undefined output and undefined input)

Wikimedia interviewees generally felt that the process of making Wikipedia included elements of all three types of task networks in different parts of it functions, but coalesced around the idea that the core process of making Wikipedia is essentially a collaboration network, where the output

[4] Slaughter, "The Chessboard and the Web", 134.

is well defined (trusted encyclopedia pages) with the input undefined: "The rules that have been set up about what kind of info goes into the final product makes a pretty well defined output. The input, because it can come from anyone, is undefined." Another noted that "The trust is also an output." While we leverage much of Slaughter's framework on task networks to focus our investigation efforts for this case study, it is worth noting that she specifically calls out the production of Wikipedia as a cooperation task network.[5] The differences between her and our point of view on this subject likely stems from a difference in the level of understanding in what it takes to produce Wikipedia. As a complete outsider, Slaughter sees it as a more bounded set of inputs and outputs. As a slightly more informed outsider, we see the fuzziness that the Foundation and Community navigate regularly to produce Wikipedia.

As with most complex organizations, supporting Wikipedia and other wiki projects at the Wikimedia Foundation level also includes some aspects that the interviewees view as functioning like an innovation network, particularly when it comes to developing new functionalities or new tools. One noted "When we want to make a new product or a new improvement we'll have a whiteboard space" and nearly all interviewees noted innovative aspects of the organization's work and the value of being co-located at some point in the process to frame up those kinds of fuzzier tasks.

Nodes of the Wikipedia Task Network

A relatively small number of Foundation staff and contractors facilitate the making of Wikipedia by a vast network of volunteer participants, donors, affiliates, and partner organizations. Wikipedia has 1 billion readers, 8 million donors, 1 million occasional editors (who edit articles approximately 1x per year), 280,000 "active" editors (who edit articles at least 5x per month), 1,000 highly-involved "power" editors. There are more than ~500 staff and contractors globally, of whom less than half worked in-person at the San Francisco headquarters pre-pandemic.

[5] Slaughter, "The Chessboard and the Web", 156.

Locations of Wikimedia Foundation Staff + Contractors

Image: locations of ~500 Wikimedia staff & contractors at end of 2020

Location of Wikipedia Editors

Location of editors in all languages of Wikipedia active during an 18 second window on the afternoon Pacific Standard Time of 2/18/21 (real-time tracking map refreshes every 18 seconds).

Image: real time map of approximate 100,000 active editors at work. Map above shows 18 seconds of editing: http://rcmap.hatnote.com/#en

Links of the Wikipedia Task Network

Wikipedia relies on both digital channels and face-to-face convening to link the nodes of its network. Information flows around the clock through conversation among Foundation staff and contractors, among members of the editor community and between the staff and contractors and the community. They connect to each other and to the editor community through many digital channels, as well as periodic face-to-face interactions at Foundation headquarters and at offsites and events around the globe. When asked what communication methods were preferred, one interviewee replied "All methods. And then some. We engaged with an astronaut editing in space."

Standards that Facilitate Links

How does reliable information emerge from this churning sea of communication flowing across digital and physical links? At the root, there are some core standards and rituals, both positive (principles) and negative (taboos), that provide a foundation for reliable information to flow. The principles and taboos of the Wikipedia community serve as channels to sift out what information moves through the network and out into the product, and what information doesn't.

At base, the writing of Wikipedia is guided by the core policies of:

- Verifiability: "You should always be able to verify that the content of a Wikipedia article is factual, using reliable outside sources that are cited in the article."[6]
- No Original Research: "All concepts and theories in Wikipedia articles should be based on previously published accounts or ideas. Wikipedia articles shouldn't contain original ideas, conclusions, descriptions, or interpretations of facts."[7]
- Neutral Point of View: "All points of view about a topic should be fairly represented . . . A Neutral article makes no case and concentrates on informing the reader by providing a good survey of its topic. It is fair-minded and accurate and deals with controversial matters by reporting the main points where there is disagreement."[8]

Broad, longstanding reliance on these principles has created a culture of trust that many interviewees called out as essential to the production of Wikipedia. One noted that "The brand is produced out of trust" and is "held together by a sense of shared values and big mission." All Foundation staff and contractors that we talked with referred to the importance of trust, transparency, and universal access to the production of Wikipedia at least once and usually did so at length or multiple times.

[6] Ayers, Matthews, and Yates "How Wikipedia Works," 13
[7] Ibid, 14
[8] Ibid, 16

We asked about whether there were any communications taboos inside the organization. The primary one is the ironclad, widely-cited rule that "A staff member cannot contribute to Wikipedia content in their official capacity." Other taboos that interviewees felt were important all related to the foundation's emphasis on access, transparency, security, and trust. The main type of unwelcome communication was communication that made people feel unwelcome or at all unsafe. Referred to as "hazing" or "piling on" or being a "persistently unpleasant person." In the conversation centered culture of Wikipedia, "Discourse can devolve into debate and that can become a barrier to people," and "We've had some changes . . . but it's still a thing." Another acknowledged that, "We are trying to find the right balance between clear feedback and being respectful," but "There is an increasing tension around direct communication. The kind I grew up with."

The second communication taboo we heard about relates the Wikipedia values of openness and transparency, and was described as "the big reveal", where someone presents something for the first time as completed. In the highly collaborative culture of Wikipedia, people expect "to see how it's going while it's being built, to give comments. Surprise communications tend to go really poorly - don't pull back the curtain and reveal something completed already."

Digital Links

On a day-to-day, minute-to-minute basis the individuals of Wikipedia are linked by information flow across digital communication channels. Although Wikipedia has long been a globally distributed, remote endeavor, communication amongst the Foundation staff and contractors has been entirely digital since the pandemic began. One interviewee noted "the majority of our users are skilled" and were able to shift to entirely digital communication, focusing energy on how to tune the digital communication to meet the needs of their teams and figuring out ways to compensate for lack of face-to-face interaction.

Within this culture of prolific communication, protocols have been developed so that people "know how to get feedback and help from their teammates - balancing for both timeliness and our distributed time zones" and try to avoid "the pitfall of so many times where people didn't have a chance to respond to something because it was in one channel not another".

Key: Black text is from a formal digital communication protocols matrix
Grey text is from informal digital comments made during interviews.

E-mail	"For formal requests, such as document feedback, Notifications of important decisions, Announcements that the whole team should be aware"

	"Lately, it has become more official."
Slack	Best for a "conversation with multiple rounds of back-and-forth" "Use for quick check-ins, questions, and low priority share-outs." "The people who are more people-oriented gravitate toward Slack because they are more social. It's more the managers than contributors that are on Slack." "It's not open source, for a small but vocal part of the org it's sinful to not use open source."
Google Meet / Hangout	"99% of conversation is on Google Meet." "Everything internally is a Hangout." "The most important medium these days is Hangout."
Google Docs	"Used for follow ups of documents that are already being collaborated on in many areas of the organization and as a precursor to Phabricator in others." "We heavily use the comment function. Heavily use the @ feature to directly drop comments."

Asana	"Use for tasks that this team is responsible or accountable for. Tasks that require higher visibility and may impact long term planning for the department." "Create or update a process, make a technical decision"
IRC	"Engineers talk in IRC in real time. IRC is philosophically different - it's open source, rougher, no bells and whistles. People don't trust Slack because it's not open source. . . Also now people have integrated workflows to flow through IRC and get notifications in real time."
Phabricator	"Every [engineering] team maintains their own Phabricator boards." "This is a connection between the Community and the Foundation."
Talk Pages	"Among the people who are writing [Wikipedia] the main communication is the Talk Pages." "As the readers use the articles, the editors use the talk pages" "Let's say the English language Wikipedia is debating about a policy . . . that directly impacts how the product is made two months later. . . They talk and it shapes the content that goes on that page. "
Telephone	"Very unusual. Calling denotes a lot of urgency."

Physical, Face-to-Face Links

Although digital communication is the daily norm and people at the Wikimedia Foundation convene frequently for digital meetings, face-to-face interactions are also crucial to the functioning of Wikipedia as a network. Pre-pandemic, fewer than half of Foundation staff and contractors regularly worked in-person at the San Francisco headquarters. The rest relied on travel to see their teammates. Over the years a regular cadence developed and formalized this travel to bring teams together in the same location so that almost everyone would have a minimum of 3 face-to-face meetups per year, cross-functional staff or contractors could have up to 5 or 6 and managers could have 6 to 9. Key face-to-face interactions included the following:

- Team Offsites: (2x per year) All Wikimedia Foundation teams with remote members qualify for two offsites per year. A variety of considerations dictated the location of these offsites including ease of access by airplane, availability of visas for the team members, proximity to one of the other face-to-face convenings. Many interviewees also noted the value of holding an offsite in San Francisco to acclimate new staff and contractors at the headquarters and interact with the large cluster of people working at the headquarters. An offsite is typically 3 or 4 days, with one of those days devoted to a team-building activity.

- Cross-Team or Mega-Team Offsites: (1x per year) Many teams that include shared members or that are part of a larger department also travel to one additional offsite per year.

- All Hands Meeting: (1x per year) This event gathers all Foundation staff and contractors annually, at the end of January.

- Wikimania: (1x per year) Many staff and contractors attend the annual Wikimania conference, which also includes Wikipedia volunteers, partner organizations, Wikimedia affiliates, and donors, and is co-organized by a volunteer-led committee and the Wikimedia Foundation.

- Hackathon: (1x per year) Many people also attend the annual Hackathon, often held in Europe in May, which also includes community members. Unlike Wikimania, the Hackathon is mostly community-organized. It is funded by a grant from the Foundation, but the local community is in charge, with help from a Foundation liaison.

