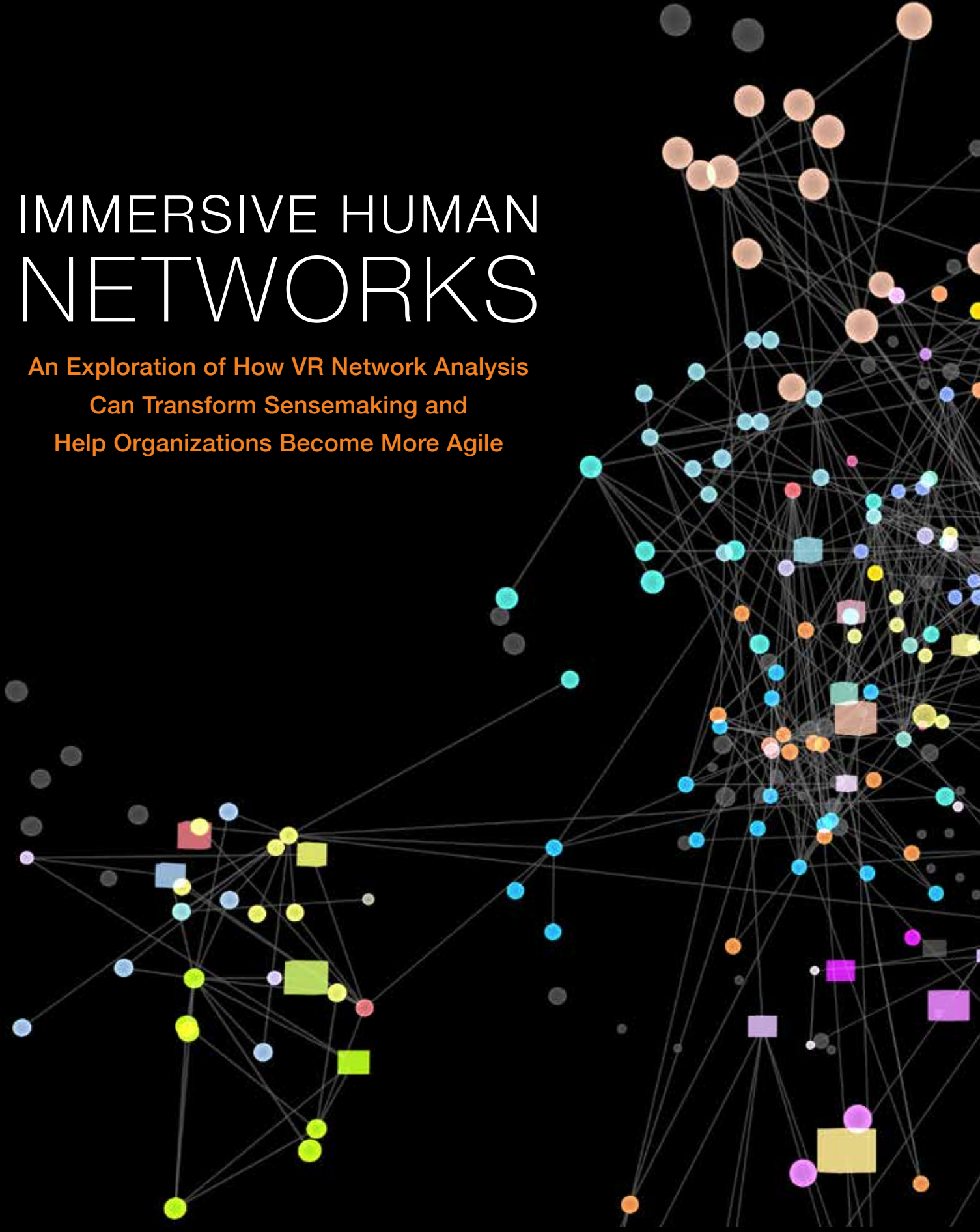
IMMERSIVE HUMAN NETWORKS

An Exploration of How VR Network Analysis Can Transform Sensemaking and Help Organizations Become More Agile



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ABOUT THIS REPORT

This Institute for the Future (IFTF) research report was commissioned by Cisco and developed by IFTF's Emerging Media Lab to contextualize and provide a new visualization graph for the Organizational Network in Virtual Reality (ONVR). The ONVR application is a proof-of-concept prototype of a collaborative multiuser VR network analysis tool developed in partnership with Slanted Theory. This report draws on related research and interviews of domain experts to sketch the context for the ONVR application, document and analyze the application, and identify future possibilities opened up by immersive sensemaking tools like this one.

INSTITUTE FOR THE FUTURE

IFTF (www.iftf.org) is an independent, nonprofit 501(c)(3) strategic research and educational organization celebrating fifty years of forecasting experience. The core of our work is identifying emerging trends and discontinuities that will transform global society and the global marketplace. Our research generates the foresight needed to create insights that lead to action and spans a broad territory of deeply transformative futures, from health and health care to technology, the workplace, learning, and human identity. IFTF is based in Palo Alto, California.

IFTF's Emerging Media Lab (EML) explores the rapidly evolving technologies and platforms that are transforming human communication. The lab serves as an independent research group and prototyping studio housed within the wider institute. Currently the EML focuses on exploring rapidly emerging areas of experiential communication technologies, including virtual reality, augmented reality, mixed reality, and other forms of ambient and immersive media/computing.

CISCO

Since its founding, **Cisco** has shaped the future of the Internet by creating unprecedented value and opportunity for its customers, employees, investors, and ecosystem partners and has become the worldwide leader in networking. By transforming how people connect, communicate, and collaborate, Cisco has changed the way we work, live, play, and learn.

The Leadership and Team Intelligence (LTI) Digitalization Office in Cisco HR explores the edges of today's technologies, approaches, and innovative concepts to architect the work of tomorrow for Cisco's people and leaders.

SLANTED THEORY

Slanted Theory is a virtual and augmented reality creative team located in Sheffield, South Yorkshire, UK, co-founded by Laura Smith and Mark Burkitt. For more than a decade, they have worked in the field of 3D design, with expertise spanning data visualization, virtual reality, augmented reality, and 3D object (CAD) design. Their most recent work in this area includes a cloud platform for immersive data visualization and collaborative analytics.

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Executive Summary

Digitalization is driving new levels of globalization, deregulation and disruption, the dimension of connectivity and convergence we're experiencing is unparalleled. People worldwide and customers across all industries increasingly insist on instant, intimate, frictionless, incremental value at scale. Enabling agile responses to these ever faster changing demands plays an increasingly vital role for any company. The hierarchical organization that flourished in the 20th Century is simply too stiff and static to deliver this. Organizations need new approaches to leverage the new technologies and make sense of the shapeshifting network structures, which already make up the new nature of work. Tools for organizational network analysis are traditionally focused on 2D network graphs and tend to frame network insights as the domain of executive leadership. Now emerging media give us immersive tools to make sense of networks collaboratively in virtual reality. These new tools leverage embodied cognition—the idea that thinking involves not just our brains but also our bodies, our environments, and our interactions. And they are potentially transformative, because humans literally think differently when given new tools to think with.

This report demonstrates these ideas through a proof-of-concept prototype application we call the Organizational Network in Virtual Reality (ONVR). ONVR enables people to collaborate through a large-scale immersive environment as they make sense of a range of organizational network features. In particular, the environment enables swapping between informal and formal structure, visualizing network flows along key categories of social benefit and value, translating between individual and team contributions to the network, and diving into custom network visualizations. ONVR lets users leverage the space around them as they visualize and interact with the network at multiple scales and from multiple vantage points.

By situating network data visualization in virtual reality (VR) and enabling users to manipulate larger datasets in a volumetric environment, ONVR points to a range of new opportunities. Among them are the following, explored in detail in the last section of the report:

- *New ways of visualizing data in a multidimensional immersive environment.* The emerging field of virtual analytics facilitates analytic reasoning through immersive forms of interactive visual interfaces. Virtual analytics has been applied in a range of contexts—including the life sciences, air traffic control, and social network visualization—and has also seen recent success in commercial big data applications. The future of 3D data visualization and analytics in VR is likely to be shaped by innovation opportunities in the areas of collaboration, filtering and comparison, and interface techniques.
- *New methods of intervening in the workplace.* Organizations have an opportunity to rethink the kinds of interventions that network intelligence can lead to. We identify new methods of intervention in the workplace, in particular focusing on the power of teams in networks and organizational ritual design as an emerging signal of innovation. Organizational ritual design represents a shift from top-down implementation of organizational change to decentralized creation of new work forms and practices. Capitalizing on this shift, the next generation of ONVR could empower teams to redesign their rituals as a way of reshaping the network.
- *New ways of understanding how organizations work best.* Innovative insights on organizational effectiveness and design can be derived from the field of biology. For example, epidemiological frameworks of contagion can help us better understand how patterns of human behavior and emotion flow through a network. With new sensemaking capabilities, organizations can be intentional about harnessing the power of the human superorganism through distributed leadership, swarm creativity, reciprocity, and regenerative value. In addition, the way organisms communicate by leaving signals in their environment can inspire thinking about how the next generation of ONVR might provide new pathways for individuals and groups closest to a problem or opportunity area to send signals back into the organizational network model itself.

These emerging opportunities will reshape the ways we engage with and think about our human networks.