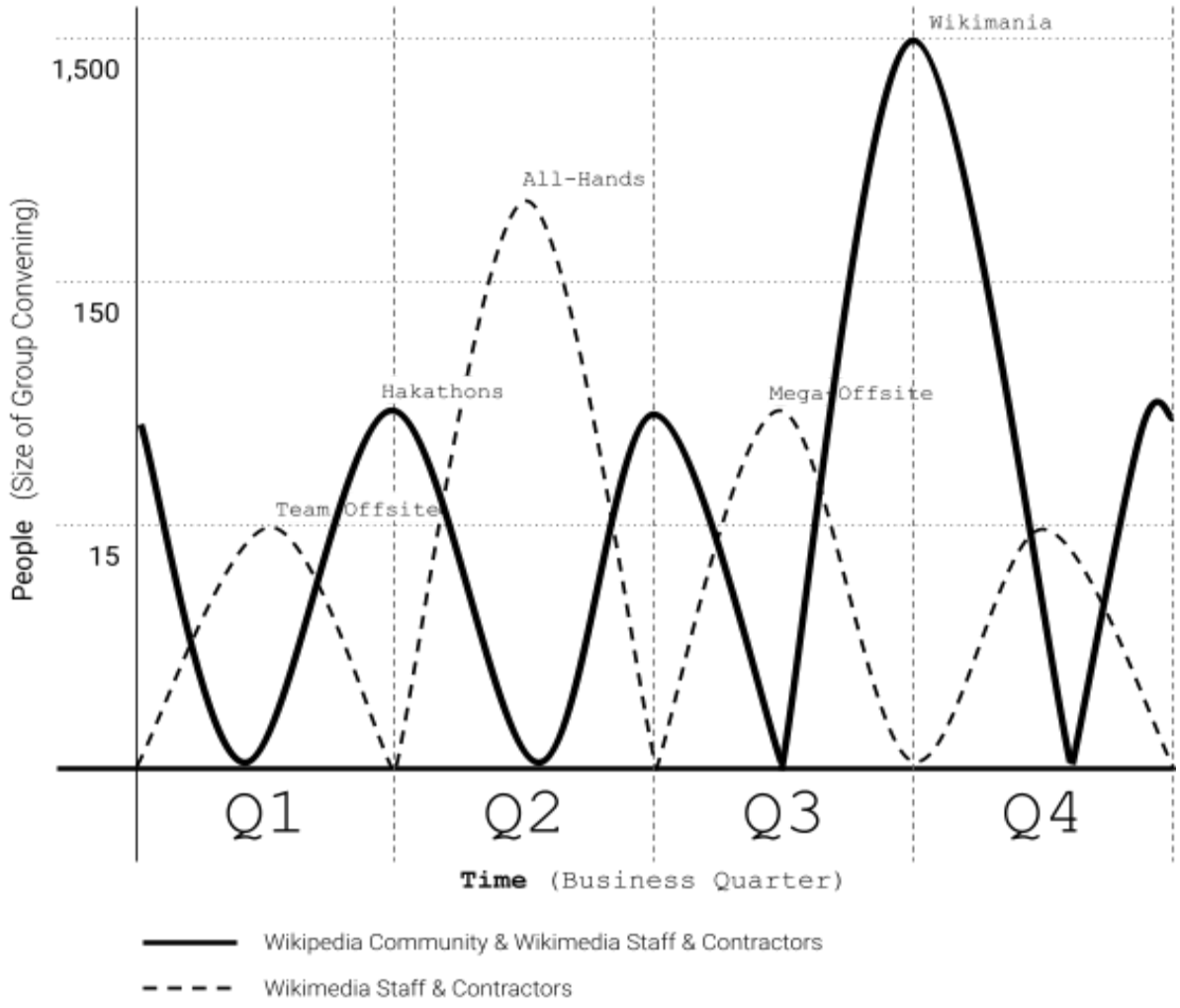

Image: Our concept diagram capturing cadence of convening. Note, unlike many post-pandemic conversations looking to identify the optimal "hybrid model" within the framework of 2 or 3 or 4 days a week in a traditional office, the high-trust culture in the production of Wikipedia allows them to come together more strategically, on a quarterly basis to focus not on attendance in a permanent workspace but on achieving milestones toward shared goals in a shared temporary workspace.[9]

[9] Cadence of convening diagram interpolated from interviews with Wikimedia staff and contractors as well as 2019 figures on Hackathons - https://www.mediawiki.org/wiki/Hackathons

Internal Production Costs: Bonding & Bridging Capital

By operating as a network distributed around the world Wikipedia (through its volunteer network) and the Foundation (through its staff and contractors) have access to the widest possible talent pool to further the mission of universal access to the world's knowledge. Wikipedia's success in being produced by a globally distributed network even pre-pandemic shows that purely digital products can, by and large, be effectively produced remotely by staff and contractors whose primary links are digital and whose purpose is clear. Interviewees felt positively about the distributed nature of the organization. A manager noted that the past year had proven how well technology allows his team to do most work remotely with great success, "I think we're also getting to a place with Google Docs and working asynchronously and the ease of use that it has limited the need to actually be in the same environment. The work we've been able to accomplish over the last 9 months has borne that out."

However, many interviewees acknowledge that they have encountered barriers and frictions as a result of this distribution and the primacy - especially during the pandemic - of digital communication. Many had evolved strategies to manage and or minimize these challenges, and were already planning post-pandemic in-person meetups to resolve built-up frictions around production. The two main areas of internal production costs related to functioning as a distributed task network were the need to invest deliberately in building strong trust relationships (links) within their distributed team nodes through team "offsites" and while also investing in larger events to bring in new nodes, particularly diverse groups of newcomers, into the network. The Wikimedia Foundation addressed both of these challenges through investment in what we will call for the rest of this paper "cost-of-convening", which includes real estate costs, event costs and travel costs.

From 2010 to 2020, many organizations in a marketplace like San Francisco were used to spending 10%-20% of compensation costs on office space.[10] In the case of the Wikimedia Foundation and the production of Wikipedia, we have found cost-of-convening to be a more useful metric than cost-of-office-space for capturing the value of investing in the strong and weaks ties of a network of production. The value is in the connection between people. The value is in the trust and rituals team members make when they share a space for a few consecutive days. The value is in the new insights and perspectives that can be gained by mixing with other people at large mission-driven events. Cost-of-convening represents a direct investment in communication of shared vision and values, the development of strong, cohesive teams, and the creation of informal connections that promote the efficient flow of information across an organization.

[10] Costs for traditional office space range from $6,000/year/person source to $15,000/year/person source. With amenities, a WeWork in premiere NYC location would be more in the range of $20,000/year/person before the pandemic. Translating this to 10%-20% of salaries would mean a salary range of $60,000/year-$200,000/year which sits happily on either side of the average salary for a software engineer in San Francisco at $125,000/year source.

At this point in the case study, we will insert a bit of our own opinion about the relationship of workspace to the performance of a network, like the one that produces Wikipedia. Along with many other functions that we will discuss in Chapter 4, traditional office space facilitates connections. In many ways, the centralized office is a holdover from an era when we needed proximity to facilitate the flow of information. There was no alternative, and the medium of communication, paper, created a strong forcing function for knowledge workers to centralize in downtown commercial business districts. Now, however, for so-called "knowledge work" and much of the tech sector, the need to be together in shared space isn't about proximity as a requirement for information flow. However, if physical co-location didn't add any quantifiable value or advantage to production, firms would have less incentive to continue to pay for it. So, we have to state the value of permanent shared workspace, a.k.a. the office, more instrumentally. At this point in history, in what we hope is the back half of a global pandemic, we have learned both how much less we need to be together on a daily basis to get tasks done and, simultaneously, just how critical it is for long term growth and mental health. We need to be together less often, but more intensely and intentfully. This puts real estate and convening events on more equal footing, because the general "place to go" theory of workspace has been shown to be a relic. We have to ask the question what do we need to be together to accomplish? And if we can be centralized for shorter, more intense periods of creativity and collaboration, but mostly operate in a distributed way, then shared workspace and convening via travel accomplish much the same ends -- to communicate information, shared vision, and company values, to foster strong bonds and cohesion among teams, and to create the conditions for bridges to form and allowing information to flow between organizational silos.

By bringing people together, the Wikipedia Community and Wikimedia Foundation can both build the strong social bonds required for growing Wikipedia as a product as well as infuse new ideas from all members of the broader free knowledge movement it exists within, such as partner organizations, affiliate groups, and policymakers. It is not surprising then, that as a distributed organization, the Wikimedia Foundation's convening costs are more focused on travel and events and less focused on traditional office space. Organizations considering workspace strategies like "remote-first", "HQ in the clouds" or even the elusory "hybrid model" would do well to learn from the Wikimedia Foundation that to produce even a wholly digital product like Wikipedia, an organization will still make meaningful investments in shared space to bring people together to build trust and tackle the hard problems.

As we will discuss more in Chapter 4, we believe there is an important lesson here for any organization considering a distributed workspace strategy: The focus should be on investing in people to facilitate idea flow within your network as the Wikimedia Foundation has done. Well-designed, traditional office space historically helped with this idea flow for an office-based workforce. For a distributed workforce, costs of real estate may shift to costs of travel if social capital, trust, and efficient information diffusion within the network are to remain robust. Before

claiming savings on their rent expenses, firms should budget for, and hire for, increased travel and events - the need for strategic convening is not going away and there is a cost to it.

Bonding Capital: Strengthening Links through Trust and Social Fabric

Trust and shared values are the glue that hold Wikipedia together, and are the bonding social capital that underlies the strength of the links among nodes in the Wikipedia network. As Hidalgo notes, "Bonding social capital is accumulated in dense social structures characterized by strong links. These are the links we share with our best friends and lifelong collaborators. Bonding links are also the link that we use to produce things, since complex productive activities are not viable among people who do not interact regularly. In other words, bonding social capital represents the tacit ability of a group of people with recurring interactions to act as a team"[11]

Foundation staff and contractors that we interviewed felt that the social interactions which naturally occur during in-person interaction were a key part of nurturing and maintaining these strong ties and the sense of trust and shared purpose and fretted about maintaining social fabric under remote-only circumstances. One noted that, "Most people here genuinely like the people they work with," and they missed the chance to come together and connect, and that although people, "more or less know how to do 'work-work' remotely, it's harder to weave the social fabric."

Time zones presented a widely-shared pain point for Wikimedia's globally distributed staff and contractors. Many echoed the sentiment that "time zones are becoming a big problem" and "I wish the world was actually flat and we were in the same time zone" because "it's always a bad time for somebody." Despite the real friction around times zones, interviewees all acknowledged that asynchronous work was here to stay. One interviewee whose team happened to be all based on the west coast even said that they were, "Starting to think that having someone outside our time zone would alleviate a lot of work." Several interviewees noted that although digital tools such as Slack and Google Docs could ease some of the challenges of asynchronous work, they still highly valued the "luxury" of being in the same time zone during periodic face-to-face convenings and missed that opportunity during the pandemic. One went so far as to say, "I think we should get really good at the [team] offsites. . . .the time zones and all that can work if we get really good at the [team] offsites." For now, while video calls through Google Meet are still performing an important linking function, time zones will continue to be a friction that needs to be managed.