Introduction

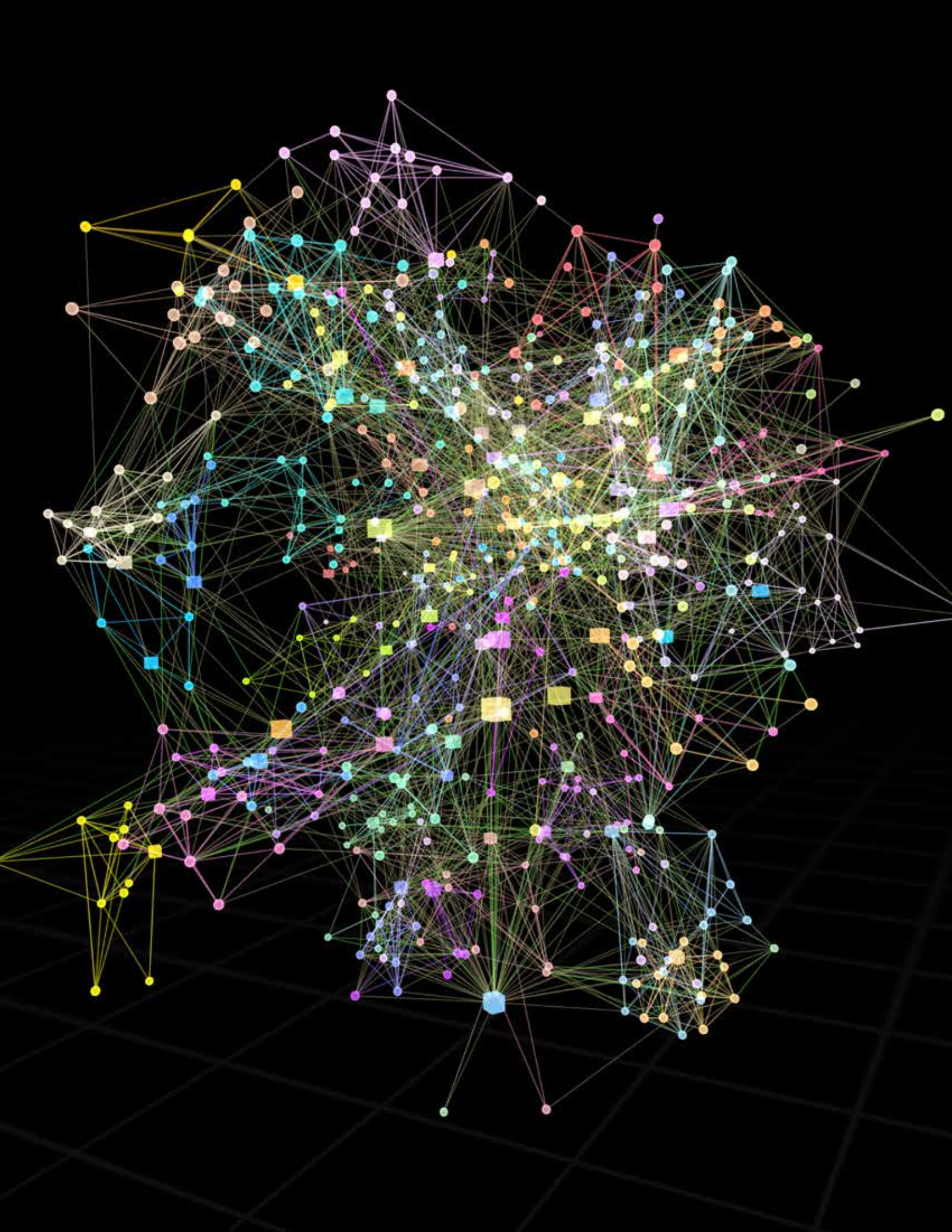
While organizations tend to be formally structured into teams and hierarchies, actual work often happens through the flows of informal networks.[1] These informal networks have shaped our world in ways we are often blind to. As historian Niall Ferguson points out, human history tends to be written in the language of hierarchies because they are easier to see, but as a consequence we miss the more fundamental role played by informal network flows.[2]