Having recognized this challenge of weaving social fabric through asynchronous digital communication, the primary response we heard about from managers and senior staff could be described as deliberate over communication. One senior manager said, "We solved it by being much more deliberate and intentional. We used to have unstructured semi-monthly meetings and

[11] Hidalgo, "Why Information Grows", 150.

as we became increasingly distributed we increased structure. We became much more deliberate and intentional about which channels we used as a group and set a specific time each week and a forum for everyone to ask questions." Another manager noted that, "Since the pandemic we communicate more. We are over communicative to make sure everyone is getting it," and, "We really force the chit chat . . . it can be awkward" but it is clearly worth it.

Pre-pandemic, in addition to the shared office space in San Francisco, team offsites were the primary tool for building the team social fabric necessary to work through challenges, and the frequency and formalization of offsites increased as the organization became more distributed. An interviewee said, "We need space and time in different environments to solve some of the more challenging parts of being dispersed. The value of offsites has grown immensely." Another said of offsites that, "Bonding is the major outcome. Human contact and feeling more connected," and that "We always make a t-shirt. By the end almost everyone is wearing the t-shirt." While it could seem amusing to some, this kind of visual marking of a group is a meaningful signal that they share some level of common identity. Every offsite doesn't need a t-shirt, but it does need to generate the common identity the t-shirt represents.

Several interviewees felt that as soon as travel and face-to-face meetings were once again possible, the importance of offsites would likely increase. As the organization continues to become ever more distributed, "Having those connection points is important to discuss more difficult topics that you need people to stay engaged [with] for a long period of time. There are just limitations to that with a screen."

Wikimedia's investment in convening is more targeted than some of the responses that we are seeing out in the marketplace. For example, PwC's US Remote Work Survey for 2021 found that 68% of employers say a typical worker should be in the office at least three days a week to maintain a distinct company culture.[12] This differs meaningfully from Wikimedia's less frequent but more intense use of team offsites once every three months. Our hypothesis is that Wikimedia can convene less often because (1) they are more intentional about their gatherings (2) they operate a wholly digital product that exists entirely in the cloud and (3) their experience when they do gather is immersive and specifically targeted at team bonding in addition to complex problem solving.

Bridging Capital: Integrating Newcomers by Adding Links to New Nodes

Being universally accessible and open to anyone is a core piece of the Wikipedia mission. However, many interviewees noted that although open to all, there are some frictions to integrating newcomers into the production of Wikipedia as volunteer editors and as Wikimedia Foundation staff or contractors, particularly in technical roles. One noted that "The [Wikipedia]

[12] "It's time to reimagine where and how work will get done," PwC's US Remote Work Survey, January 12, 2021, https://www.pwc.com/us/en/library/covid-19/us-remote-work-survey.html

Community tends to be somewhat harsh." The frictions people described generally related to "piling-on" behaviors by veteran editors or engineers. One noted that, "Discourse can devolve into debate and that can become a barrier to people. New people might be intimidated to talk to the engineer who built the platform. Or if the engineer is pointed in their conversation. . . We've had some changes . . . but it's still a thing." Another interviewee estimated that the process of learning how to communicate effectively on the Wikipedia Talk Pages used by the volunteer editors can take "8 to 12 months" because new contributors need to "figure out the best procedures to not step on toes, like when you visit someone's house for the first time." From our perspective, and using our lens of network science, we can see this type of behavior as being particularly useful for creating strong social bonds within a community but will simultaneously create barriers to new links forming with people who are not already part of the community. It's good for bonding capital, but not for bridging capital.

Several interviewees described the particular challenge from this type of friction for newcomers to Wikipedia, so the Wikimedia Foundation explicitly works to broaden participation of volunteer editors beyond the largely white, male-oriented, Northern Hemisphere demographics that have historically dominated the Wikipedia editor population. However, a veteran staffer acknowledged a functional reason that this dynamic persists: "The more successful Wikipedia is, the more newcomers it gets, but you can end up with an inexperienced pop of editors which burdens the more experienced editor over and over. Then the population of veteran editors can get overwhelmed by newcomers. They want to add more rules, and they add friction to make it easier to manage."

Although many people we spoke to described the ongoing challenge of managing friction between open access to newcomers and experienced veterans, one expressed the bottom line as, "If people don't feel safe they can't contribute," and "People need to feel safe doing their work." Several described strategies for resolving or minimizing these frictions and for increasing feelings of psychological safety throughout the network. As with building trust, people first looked to a sense of shared purpose to push through these frictions, specifically the, "notion of ideals within the organization and aligning behavior with values: These behaviours are acceptable, these are not. If you are a repeat offender we are going to help you find your way out."

The concept of bridging social capital, which describes connections that link people across a cleavage that typically divides society (such as race, or class, or religion), applies to the challenges Wikipedia faces in integrating newcomers, especially from populations that have not been well represented previously. Several interviewees noted the importance of face-to-face interactions for building links across groups and among diverse individuals as the Foundation seeks to grow a more diverse and inclusive editor population: "The population skews towards young white men, we've tried to build a more diverse set of communities and members. Online communication through Wikimedia channels [such as Talk Pages] works for the historical population but also puts at a disadvantage new populations. When people actually meet people who are not like them, they are confronted with their own assumptions and have to re-think those.

If Wikipedia manages to go through that shift to being less biased in terms of editors and content it can only happen by having more of those in-person interactions."

A senior manager also noted that periodic in-person interaction is an important ritual for resolving conflicts, "When there are conflicts it's really hard to resolve them in online environments. You don't know the communicator and there are all these delays. At a conference we can set up a meeting with someone and talk it out. That's usually how things get resolved. Like Wikimania. There will be a community member who's upset about something and I'll set up a meeting and talk to them in person for an hour." This interviewee looked forward to the resumption of face-to-face events once the pandemic is under control, saying that "Yeah people are getting a little raw already in 2020," a sentiment that was generally echoed by several others, one saying that "The flood gates are going to open on the travel team."

Bridging Capital: Connecting to Innovate and Overcome Complexity

As noted above, interviewees most missed face-to-face interaction in shared physical space for the nuanced interpersonal challenge of building new trust bonds and for the resolution of frictions or conflict. Several also noted that there was a third category of problems that benefited from in-person interaction in physical space: problems that were particularly complex, especially those involving the need for innovation. One staffer pointed out that, "there are times when you need to actually whiteboard things out physically, things are complex enough that you need to put something on paper and that's where the digital environments start to break down" and another said that, "I think one of our biggest challenges by not being in office is having a space where you can hold an actual meeting with 10 to 15 people and talk it out. Turn it into a lunch, turn it into a whiteboard activity." A senior manager whose widely distributed teams long been working successfully in a largely remote, digital environment, emphasized that in-person convenings were still where "the most important conversations bubble up." We think this is an area where improvements to communication technology, specifically remote digital whiteboards (for which Microsoft, Google and others are vying for market share) could address this functional need for collaborative problem solving. The technology isn't there yet, but once it is, it will only heighten the role of physical space as a medium to build trust among team members once the technology can take on more and more complex information.

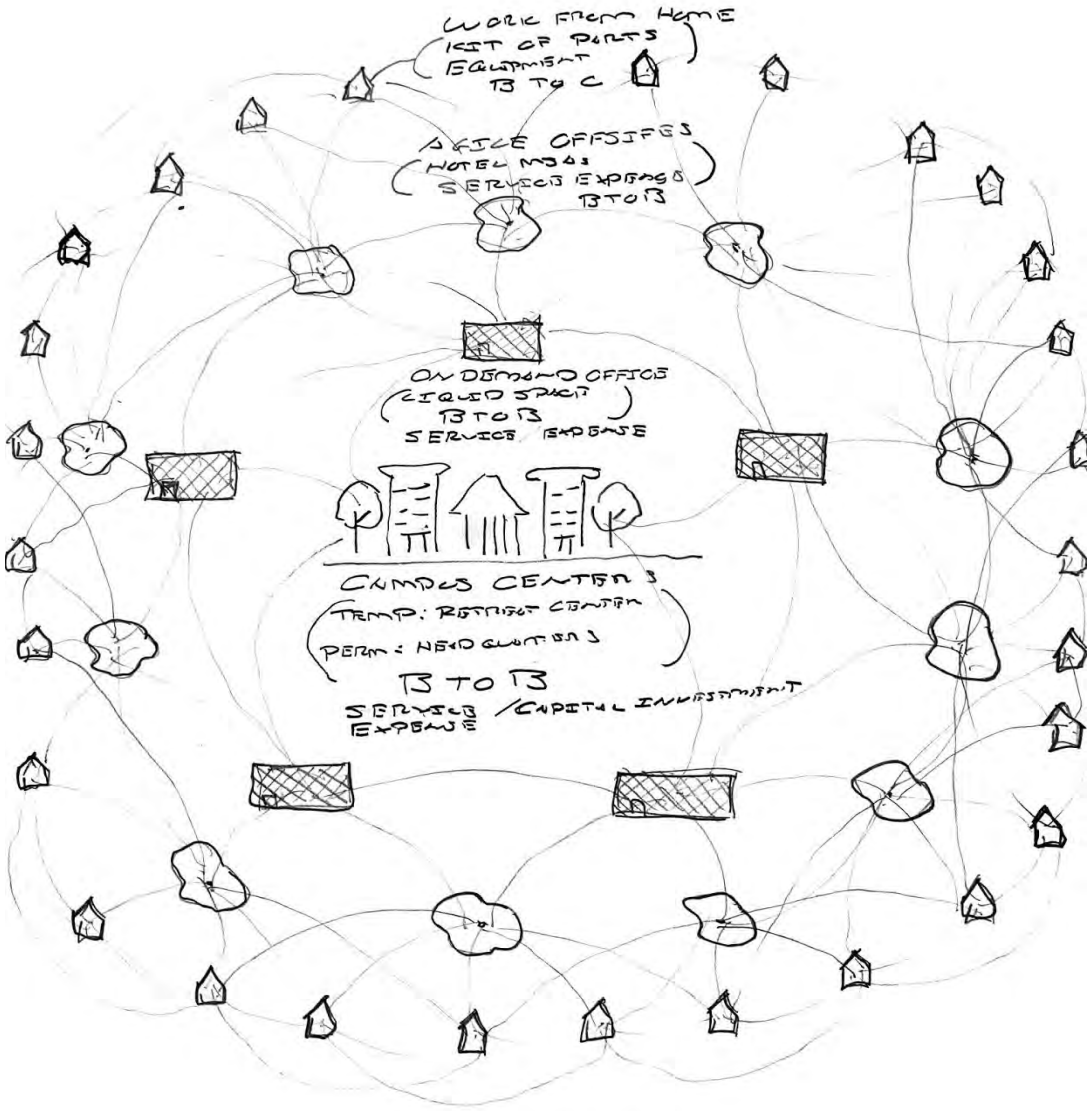

Image: our interview notes outlining Wikimedia space type needs. Note, the interviewees themselves did not reference their space needs with this type of centralized framework, the chart on page 22 is a better reflection for how they outlined their specific space needs - from the individual to the team to the Community.