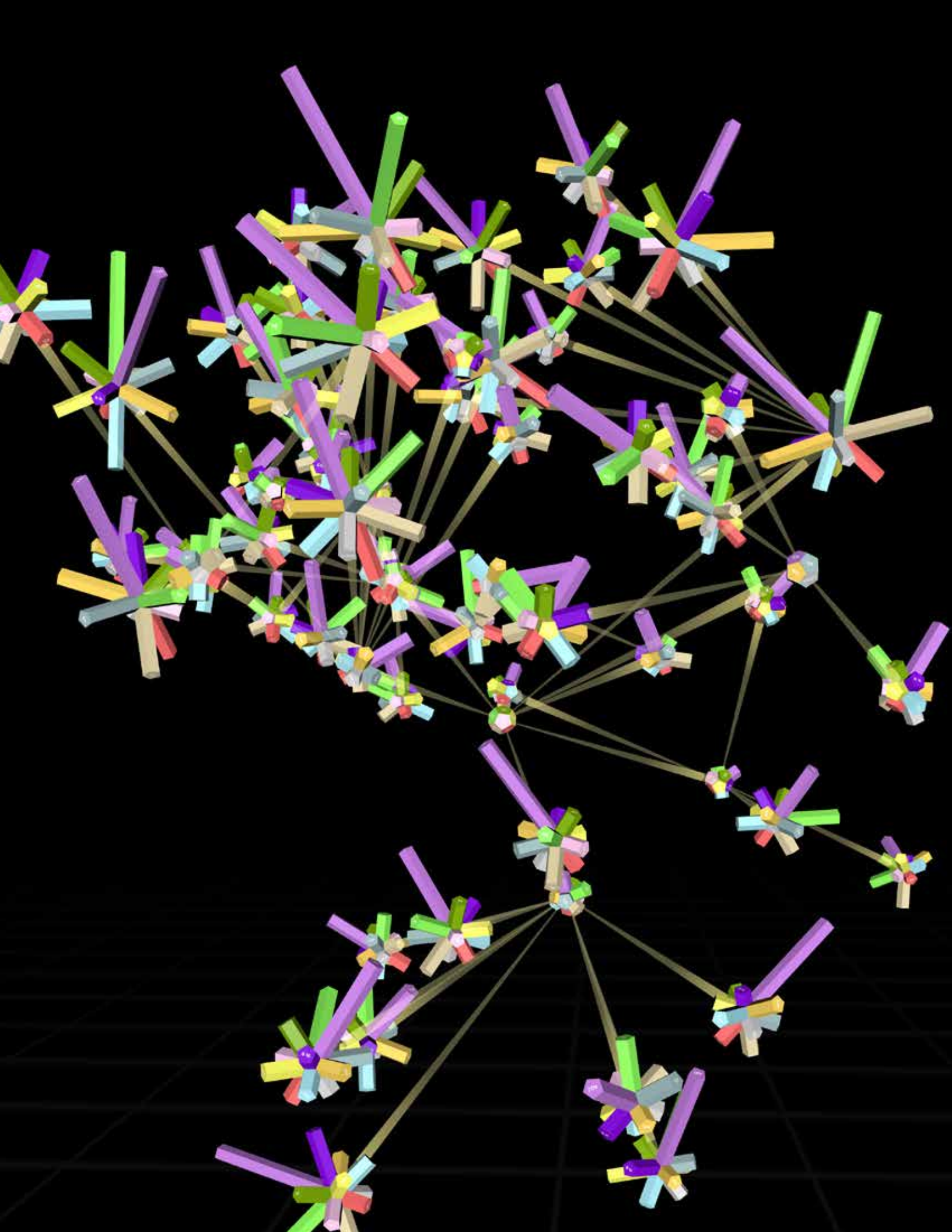
Organizational network analysis approaches have been used for more than two decades to help make visible the informal patterns, information flows, and collaboration pathways that characterize complex systems. They can, for example, help us identify the important role brokers play in bridging the gaps that separate different clusters within a network.[3] But while traditional network analysis tools have yielded useful insights, the nature of work has continued to change, and organizations need innovative perspectives and tools to address these new challenges.

This research report contextualizes and documents a new network analysis approach that has the potential to transform how people in organizations make sense of, enact, and respond creatively to change. The Organizational Network in Virtual Reality (ONVR) application is a proof-of-concept prototype that enables multiple users to collaboratively interact with network graphs in the volumetric space of virtual reality. The prototype was initiated by Cisco HR, with the objective of augmenting and scaling their existing 2D human network platform through the innovative lens of immersive experience design.

Cisco HR has been blazing new trails in organizational network analysis by placing the network map at the center of interaction and empowering the entire organization to leverage network intelligence. With ONVR, the LTI Digitalization Office wanted to explore new ways of working with large-scale network data, to evaluate innovative approaches to extracting intelligence in a 3D environment, and to demonstrate to Cisco leadership the transformative potential of collaborative VR environments to support new kinds of network insights. Slanted Theory built ONVR on top of its VR data-visualization platform as a custom exploration of multiuser collaborative network analysis utilizing Cisco datasets and use cases.

We aim in this report to share insights surfaced by the prototype development, expert interviews, and a literature and landscape review. (See the Appendix for more on our research methods.) We first situate VR network analysis within the broader context of changing organizational demands and workplace challenges. We identify the transformative potential of VR network analytics and call attention to the concept of embodied cognition. We then describe and analyze the features of ONVR. Finally, we identify possibilities for the future opened up by immersive sensemaking tools like ONVR, focusing on new approaches to 3D data visualization and analytics, organizational ritual design, and organizational structures inspired by biology. These emerging opportunities will transform work and workplace relations by reshaping the ways we engage with and think about our human networks.





Network Analysis Tools: From 2D to 3D

Organizations once competed through optimization and efficiency, but the future increasingly demands flexibility, creativity, and agile responsiveness to change. Sociologist Zygmunt Bauman has described this emerging future as "liquid modernity."[4] Bob Johansen, distinguished fellow at the Institute for the Future (IFTF), points to a future that is increasingly volatile, uncertain, complex, and ambiguous. He argues that organizations need to learn how to shape-shift their own human networks in order to respond to these conditions.[5]

As shape-shifting network structures play an increasingly important role in getting work done, organizations need new approaches and tools to make sense of changes and respond in agile ways. Tools for organizational network analysis are traditionally focused on 2D network graphs and tend to frame network insights as the domain of executive leadership. Now emerging media give us immersive tools to make sense of networks collaboratively in virtual reality. These new tools leverage embodied cognition—the idea that thinking involves not just our brains but also our bodies, our environments, and our interactions. And they are potentially transformative, because humans literally think differently when given new tools to think with. This section explores these ideas further to set the stage for a closer look at the ONVR tool and the world of new possibilities such immersive sensemaking tools might open up.