Flows: Physical Space as Candid Communication

Another role for physical space in the Wikipedia task network that emerged from our interviews was the importance of space for communicating the Wikimedia Foundation's values and goals to outsiders, particularly for the purpose of persuasion. Numerous interviewees mentioned the value of bringing someone to see the puzzle globe when they wanted to convince, impress, or please the visitor. Hosting a visit to the Foundation's San Francisco headquarters was cited as a powerful tool for communicating how Wikipedia is different from other top 10 websites. One

interviewee involved in policy said, “We have to convince people to come to our side. In-person diplomacy helps establish a personal connection. Especially with [visitors from] the EU it's very common to tour tech company headquarters, and then we can show them how we’re different. I haven’t found a way to do that digitally.”

This role of space for messaging priorities and values was also reflected in discussion about the Foundation’s Washington DC office, which is located in a WeWork and opened shortly before the pandemic started. One elaborated on the meaning of the Foundation’s physical presence, saying that the office “had to be in an area of DC where the themes that you see help you focus - the location messages that you are there to make change. In the policy focused area, other champions are there working on the same themes as you.” and “the message is that . . . we want to be able to make change in the right, effective way.”

Image: our interview notes - space types by group size (right hand column reads "task/function" or "sense of belonging" at a driver of the space type)

What Kinds of Physical Spaces Work as Links or Flows?

This research, which has been more qualitative than quantitative, doesn't provide firm conclusions about what types and organization of space is optimal for a distributed organization. However, we can categorize, in broad strokes, several themes that we consistently heard. A few space types emerged as key to the functioning of teams, departments, and the organization as a whole entity. In particular, the challenges and frictions identified by interviewees in the preceding sections point to crucial roles for space in the context of a task network, both in service of the short-term goal of producing Wikipedia and in service of the long-term goal of supporting the Wikimedia mission and values.

Because the Foundation had begun to pivot to remote work pre-pandemic, staff have already accumulated significant experience with the logistics and cadence of convening remote teams around the globe periodically in "physical collaborative spaces" and interviewees expected the importance of these periodic "team offsites" to grow post-pandemic. One said, "We need space and time in different environments to solve some of the more challenging parts of being

dispersed. The value of offsites has grown immensely. Even within the past year, departments that are based in San Francisco now have at least 25% to 50% of those teams that are remote"

When asked to describe spaces that worked well for the types of interactions they felt were important, interviewees explicitly shied away from traditional office spaces, with no mention of desk spaces and numerous mentions of the need for small group spaces with, "lots of windows. I would not put anyone in a room without windows ever." One lesson for selecting gathering spaces that managers and other planners echoed was to avoid conference rooms and traditional boardroom-type spaces as much as possible. In fact, one senior manager said, "The worst outcomes are in conference rooms - places that are specifically designed for meetings. . . People want niches, open space, couches. It almost always doesn't work to be in a conference space." See Chapter 4 for how this desire for informal spaces is congruent with our draft framework for team-level bonding ties in Network Space.

Team offsites need to build strong bonds at the team level. For this type of outcome, flexible space that can be shaped to the team's needs is the most effective and rigid spatial layouts are off putting. However, it is worth noting that this same type of flexible space can in turn be off putting to people outside the team. Those outsiders pick up on the social cues that space belongs to others (in this case the team) and it doesn't feel inviting to them. Therefore it is important to remember that while more rigid spaces are not the right workspace for team offsites, they do perform a role with connecting outsiders to teams, by standardizing that interaction so everyone feels the same amount comfortable. That openness to outsiders through standardization of workspace was not something that we heard explicitly in the Wikimedia interviews; instead it comes more from our observations from across the industry when viewed through our evolving understanding of network science. To facilitate new ideas to flow in from outsiders, more standardized space can help create weak ties with more people.

As we started synthesizing the interviewee feedback into a framework of space types that support Wikimedia's production of the Wikipedia product, we found three general categories based on group size and attributes of space. Each of these workspace types can be either permanent (owned or leased) or explicitly temporary (booked or borrowed). More permanent workspaces will carry with them more overhead costs for the Foundation while at the same time providing more communication value of where the Foundation's priorities lay. The draft naming conventions listed below are intended to help readers think through these use cases. (There is nothing sacred or universally understood in these particular names):

- **Campus Center** (for 150 - 1,500 people) Big enough for a whole organization to gather, as for the Wikimedia Foundation All Hands, or to accommodate multiple teams at the same time, this could take various forms. An event center that is a short term rental would most efficiently fulfill the functional need to gather at the organizational level. Or it could be an owned asset, such as a permanent retreat center, that also communicates longevity, stability, and organizational purpose while allowing groups of various sizes to come

together in the same location repeatedly. One interviewee said, "People laugh when I say this but we should have a retreat center, not an office. Somewhere on the east coast. Just funnel teams in and out of there . . . . to me that would be more along the lines of what we need than an office these days."

- **Mini - Hub** (for 5 - 15 people) to facilitate small-group collaboration and bonding, such as for team offsites as well as expansion into new mission-aligned territories. This need could be met with a hotel-type space, described by one interviewee as, "A building where half is apartments and half is workspace. When we convene it's turnkey. I get on a plane and fly there and I have my hotel and workspace there already. Zero transaction costs." Or it could be an office-on-demand space like Liquidspace offers through real estate service providers like WeWork, so long as the space is flexible and has natural light. One team leader described an ideal location as, "a place that has a lot of space to comfortably move around, being able to set groups, move chairs/tables, organize groups, etc. I think that when we're able to self-organize in smaller groups when needed without much complication, these meetings tend to be more successful." This same team leader also highlighted the importance of removing distractions - unwanted noise, temperature swings or stale air should be top of line considerations for designing or selecting a Mini-Hub workspace. On the more permanent end of the spectrum (less hotel and more build-to-suit space) establishing a Mini-Hub in a new strategic location, like Washington DC, can quickly communicate the Wikimedia Foundation's priorities, helping the network grow and create new bonds with outside partners through the investment in physical space.

- **Home Office** (for 1 person) Experience during the pandemic created a broad agreement among Interviewees the basic kit of physical space needs for an effective remote staffer or contractor, most succinctly described by one as, "(1) a decent seat, not the couch; (2) a reliable network connection; (3) some other small things." An expanded kit would include ergonomic seating, upgraded internet speed, improved lighting and acoustics.

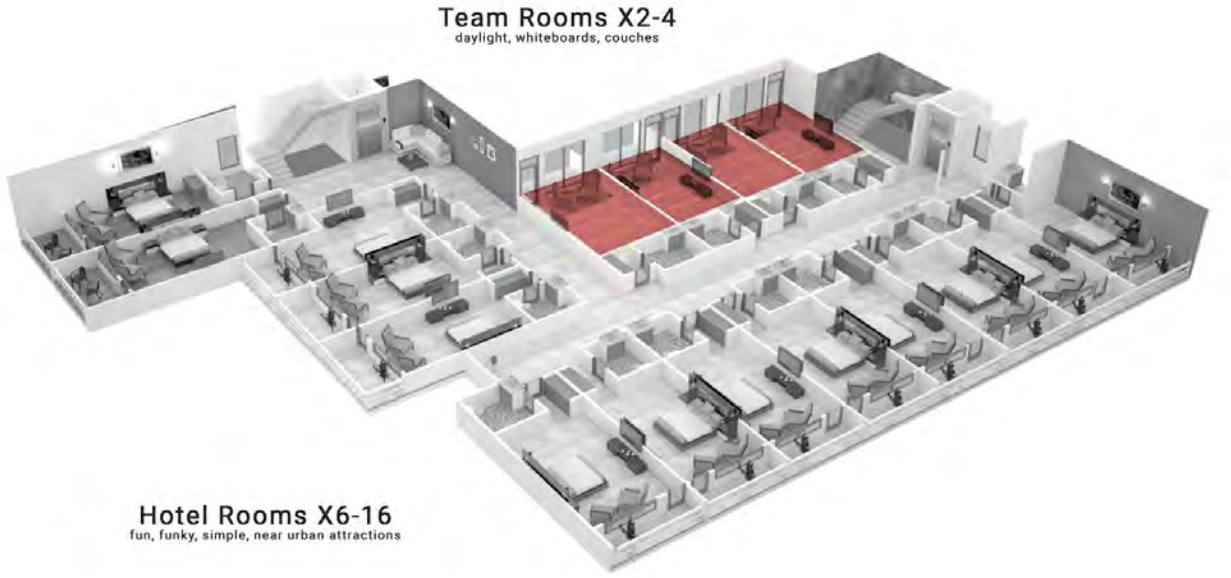

Image: Our diagram of "hotel as workspace" based on feedback from interviewees about what was needed for the quarterly team offsites. Note: all attendees were explicit that traditional conferencing spaces typically found at hotel chains were not conducive to work - boutique hotels or casual spaces with ample light and air were consistent themes across a number of interviewees.

What did we learn?

Through the purity of Wikipedia being a digital product, we can see certain network forces at play. For a task network that produces a digital product:

- Nodes can be widely distributed geographically due to the low internal production costs of linking internal people with one another (through GSuite, Slack and Talk Pages). This distribution allows the Wikimedia Foundation to better fulfill a global mandate and to have access to a far wider and more diverse pool of talent. Time zones and asynchronous work present challenges that can be mitigated through technology and periodic face-to-face convening.

- Digital links generally suffice for the day-to-day flow of information to support the ongoing production of Wikipedia in its current form. The network will develop standards and protocols around what type of information flows through what link and nodes will adjust their links to meet these standards.

- Though more costly to maintain, face-to-face links are required on a regular and reliable cadence to create bonding capital (the trust and shared purpose that allow for complex and nuanced activities like dispute resolution or innovation) as well as to deploy bridging capital in service of adding new nodes that stick (integrating newcomers successfully as staff or editors).

- More link than node; from our perspective as architects and designers of physical space, we see an essential role for certain types of physical spaces in even the most widely-distributed, fully-digital organizations. Two space types with particular significance are (1) gathering spaces, spaces to convene and (2) spaces that communicate the organization's priorities and purpose.