EMBODIED COGNITION AND SENSEMAKING

Cognitive scientists and designers have long argued that humans think not only with our brains but also with our bodies, our environments, and each other—a concept known as embodied cognition. Research in neuroscience and cognitive science has demonstrated that "human consciousness is not localized in a set of neural connections in the brain alone but is highly dependent on the material substrate of the biological body, with emotions and other dimensions as supportive structure."[6] Included in these "other dimensions" are aspects of the environment such as tools, artifacts, and opportunities for social coordination.[7]

Our cognitive and linguistic frameworks reflect embodied metaphors rooted in the physics of the body and its relationship to the world.[8] We associate "up" with happy and "down" with sad. We "dive" into a relationship, "pour" ourselves into our work, and "carry" the weight of heavier emotions. Similar associations exist in all human languages. Cognitive scientists argue that these metaphors are rooted in bodily experiences that reinforce their linguistic underpinnings.[9] These metaphors reflect the ways that our bodies and our physiology are inscribed into the way we think. According to this approach, abstract concepts like "communication" leverage the mental imagery of transferring physical "stuff" from one vessel to another.

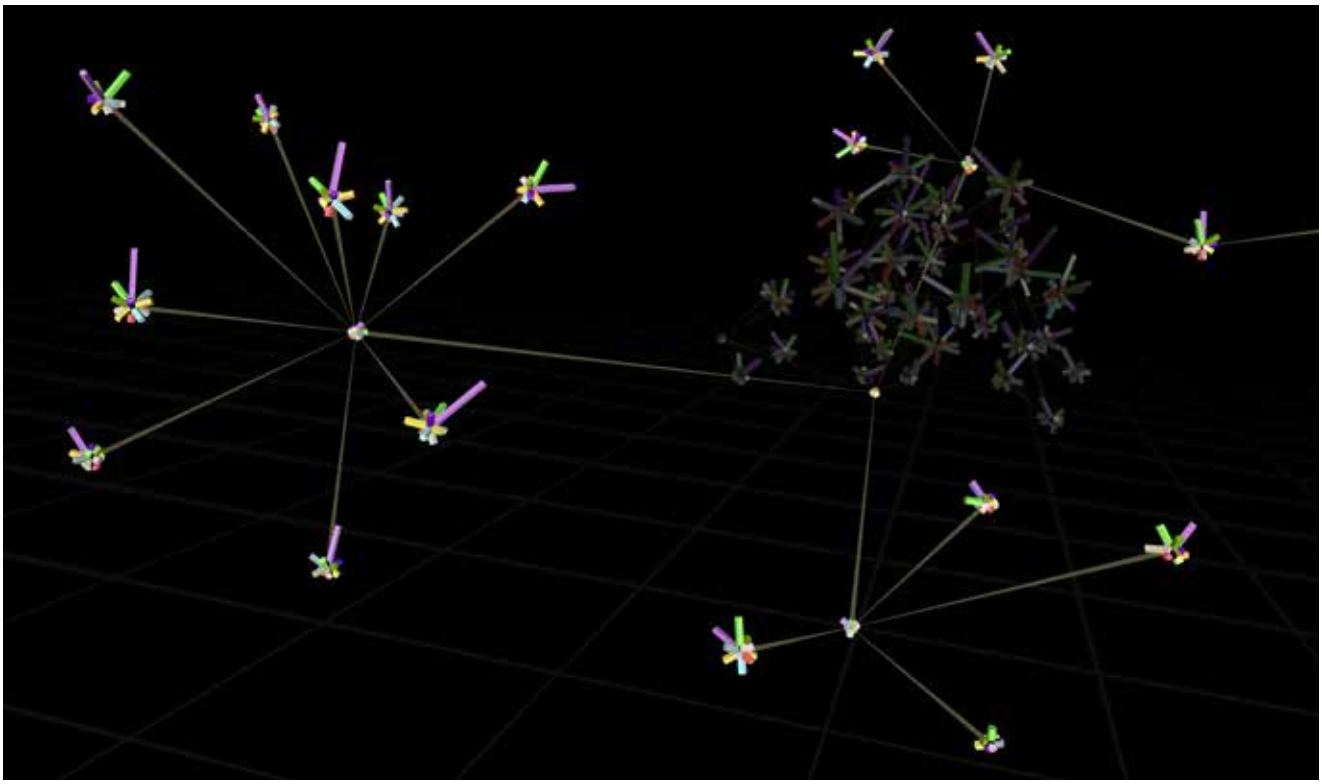
> "We think with things and struggle to think without them."