What did we not learn?

Connectedness

Every network can be described not only by the number of nodes and the types of links but also the degree to which each node is connected to other nodes as well as their clustering. We want to acknowledge that this level of quantitative analysis did not occur in our Wikipedia Case Study. Consultant groups like Ben Waber's Humanyze or other SNA (social networking analysis) consultants (see Chapter 5) would shed additional light on the hubs, clusters and degree of connectivity that produce Wikipedia. While that level of research extended beyond this more qualitative, interview-based research we would encourage that any SNA look at all of the formal and informal communication channels within the Wikipedia Community first and the Wikimedia Foundation second as the bulk of the production of Wikipedia occurs through the volunteer network of the community and the communications channels between the Foundation and the Community are both varied and complex.

Physical vs. Digital Products

Because Wikipedia is a purely digital product, studying its production through a distributed task network may not provide insight into the needs of a company that delivers a physical product or a product with both physical and digital inputs. Given the nature of the product, the distribution of nodes (people and teams) would likely follow a different distribution, their preferred digital links would likely differ, as would their cadence of face-to-face links. We would speculate that a company making a physical product would tend toward more concentration of nodes to the extent required for proximity to the product, but that question would need to be answered in a subsequent case study of a physical product company.

Interview Participants

Listed alphabetically by last name:

- Danielle Alexander, Program & Office Manager, East Coast Operations, Operations
- Eliza Barrios, IT Manager, IT Services
- John Bennett, Director, Engineering, Security
- Runa Bhattacharjee, Director of Engineering, Language and Translation
- Erika Bjune, VP of Engineering, Technology
- Ramiro Caceres, Workplace Services Specialist, Administration
- Bryan Judan, Director of Global HR, People Operations
- Stephen LaPorte, Legal Director, Legal Affairs
- Toby Negrin, Chief Product Officer
- Guillaume Paumier, Principal Program Manager, Advancement
- Lisa Seitz-Gruwell, Chief Advancement Officer, Advancement
- Jorge Vargas, Senior Partnerships Manager, Partnerships
- Karen Zwicker, Senior Project Manager - Travel, Administration

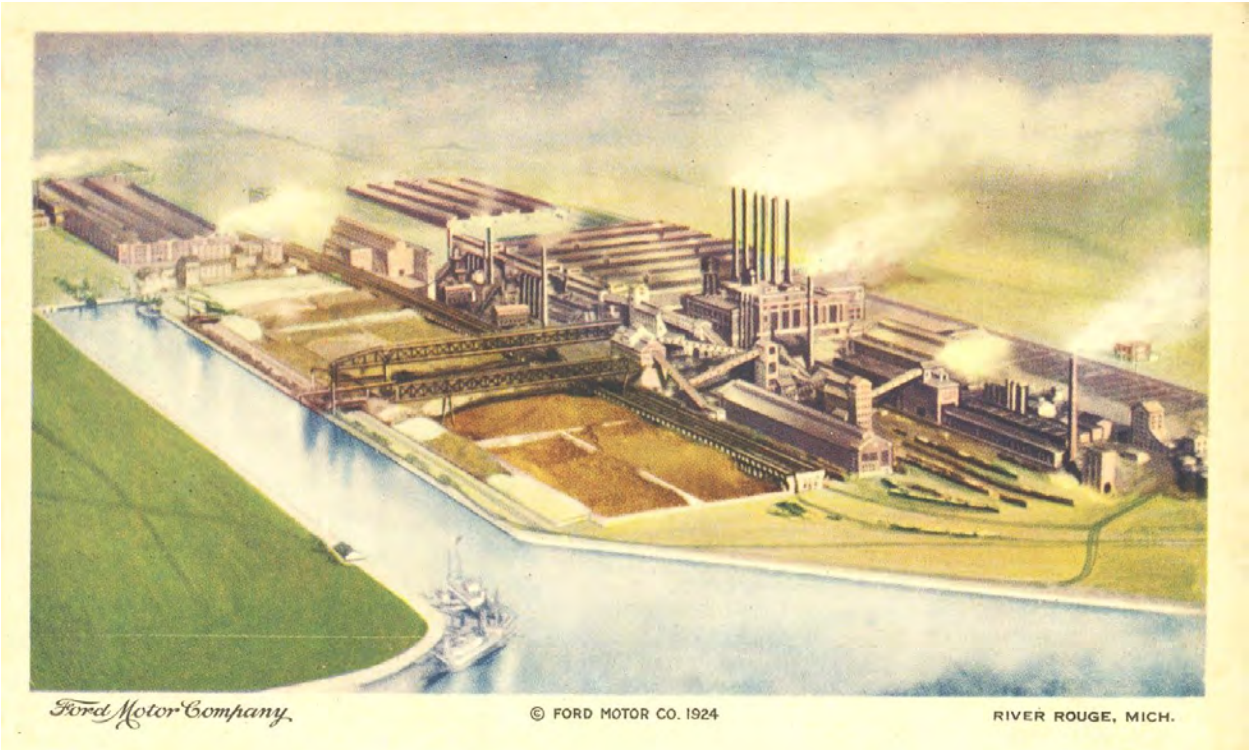

Image: Ford's stylized postcard of its River Rouge manufacturing plant at the height of its centralization of production – note the flattening of the world outside of the Ford factory, 1924

From 1920 Ford to 2020 Salesforce

The cycle from centralization to distribution has always been part of long term economic growth. If you were born a century ago in America you may have thought of Dearborn Michigan as the land of economic opportunity. Much like the Bay Area in 2020, an energetic worker would be attracted to the high wages and abundant opportunities for advancement. Where else in the world could you have such a fast track to owning your own piece of the American dream?

The long-term cycle that led to the centralization and eventual distribution of the productive forces of Dearborn Michigan a century ago may well have some hard-earned lessons for the highly-centralized state of the Bay Area today. These forces can be filtered through the network lens and understood through Transaction Cost Theory – the relative internal and external production costs and the transaction costs that sit on the edge of the firm. A century ago, Ford was operating in an immature marketplace. Cars were new. The means of producing cars was still evolving. The supply chain was riddled with labor disputes and high transportation costs of moving material from one place to another. There were few universal standards for the car industry. These combined forces created incentives for Ford to centralize. By bringing more of the materials and processes in close proximity to each other, by bringing more of the labor force

under one roof, Ford drove down the internal cost of production while offering a higher than industry-standard wage for the labor. Over the course of the 1920s, Ford's River Rouge became a world unto itself. That state of centralized network production of Ford was not to last.

A generation later, by the 1950s, the car industry was a mature industry. There were many reliable suppliers of the parts and pieces of what went into cars. In addition to the growth of the number of parts suppliers, there were more standards to engage with these third party suppliers. The combined impact of the maturation of the industry (lowering external production costs), the development of standards (lowering of the transaction costs) as well as the ever-increasing complexity of managing overhead costs (increasing internal production costs) led to a new equilibrium – one where it made more sense to buy parts and pieces from the external network of suppliers than to produce them internally. This moment of a new equilibrium was an important moment for Ford's workspace (the River Rouge plant). It was the moment when the forces driving centralization of workspace stopped and began to become forces for distribution.

Over time, Ford's network of production has expanded well beyond the constraints of Dearborn, Michigan. A Ford car today is likely to have a significant portion of its parts made outside the United States[1] and its plants are spread across North America.[2] Instead of processing raw materials into final products, Ford's workspace is now an "assembly plant" where parts and pieces are assembled from a distributed network of suppliers. Ford's assembly plants have become a place where components link together into a higher value final product. Ford's workspace evolved from a centralized node of massive local production into a series of links of internationally distributed production.

[1] Pete, Joseph. "Cars made here, but with a lot of foreign parts" NWI.Com Jan 3, 2014
https://www.nwitimes.com/business/local/cars-made-here-but-with-a-lot-of-foreign-parts/article_0cdd9c17-b706-5661-b00a-7ce01e7aa515.html

[2] Where are Ford Vehicles Made? January 23rd, 2019
https://www.kimbercreekford.com/blog/ford-plant-locations/

Image: Saleforce's stylized view of its Dreamforce Campus at the height of the last business cycle – note the flattening of the world outside of the Dreamforce Campus, 2018

What does Ford in the 1920s have to do with today? The economy of the 2020s is driven as much by ideas and innovation as it is by materials and manufacturing. Instead of the underlying value being held in physical products, much of the value now resides in digital products, like those made by Bay Area technology firms. Over the last business cycle, the wealth of these firms reached levels previously unseen. But what was the generator of all this wealth? Ideas, people, or things? We posit that it was the connection between these ideas, people and things. More people under one roof (or at least in one city) meant more ideas and more possibility for innovation. Following that logic, there was a correlated centralization of workspace. Facebook, Google and Salesforce all undertook the construction of massive centralized campuses in the region. (Salesforce went so far to strategically take advantage of San Francisco's urban fabric, expanding out into the city for its annual Dreamforce event that boasted more than 170,000 people.[3])

[3] "Dreamforce 2019 in Review: Key Facts and Figures" December 3 2019 https://www.salesforce.com/news/stories/dreamforce-2019-in-review-key-facts-and-figures/

As we saw with Ford's River Rouge a century ago, as we entered 2020, there were signs that we were approaching the limits of what gains could be made by continuing to centralize production in one location – not in a plant this time, but in a larger metropolitan region. Cost of talent (driven by the cost of living, cost of education and the cost of commuting) kept rising. Despite this, the dominant paradigm of centralized workspace remained: prioritizing more casual collisions, more time together under the same roof as the way to continue to stir the petri dish of innovation and drive more value into digital products.

Then, 2020 took a different turn. In response to the global pandemic, Facebook, Google and Salesforce suddenly learned to work from home. This short-term change may have been facilitated by the reduction in costs of remote communication and collaboration technologies (like Zoom, Dropbox and Microsoft Teams), but the lasting effect may well be the new standards and rituals that have been developed to allow more digital product talent to work from more locations. These new standards for communicating among workers on digital products could well have a similar impact that rising internal costs had for Ford's physical products in our grandparents and parents generations: a tendency toward distributed production and economic growth across more locations. To this point, after announcing their plans for most of its employees to work remotely part or full time, Salesforce's Chief Operating Officer said "On the other side of the pandemic I do think we're going to see more innovation in more parts of the country, and I think that's healthy."[4]

Again, like Ford, it is not just about moving the same activities and relationships that were centralized to different locations, it is about the growth of the firm through the growth of a distributed network of production. In fact, Salesforce plans to add 12,000 employees this year.[5] But to maintain this new decentralized network of production, we can use our network lens to predict that the Salesforces of the world will begin to invest in workspace as the links of production – the connections between their internal talent and external connections. If they do not invest in building this sort of bonding and bridging capital through workspace as a link, they run the risk of becoming one of Ben Waber's[6] cautionary tales of firms who crumble after burning through their stores of social capital - both the bonding and bridging kind.