We also think with our environments, as we inhabit them and engage with objects that surround us.[10] Geoff Mulgan, an expert in the field of collective intelligence, describes the important role that objects play in enabling large-scale coordination and collaboration: "We think with things and struggle to think without them. It's often easier to solve a problem if you can visualize it with a pen and paper, or a data visualization."[11] Margaret Wilson, a noted psychologist with deep expertise in embodied cognition, describes this phenomenon as off-loading cognitive work onto the environment: "Because of limits on our information-processing abilities (e.g., limits on attention and working memory), we exploit the environment to reduce cognitive workload. We make the environment hold or even manipulate information for us, and we harvest that information only on a need-to-know basis."[12] We off-load our thoughts onto physical surrogates (like books) that stand in for more complex ideas.

> "... we exploit the environment to reduce cognitive workload. We make the environment hold or even manipulate information for us, and we harvest that information only on a need-to-know basis."

Evidence from psychology research suggests that offline cognition (careful consideration apart from here-and-now tasks and input) is also body-based. Wilson articulates this position as "even when decoupled from the environment, the activity of the mind is grounded in mechanisms that evolved for interaction with the environment—that is, mechanisms of sensory processing and motor control."[13] If humans can use their bodies for abstract thinking (such as by counting on one's fingers), we can also do this quite subtly. "To the observer, this might look like mere twitching. Imagine, then, that we push the activity inward still further, allowing only the priming of motor programs but no overt movement. If this kind of mental activity can be employed successfully to assist a task such as counting, a new vista of cognitive strategies opens up."[14]

Making sense of the world often involves externalizing thoughts onto the physical environment. Research on the cognitive processes of intelligence analysis, for example, has observed how analysts utilize the environment in particular ways to help them make sense of data.[15] As analysts organize their evidence, they manipulate artifacts in their environment. For instance, they might annotate particular pieces of evidence by hand or lay multiple pieces of evidence out on a large desktop or connect evidence with string on a corkboard. They might organize their evidence into files and place these files



in shoeboxes. As they gather evidence and organize it into physical locations, analysts are helped by these homegrown organization and annotation systems to model their emerging mental schemas. Analysts can then channel a particular schema into a hypothesis. With a hypothesis in mind, they can return to their evidence to test the hypothesis and then reassess their schemas as needed. Throughout this cycle, they shuffle their evidence into new organizational categories, locations, and annotated formats as their thinking evolves.[16]

Data analytics research has built on these observations about the role that artifacts and environmental features play in sensemaking and has identified particular advantages of large-scale interactive displays like the one offered by the ONVR tool. Chris North, professor of computer science and human computer interaction at Virginia Tech, describes the value that these emerging display technologies can offer: "[When] analysts manipulate documents on their desktop in order to create structure, that's them thinking with these documents on the space. When they reorganize the documents to make groups and clusters, that's them embedding their thoughts into the space. That helps not only in just helping them create structure out of chaos, but it also supports their memory of it, so later when they come back to it, they can say, oh yeah, I remember what I was doing here; let me finish now. So I think there is a research agenda for us in visualization to think about how we can create sensemaking tools that better exploit the environment, the space around us, to support analysts in that kind of work."[17]

NEW TOOLS, NEW POWERS

Media theorists who study the history of human technology point to the ways that new artifacts and tools offer new embodied metaphors to think with.[18] In McLuhanesque terms, "We shape our tools and then our tools shape us."[19] Humans literally think differently when given new tools to think with (and through).

> "We shape our tools and then our tools shape us."[19]

Technologies like the train and the telegraph shaped the ways we thought about how our bodies extend and move through time.[20] Likewise, the ways we think have been shaped by the invention of writing,[21] the printing press,[22] and the word processor.[23] The Jacquard loom not only ushered in an era of automated textile manufacturing but also shaped the thinking of a trailblazer in the history of the computer, Ada Lovelace. Taking inspiration from the embodied activity of "programming" a loom, Lovelace started to see Charles Babbage's Analytical Engine as more than a mere accounting tool. Instead, for Lovelace, the future of computation—like the Jacquard loom—offered a new form of generative creativity.[24] Examples like these point to a feedback loop between the way we think and the tools we use to think with and through. If you alter artifacts, tools, media, or other environmental tools of thinking, you inevitably start to reshape thought itself by making new kinds of cognition possible.

What new possibilities for thought, then, might be offered by an application like ONVR, which enables organizational network analysis in multiuser VR environments (something researchers have not yet studied)? In room-scale VR, users can step into and manipulate data with their whole bodies, using the space around them to make sense of the network's component parts. By working together in these immersive data spaces, users can engage in new kinds of collaborative sensemaking. For example, they might coordinate with one another to pull out particular regions of a network for deeper exploration or comparison. And in thinking together through this novel medium, they will most likely develop new literacies to communicate with one another about the discoveries they have made. By making these immersive media tools broadly accessible, organizations will democratize the analytical techniques traditionally available only to leaders.