Why talk about Ford of yesterday to explain Salesforce today? Because the decisions that were in front of Ford executives, in our grandparents and parents generations when they were considering distributed production models, were clearly visible. If you didn't have a railway going to a town, you weren't going to consider partnering with a firm there. When products were physical and their links were physical, it was clear and obvious where it made sense to have

[4] Bindley, Katherine. "Most Salesforce Employees to Work Remotely at Least Part Time After Pandemic." Wall Street Journal, February 9, 2021 https://www.wsj.com/articles/most-salesforce-employees-to-work-remotely-at-least-part-time-after-pandemic-11612897201

[5] Ibid.

[6] See Chapter 02 - Network Mindset.

distributed nodes of production. For digital products the connections of the network of production are less clear and consequently the decision making about the location of distributed nodes of production can be less clear. What is important about looking at Ford in 1920 and Salesforce in 2020 through the same lens is that the properties of network science hold true in both cases. Both the 1920 Ford and the 2020 Salesforce will be able to grow economically as they are able to grow their network of production. In both cases, their network of production will have internal production costs, external production costs and transaction costs that sit on the edge of the firm. In both cases, their network of production requires high quality links and nodes that allows for the flow of complex information. No single node can compete with a network of nodes, and no network of nodes can function without high quality links.

So as our economy continues to evolve and cycle through phases of centralized and distributed workspace, it is important to remember that when workspace is no longer serving as a node of production – it is likely performing as a link.

Image: Centralized workspace, Ford 1924 and Salesforce 2018

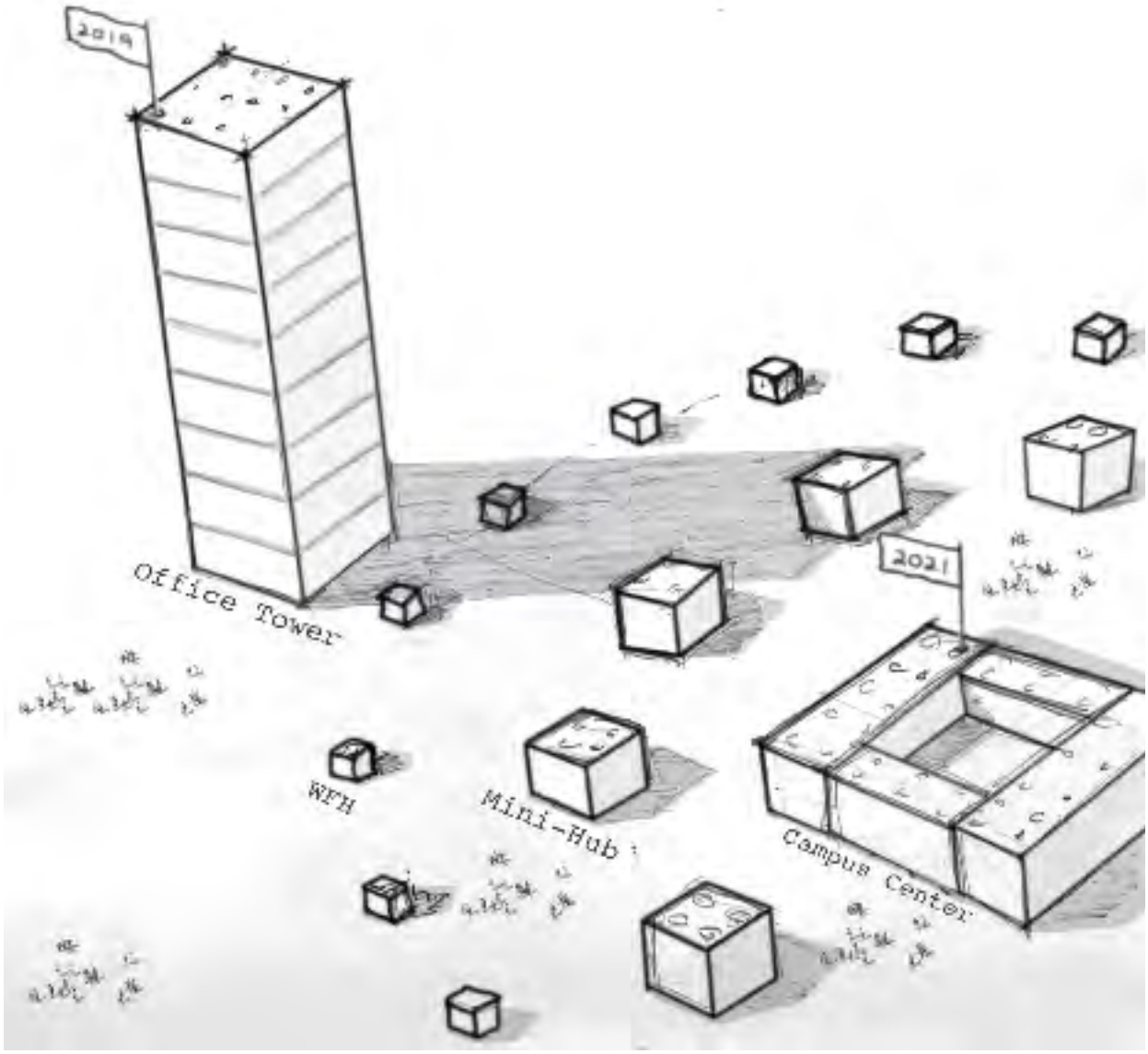

Image: our concept diagram of the forces changing workspace in 2021

2021 Workspace in a Task Network

While the network mindset is expansive and the potential of network science is exciting, it can be unclear what it all means for us as practitioners of workspace design. This lack of clarity can become even fuzzier as workspace does not have a singular role in a task network. Furthermore, the roles workspace plays have changed along with social and technological advances in the last generation. In many cases, we may have inherited our grandparents' and parents' buildings for workspace but we certainly have not inherited their means of production. As a step toward clarity, in this section we will outline how we see workspace contributing to the performance of a task network – toward the performance of the firm and the product it makes. This framework filters workspace through the network lens as a node, as a link and as a flow. For each filter, we provide

our assessment of what developments over the last generation may present an opportunity for a change to behavior or a change to workspace or to both.

Workspace as a Node

Boundary Condition

Workspace can define the edge of an organization. Equipment and ideas that exist within the extents of the workspace typically belong to and partially define the value of the firm. Over time, equipment and ideas accumulate and are artifacted in the workspace. Through this lens, the workspace serves as a useful accounting mechanism for understanding the value of the firm at any given moment in time. Also through this lens, it is possible to see over time that the workspace itself serves as a filtering mechanism where people know to bring in material that belongs to the firm and leave behind material that does not belong to the firm.

What has changed from our grandparents and parents workspace is that much of the value of the firm today may reside in the cloud. With new context comes new challenges. Firms are grappling with how to systematize the accumulation of the digital wealth often by instituting communication standards through platforms like Slack and GSuite. Today when a firm provides an email address to an employee or contractor or consultant, it is similar to when previous generations walked across the threshold of a workspace. Both communicate that on the other side, property belongs to the firm not the individual.

Capacity, Physical Plant

Workspace provides access to capacity captured in the physical plant. For physical products, this capacity could take the form of machinery used to shape and sculpt raw materials into final finished products. (A physical product example is a Ford car and the corresponding workspace is a car manufacturing plant. Your ability to make a Ford is greatly enhanced by access to a car manufacturing plant.) For digital products, this capacity could take the form of specialized equipment that allows you to capture physical elements digitally before releasing a final digital product. (A digital product example is a Netflix original series and the corresponding workspace is professional quality studio. Your ability to make a broadcast-ready series is greatly enhanced by access to sound rooms and light stages.)

What has changed from our grandparents and parents workspace is that historically an enormous amount of capacity was ubiquitously held in the paper records and mainframe computers of most organizations. Before the cloud was a reliable option, processes, protocols, data and computing power were physically held on site. To access that data and computing power, you had to physically come into the workspace. As late as 2010, the workspace still provided access to capacity that was captured in the paper records and hardrives of specialized

office computers. Today, the capacity is largely dispersed and readily accessible through the workers' personal devices.

Workspace as Link

Bonding, Strong Links

Workspace facilitates strong ties by creating a shared social focus for people. These strong social bonds become stronger through recurring interaction with the space and allow a group of people to eventually act as a team to tackle more complex problems. Workspace that facilitates these types of strong social bonds will likely be informal, non-standardized and will carry with it the markings of the identity of the team as opposed to the firm. Marked space in this context will increase homophily, providing a group of people with shared experiences that further the oneness of their identity.

What has changed from our grandparents and parents workspace is that task complexity has increased with economic complexity. Today, tasks often exceed a single person's capacity. Tasks are more likely to require at least a team's worth of capacity. As the complexity of the economy continues to increase, there is correspondingly increased pressure to have a greater percentage of non-standardized space to foster strong bonds at the team level and increase the team capacity in the firm. For distributed teams, establishing a "cadence of convening," (see Chapter 3) a structured schedule for coming together physically in these spaces, is critical to maintain trust and ensure that the capacity of a team is not lost in the costs of inefficient flow of information.

Standards, Weak Links

Workspace provides a standard for people to come together and connect without the need for a third party intermediary. The removal of this third party intermediary decreases the costs of engaging with people outside of and within your organization – allowing more ideas to flow into and around your company. Much like a computer VGA port this standardization allows for more people to directly engage with your product because the rules of engagement are clear. Instead of the size and the number of pins, as in the case of a standard VGA port, workspace that acts as a standard has embedded within it clear rules about social norms and the ways in which people can or should interact. However, not all workspace acts like a standard: Workspace that is highly personal or requires specialized training is not a standard. By contrast, lobbies, formal conference rooms, and lecture halls, all of which act as a standard are typically free of personal markings, have a fixedness to their spatial layout and wordlessly communicate to people which activities are allowed and which are not.

What has changed from our grandparents and parents workspace is that there has been a meaningful increase in the number of workspaces that are not acting as a standard. Flexible

rooms filled with sofas, armchairs, bean-bags and personal paraphernalia have grown in popularity. These types of rooms are serving a different purpose in the production of the network – see discussion of space as a bonding link above. In addition, the decreased reliance on paper from previous generations is removing a standardization function of workspace. Starting from clerk's offices and moving through to our faithful filing cabinets, much of the professional workspaces of the last two generations was devoted to storing and organizing paper documents in a standard way that could be easily accessed by most people with little specialized training. The diminished reliance on paper as a communication medium has correspondingly diminished workspace's role as standard method of storage for that type of communication.

Complex Information, Strong Links

For some types of information, digital links are not sufficient. When the information that needs to flow is particularly complex, stubbornly unresolved, emotionally loaded or concerns the physical presence of a product, the digital channels that serve as staples of communication for so much knowledge work start to break down. Face-to-face interactions are needed to push through information blockages – whether it is the opportunity to pick up and handle a product sample, the ability to see the nuances in someone's face and body language as you navigate a disagreement or the ability to add to a colleague's whiteboard sketch from earlier in the day, there are many instances that still rely on physical space to communicate.

What has changed from our grandparents and parents workspace is that the flow of complex information has options now – preferential options with lower internal production costs. Digitized, screen-based flows of complex information being the most ubiquitous. Due to their two dimensional nature, screen based flows have a limit on the amount of complexity they can carry. As a result, the flows of the more complex information still reside in the medium of workspace. The higher complexity tasks that require these higher than screen-based flows include but are not limited to physical product development, conflict resolution and innovation initiatives. The fuzziness of these tasks requires ultra high complexity of information flow that, as of today, is met largely through workspace.

Adjacency, Weak Links

Workspace, strategically located, can provide a link to high quality human capital. Highly educated individuals are not evenly distributed across our world. These high-capacity humans tend to cluster near major universities, urban centers and major metropolitan areas, into which universities empty. Locating a firm's workspace in or adjacent to these clusters of human capital offers a higher probability for the creation of weak connections – the bridging social capital required to facilitate long term economic growth of the firm.

What has changed from our grandparents and parents workspace is unclear. The efficacy of strategically located workspace to create links to clusters of high quality human capital seems to be unlikely to change unless the clusters of high quality human capital relocate. Institutions like

universities are more resistant to change, even though they are poised to go through a major revamp in the shadow of the global Covid pandemic. Highly-educated human capital that is further removed from universities is more volatile. If work-from-anywhere becomes more of a norm, and the concentration of human capital in major metropolitan areas becomes a diaspora, the ability of workspace to foster weak links to adjacent human capital will be correspondingly less clear.

Workspace as Flows

Shared Consciousness

Workspace can be a component of the shared consciousness that flows among individuals, teams, and the firm. By entering the workspace, people can holistically take in and perceive the state of the firm. In manufacturing plants, this state of the firm is on display by the evolving visual artifacts of the products themselves. In a knowledge-based firm, critical information may be on display in the workspace. In both cases, the health and energy levels of the staff is always on display, communicating in real time whether the firm has excess capacity, if the stores of its labor are running dry, or whether the links and flows that connect it are broken. In a well-designed workspace, the space itself displays the pulse of the firm's shared consciousness.

What has changed from our grandparents' and parent's generation is that there are now more options to achieve shared consciousness. All-hands meetings have become all-eyes meetings as people tune into their firm's monthly update. That update is likely to take the form of an internal video broadcast, navigating asynchronous work styles and multiple time zones. At a lower level, firm dashboards and shared calendars also vye for a part of the shared consciousness. This area of the marketplace appears to be particularly well suited for a revolution in communication where firms invest in high quality broadcasts with real time updates – part nightly news digest and part digital town commons. Unlike the complex information required for complex product development, the workspace does not appear to be as well suited for delivering the shared consciousness for globally distributed production of digital products. The state of a firm may be changing so rapidly and across so many time zones that the durable nature of space has a hard time keeping up with the pulse of today's firms.

Communication

Workspace communicates the priorities of the firm. Due to its durable nature and high production costs, internal and external audiences intuitively understand that an investment in space represents a genuine priority of the firm. Through this lens, opening a new workspace is a signal of success and growth to come in a new area or new marketplace. Correspondingly, closing an existing space communicates an equivalent contraction or realignment of the firm.

What has changed from our grandparents' and parent's generation is little. While there are many other competing ways to communicate growth and realignment of firm priorities, the cost of

workspace always makes it meaningful to us. We take the expansion of a firm into new territory to be an expansion of power and influence. Workspace as a communication signal can be overwritten by other stronger signals but it remains a signal onto itself. This appears to be similarly true for us as it was for our grandparents.

How about me?

What does network science tell me about my distributed workplace? With the abundance of discussion about changes to the workplace since COVID-19, it's hard to know what changes apply to your firm. What is the right workspace for my product? Work-from-anywhere or back-to-work? Distributed, centralized or hybrid? These choices will all have something in common – they will be made in the context of a network of production, and what is good for the network is good for the workspace.

Physical Production is Different from Digital Production

The production of physical products and digital products are not equal when it comes to workers' proximity to the development process and to each other. The differences here are intuitive: If you're in the business of making something physical, the people involved in that making will have to be present with the material and the machines and, logically, present with each other. Here we would say that the "flows" consist of physical materials and operations on those materials. This is not true for the entire staff, as there will be portions who engage in "knowledge work," like HR or legal. There will also be departments who sit on the fence, so to speak, like design or engineering, who may engage in product development of a physical product in early phases, but have less relation to physical production, except through the prototyping and testing process.

Moving those knowledge workers to a distributed model could create difficulties for the physical production company, depending on what type of production is taking place. In a mass manufacturing model, impacts may be minimal, as there is more separation between the product development process and the production process, often to the extent that they don't happen in the same country, let alone in the same building. In a smaller scale production model or a custom fabrication company, the links between the production department, the project management office, and design and engineering teams are stronger and more frequent. Here proximity plays a huge role in enabling and structuring the flows of information in the network, and diminishing proximity can hinder those flows, which can be viewed as an increase in the cost of internal coordination. If not mitigated, these increased internal transaction costs will create a force toward recentralization.

While this is somewhat different from what we've seen in a digital environment, where the product is bits and pixels and the flows are exchanged information, the strategies are much the same. We outline a few approaches to maintaining a sense of purpose and adopting clear

standards and rituals below. However, physical production companies will also have to deal more directly with the asymmetry of expectations between who can be remote or distributed and who can't. It will be important that remote employees still feel a sense of connection to the place of production. Conversely, physical production employees should be brought into the virtual rituals of remote employees whenever possible. Management will have to be intentional in their approach to avoid schisms occurring along the lines of communication mediums – digital or physical .

From a network perspective, attention to these details serve to help create new standards and protocols that maintain the integrity of the links among people engaged in a production process, ensuring that strong ties are not lost or weakened, and that information still flows effectively throughout the network, and that shared sense of purpose and belonging is maintained when it is not reinforced daily by showing up to shared physical space.

Investment in real estate may be replaced by an increased cost of travel

Company gatherings are a well-known tool for reinforcing culture and company messaging, and many companies, especially large ones, have been producing high-quality, large-scale events for employees and partners for some time. While we don't provide numbers here, our intuition would also be that companies who recognize the value in getting people together also have business travel guidelines that encourage travel to collaborate. What we are suggesting now is that the consideration of workspace investment, travel, and the cost of gathering, be evaluated in tandem to arrive a blended strategy that supports a "cadence of convening", replacing much of the benefit of full-time collocation in a dedicated workspace.

This combining of workspace, travel, and gatherings into a regular cadence of convening, is important because one of the primary enablers of distributed workspace is the reduced costs of internal coordination through digital communications. As we saw in our case study, rituals for convening (both virtually and physically) should be built into the cadence of work in a routine way that offers a sense of structure and maintains the sense of purpose. Holding onto unnecessary real estate, while also covering the costs of digital platforms and the expense of travel required for gathering could result in a net increase. In the near term, balancing these costs will involve combining the capital and operating expenditures associated with physical infrastructure with the operating expenditure associated with travel and software. These three budgets are often set independently based on the needs established by separate business units and are typically compared about once a year. The tradeoffs here are much more strategic than simply finding an agreeable balance for department heads, and need to be considered jointly. The questions "How much dedicated workspace?" (less), "How much travel?" (more), and "How much investment in digital communications and management platforms?" (depends), should be part of a balanced strategy to maintain the necessary conditions for a high-functioning networked organization.

This shift to higher investment in convening, rather than in traditional real estate, also creates opportunities for hotel chains and retreat centers to get into the workplace game, and will be a boon to easily accessible towns with natural and cultural amenities that contribute to the overall quality of events.

Opportunities to rethink your internal communications strategy

Employees need to have a strong sense of purpose and identity, reinforced by participation in digital communication spaces that provide a sense of shared consciousness. For more on the importance of shared consciousness and empowered execution, we recommend McChrystal's *Team of Teams*. The feeling of being *in* the company or within the boundaries of the firm, will largely be replaced by a sense of purpose and shared consciousness reinforced by strategic gathering at regular times that vary by group size. Outside of these gatherings, this sense of purpose and shared consciousness lives within the communications networks with which employees engage daily. There is a negative potential, especially in large organizations, for the consciousness of the network to become divergent from the realities or intentions of the firm. Space is a candid communicator. Space is honest.

To remedy this effect, we suggest a revised approach to internal communications that becomes more like real-time reporting or journalism in its approach, and less of an internal marketing or public relations function. Staff wants the real deal, not a sanitized version. It is important to maintain the integrity and transparency of these communications in order to preserve trust. This should feel more like news and less like marketing material. Trust is the glue of the network, and nothing erodes trust faster than disingenuous corporate messaging. There is also an educational component whereby employees can be kept up-to-date on important business decisions by contextualizing them in a strategy relative to the broader market. It is not uncommon, in our experience, for employees to crave information and transparency, and it is quite disheartening to read something about your company in the news media that you didn't hear first through the company. There is also an opportunity, in this repositioning, to make internal communications more "sticky," a source that employees look forward to engaging with. All of this is greatly facilitated by the precipitously dropping cost of producing quality journalistic pieces..

Nothing reinforces a shared consciousness like the sense of being part of a shared journey. If it becomes clear to employees that their journey is different from the one that a company's leadership is on, the network will begin to generate its own narrative, it's own consciousness.

Standards and rituals will be critical to foster flows among teams

As we've discussed, the role of physical workspace in providing a container and a boundary function that reinforce purpose and identity needs to be replaced in a distributed organization. In many ways, this involves balancing the reduction in one type of structure with the addition of other types of structures. We broadly refer to these as standards, protocols, and rituals. Standards provide guidance and expectations for interaction and exchange. Protocols establish

format and process for efficient exchange. Rituals refer to recurring interactions or exchanges performed at set cadence. While this may sound very rigid, consider that it is replacing the structure of the daily workspace.