RETHINKING THE "RULES" OF DATA VISUALIZATION

Traditional tools of organizational network analysis include surveys and network graphs that help reveal the structure of informal network flows. Network graphs in 2D rely on established best practices to help human observers distinguish signal from noise when making sense of network data. But as several of our interviewees noted, the time has come to rethink the "rules" of data visualization. This sentiment reflects a willingness to challenge the traditional attitude that 3D should be used only sparingly for information visualization due to issues of occlusion and noise. These concerns can be overcome with two features of higher-end virtual reality (VR) systems with volumetric tracking: stereoscopic vision and self-motion parallax, both of which enable users to see "around" objects as they make sense of a 3D environment.[25]

> "...the time has come to rethink the "rules" of data visualization."

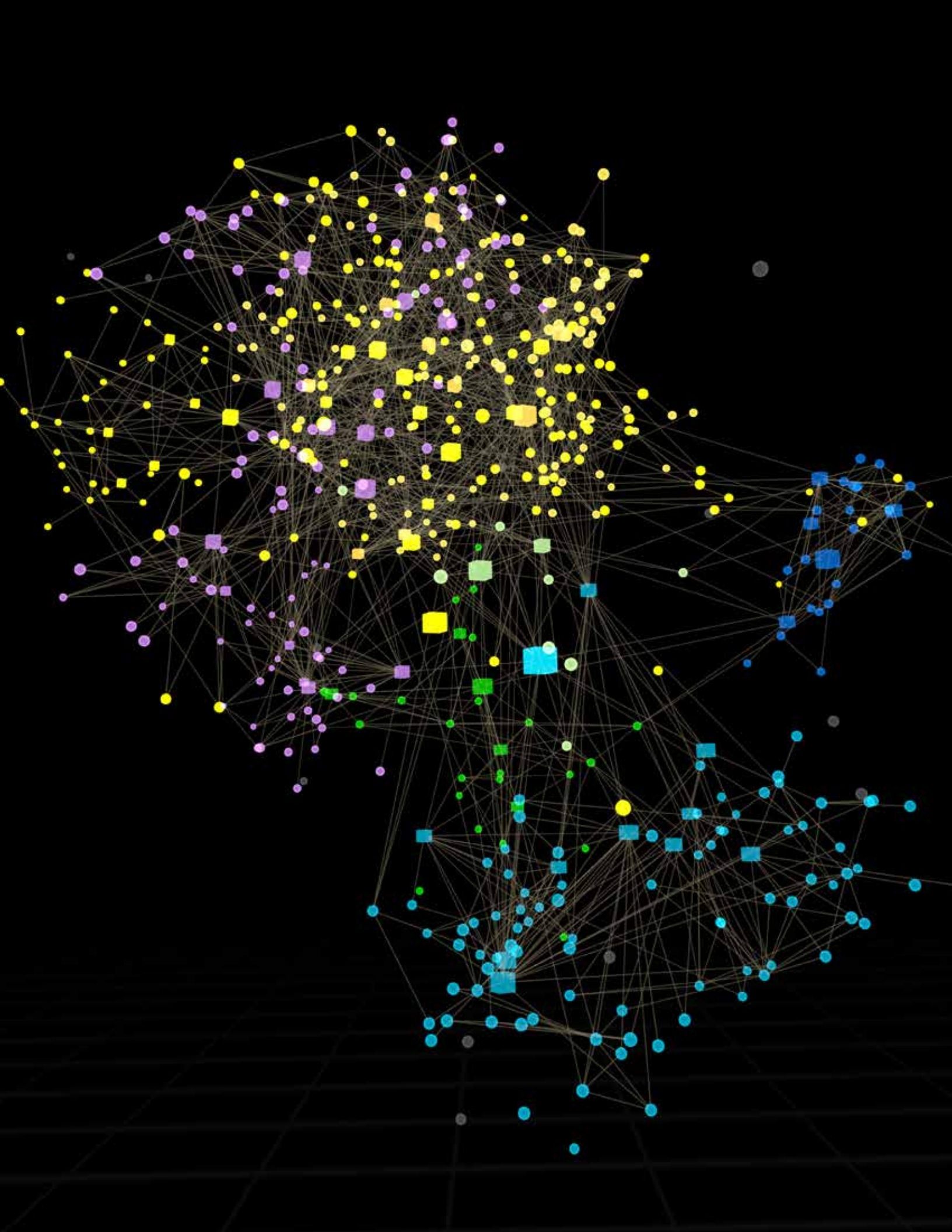
In addition, VR offers a new set of opportunities for 3D data visualization and analytics that are spatialized and embodied. Ciro Donalek, CTO and co-founder of Virtualitics, argues that "we are biologically optimized to see the world and the patterns in it in three dimensions."[26] Spatialized computing interfaces, such as room-scale VR, enable us to physically interact with our data in more meaningful ways. These interfaces allow us not only wider display areas but also deeper cognitive understanding of complex systems and relationships. A substantial body of research on embodied cognition in virtual reality has demonstrated that features of

embodiment in VR can shape aspects of cognition. In virtual reality, people form a mental model of their body based on the affordances of their virtual avatar.[27]

"...we are biologically optimized to see the world and the patterns in it in three dimensions."