A few strategies that are particularly helpful for a distributed workforce:

1. Set clear expectations and boundaries around electronic communications. Agree on the best tools for communication (Slack v GSuite v IRC,) and stick to them. Staff and contractors in less structured organizations may find themselves facing a constant deluge of messages coming in from multiple channels. Not only does this make it impossible to accomplish focused work, but an enormous amount of information is lost and time wasted on switching.
2. Set expectations around shared working hours in order to maintain alignment among team members. This doesn't mean that nobody can walk away from their computer between 9am and 5pm, but it does mean that team members generally know when each other are available, when they are "heads down," and when they are unreachable.
3. Learn to function in an "asynchronous" way through shared documentation and collaborative development of artifacts on cloud based platforms like Google Docs.
4. Set routine schedules of meetings for different purposes, such as daily stand-ups, 1:1s, sales meetings, product meetings, etc. At least one of these should be an open forum where teams can have unstructured interactions and catch-up on outstanding items, etc. Stick to the schedule, and limit ad hoc meetings.
5. Create specific channels for "white space" or an unstructured outlet. Slack is great for this.
6. High demand individuals should schedule "office hours," blocks of time when they are available (and the other blocks when they are not).
7. The company may want to consider allowances or recommendations for team members to purchase a WFH kit-of-parts to have a reliable home work space.

There are certainly other strategies out there, and each organization should tinker to find what works best. The important outcome here is that these routines and standards set expectations that are not just about managing time and attention (though that is certainly high on the list of priorities). These expectations also begin to develop into a sensibility about being "at work" when you're not in the workspace. Along with the sense of purpose we've discussed, these rituals, not that different from daily meditation, let people cross a threshold into their work life and then cross back out of it again. This ability is critical to maintaining strong ties, cohesion, and work-life balance that contributes to happiness and productivity.

Coordinating these standards and protocols can be daunting for some companies, and increasingly require dedicated focus. Facebook was probably the first out of the gate on hiring a "Director of Remote Work," but these roles are now proliferating. Organizations might also consider wholly new functions like Digital Culture, Distributed Community, or Remote Operations in order to help develop standards, protocols, and rituals that will hold distributed organizations together.

Workspace investment should be evaluated on the basis of the network

The distributed organization is a network with many components, including individuals, teams, and departments, as well as distributed physical workspaces, virtual "spaces" and communication channels. In the past, a physical workspace served as a container for the whole – a place that collected people and structured their input into the production process. Later, through the 20th century, firms became more distributed, but still functioned as networks of large nodes contained within physical space. Today, these network components are on more equal footing. A highly cohesive team split across three time zones might be more productive than a less cohesive team sitting in a room together.

Investment in physical space should be evaluated against these other components, with the goal of making the whole network as healthy and productive as possible. We won't open the Pandora's box of individual productivity and how to measure it, but we can say with some confidence that happy and healthy individuals are productive individuals, and things like having a broader choice of where to live geographical, including more access to nature, affordable housing, and quality education all contribute to workers' health and happiness. In short, we think there's a big upside to the distributed workspace. There are some risks as well, and putting everybody into the same building everyday can mitigate those risks. But centralizing workspace can also serve to mask dysfunction and is biased toward efficiency and hierarchy, rather than network strengths like innovation and adaptability. The way forward is understanding the roles that workspace previously had in production networks and adopting new strategies, like those we outline above, to fill those roles in other ways.

We think the new role of workspace in production networks is becoming clear. First, people do need to be together, but not all of the time. So, think about how often people actually need to be together to maintain cohesion, develop informal connections, and feel a part of a larger, shared purpose. Second, think about the cadence of this convening, and what this costs in travel: more frequent gatherings for regionally-based employees, less frequent, larger gatherings to pull in far flung staff. Third, think about new functions like digital culture, digital community, or digital operations that can help to build rituals, standards, and protocols for virtual spaces and to play a role in the dissemination of shared consciousness. These are the investments to balance with workspace in a routine cycle of coming together to connect, share, and collaborate and then dispersing again to execute once the tasks are clearer.

You may be thinking, "That sounds like way more than I'm spending on workspace today." So let us offer one last recommendation: You don't have to own or be the sole occupier of your workspace. In recent years, many companies have already tried to consolidate by adopting new models, like activity-based working and hotelling, aimed at making workspace more efficient. A common statistic often cited in support of these efforts is the average utilization rate of

workspace, which pre-Covid was around 60%.[7] So, even prior to this massive remote working experiment, and after a decade of efforts to densify office environments, most offices were still 40% empty on average. The opportunity now exists to shrink the footprint even more by using physical space more strategically and more sparingly. The next question will be, what can we do with what's left over -- all of that vacant space that we don't need? We suggest that there are other sectors who can use that space. (Housing comes to mind.)

Conclusion

We started off this research with a claim that investigating workspace as a network was both innovative and ageless and that is also where we end it. We have always worked in networks and our workspace reflects that. What is different now is the speed with which our networks change to adapt to new market conditions and the complexity of the tasks that our networks are seeking to solve.

Changes to the medium of our communication from physical (paper) to digital (bytes) has not only quickened the pace of information growth, it has removed physical distance as a driver of increased costs of production. The diversification of our final products from all-physical to an interdependent mixture of physical and digital products has further enhanced the non-spatial nature of modern work. With fewer costs to spread out, we should expect our workspace to become more diffuse, to move from centralized to a distributed workspace.[8]

But there are costs. Communication should not be confused with connection. Digital communication by itself is not an adequate connection for the long-term production of complex products, either digital or physical. Making complex products requires an equally complex network of knowledge and capacity, which is linked through genuine human connections and trust. Sustaining these links requires an investment of time, energy and material resources to allow them to grow.

As we saw in the distributed production of Wikipedia, the world's largest not-for-profit digital product, investment in links does require investment in workspace.[9] But this is not your grandparents' or parents' workspace. It is your workspace, and it is created and adapts at the rate required for you to keep pace with our ever changing world.

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[7] "Occupancy Planning Research Brief," Jones Lang Lasalle, 2019-2020. https://images.hello.jll.com/Web/JLLAmericas/%7B55da75cc-e702-4343-baf0-c9bafc377dcf%7D_jll-global-2020-op-benchmarking-report-design-utilization.pdf

[8] "87% executives expect to make changes to their real estate strategy over the next 12 months. These plans include consolidating office space in premier locations and/or opening more satellite locations" Source: PWC US Remote Work Survey January 12, 2021

[9] 87% of employees say the office is important for collaborating with team members and building relationships — their top-rated needs for the office. Source: PWC US Remote Work Survey January 12, 2021

If there is one thought that we would like to leave you with at the end of this research, it is to challenge your hardwired, human nature of being territorial about space. That territoriality, that hard boundary at the edge, can work against creating the types of links that allow complex information to flow. There is no doubt that we will all need to invest in physical space to continue to build the social capital and trust that allows networks to grow. And there is also no doubt that this investment will have a cost. But that cost need only be proportional to the benefit received, and we don't need to own it to benefit from it. If we can adjust our mindset to consider the network first, we can see that our workspace needs are more mutable than we may have thought. Simply put, we need to connect. We don't need to possess.

If we can focus on the workplace as a link, we can be a part of a new world of opportunity. Similarly to how the invention of the hotel in 1820 empowered huge new segments of the population to travel and experience greater social mobility, so it is with workspace. We need to invent our version of the hotel for work – the workspace of our generation. If we can do that, we can bring greater economic opportunity to more people, which at the end of the day is what it is all about – more benefit for more people through Network Space.

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Poleg Dror [@drorpoleg] (2020, October 7). The office of the future is not a place, it is a network that allows the individual to access a variety of locations that enable the task at hand: Recording a podcast, hosting a client, doing focused work, learning, collaborating. Most of them will not be at home. [Tweet] - link

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Lindsay, Greg, “Inoculating the Planet,” ULI, 18 June 2020 - link

Additional Consultants

The list of consultants below were not used in the production of this research. They are listed here as additional resources for those interested in applying a network lens to their organization and what it means for their workspace. This is not an endorsement of any of these services of these specific consultants rather it is intended to be a wayfinding aid to help organizations move toward a network mindset.

Datawheel	https://www.datawheel.us/
HiQ Labs	https://www.hiqlabs.com/
How 4	https://www.how-4.com/
Human Dynamics Lab	https://www.media.mit.edu/groups/human-dynamics/overview/
Humanyze	https://humanyze.com/
Maven7	http://maven7.com/
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Socilyzer	https://socilyzer.com/
Synapp	https://seeyournetwork.com/
Trustsphere	https://www.trustsphere.com/
Visier	https://www.visier.com/solutions/
Worklytics	https://www.worklytics.co/

Research Team

Nash and Josh each have 20 years of experience in user-centered design, product development and architecture. Jorey and Nash have run art and architecture studios together for the last 10 years. While the three have worked in pairs and been close friends for more than 15 years, Network Space is the first real project where all three have worked together - as a team.

Josh Emig, Architect and Product Designer
Josh is Head of Product Research for The Canoa Supply Co, a startup focused on helping companies scale their physical space and lowering the barriers to access healthier environments. He was previously a Product Director and Head of Research at WeWork, where he led efforts focused on shared work environments, the social, economic and urban impacts of coworking, as well as technology development for the workplace. Josh earned his Masters Degree in Architecture from Rensselaer Polytechnic Institute.

Jorey Hurley, Artist and Product Designer
Jorey is an artist and author who guides Vital Architecture Studio 's user research to create user-centered spaces and products. She has led Vital's user research on projects for the YMCA, Google and YouTube, conducting stakeholder interviews and creating synthesis documents to communicate research findings. Jorey has a Bachelor's Degree in Art & Art History from Princeton and a Law Degree from Stanford.

Nash Hurley, Architect and Product Designer
Nash is an architect and founder of the Vital Architecture Studio. Nash began his architecture career at Stanford University, worked with Josh at SHoP Architects in New York and, through Vital, has designed spaces for Google, the Smithsonian Institution, the Wikimedia Foundation, the Tides Foundation, YMCA, NRG Energy, and Elemental Excelerator. He was the first Architect-in-Residence for Google's R+D program for the built environment. Nash has a Bachelor's in Economics from Amherst College, a Masters in Architecture from UC Berkeley and is a registered architect in NY, CA and DC.