Embodied affordances can also be shaped by the virtual environment, and designers have increasingly pointed to ways that virtual reality challenges traditional user experience norms by introducing new kinds of affordances. For example, designer Gabriel Valdivia advocates embedding interface choices into the actual virtual content being affected (as opposed to within menus).[28] This approach challenges the traditional separation between user interface and content. Valdivia writes, "We are tasked with finding solutions for UI that follows the rules of our augmented world; where do the menus come from and how do we interact with them? As they've matured, video games have given us examples of how design can be woven into the environment and blur the line between content and interface." He notes that similar practices are arising in virtual reality games: "Although some games rely on the traditional 2D menu systems, others place cues in the environment to educate the user. This is important because, in VR, the player has fewer abstractions to escape to. VR controllers are often shaped around a player's hand to promote natural interactions that don't typically lend themselves to menu trees."[29]

As users in VR become increasingly accustomed to engaging directly with virtual environments (as the contrast between interface and content recedes), new aspects of cognition may become off-loaded onto the environment itself, unlocking new kinds of embodied metaphors. Theorist Katherine Hayles points out that "changing experiences of embodiment bubble up into language, affecting the metaphoric networks at play within the culture."[30]



ONVR, a Proof-of-Concept Prototype

Initiated by Cisco and designed and developed by Slanted Theory, Organizational Network in Virtual Reality (ONVR) is a proof-of-concept prototype that at its most basic level of functionality supports the visualization of 3D network graphs. Network graphs depict the relationship between nodes (usually representing individuals in a network) linked to one another through social connections (known as edges).

Cisco HR is on the path to introducing a network-based culture and perspective in its workforce and leadership by seeking to share organizational network intelligence at all levels. To support this philosophy, The Emerging Media Lab advocated for setting the ONVR experience in a multiuser collaborative environment to emphasize the social aspects of embodied cognition and provide opportunities for collaborative sensemaking. Built on top of Slanted Theory's multiuser VR platform, this approach maximizes opportunities for users to move between individual and shared attention. The collaborators also wanted to explore new ways of representing data, including new visualization techniques as well as sonification and other forms of sonic feedback.

To load the ONVR environment with real-life data, Cisco conducted organizational network analysis by means of a short online questionnaire given to a testbed of Cisco employees. The questionnaire generated two datasets, the first consisting of 508 individuals with 1,615 connections from three geographic locations and the second consisting of 2,845 individuals with 7,885 connections from eighty-one geographic locations.

The questionnaire asked respondents to identify their most important and influential relationships—both internal colleagues and external partners—for accomplishing their work. These social connections shape the topography of the network graph for ONVR. The responses were directional—for example, "Bob says he is connected to Alice, but Alice does not mention Bob"—and the links (edges) of the network graph reflect this directionality. The questionnaire also included questions to identify the benefit and value provided by each connection in a respondent's network.

Cisco's team analyzed the responses to derive a series of key "benefit and value" categories for the people mentioned by respondents, including these:

- **Information** that is important to do my job
- **Help with decision making** to succeed in my job
- **Problem solving** around challenges/opportunities in my job
- **Career advice** and development input that help me grow
- **Personal support** to discuss tough work-related problems
- **Sense of purpose:** the feeling that what I do at work has a positive impact and matters
- **Innovative ideas** and perspectives that inspire me

Taken together, the data that populates these categories provides insight about why people are connected—the benefits and values they receive from, and contribute to, the network.

CORE FEATURES OF ONVR

To provide leaders and team members with insights about their personal and organizational network, ONVR supports a range of exploration and discovery features. These are described here and include letting users pull out particular nodes, dive into substructures of the network such as teams, and isolate the networks of particular individuals. As a caveat, illustrating the subtleties of a VR experience with only text and 2D images poses a significant challenge. In order to capture the specificity of the novel interactions created, this section aims to be as literal and direct as possible in its language.

Network analysis involves first understanding how people and teams are connected and then digging deeper to understand why people are connected in that manner. We will follow the same path in reviewing the ONVR features, first analyzing the topographic layer—the nodes and edges that make up the network—and then considering the benefit and value layer, which addresses why people are connected to one another.

Basic Structure of the Informal Network Graph

Cisco HR foregrounds exploration of the informal network map as the starting point for understanding how collaboration happens. Accordingly, ONVR's experience begins with the user facing a three-dimensional network graph generated by the question "Who is most important for accomplishing your work?" The social structure of the network gives this network graph its unique geometry, since the nodes in the graph are attracted to or repulsed from each other depending on the density of each part of the graph (Figure 1). A greater number of connections creates a greater attractive force, placing the nodes with more connections closer to the center of the map (and closer to each other) while pushing the nodes with fewer connections to the fringes of the map. Users who want to analyze collaboration in more depth can grab a node to highlight its immediate connections (Figure 2). When the node is released, gravitational effects reform the original structure.

Additional network connections are determined by the following parameters:

- **Team links** connect nodes that are part of the same formal team.
- **Hierarchy links** connect nodes that are part of a hierarchy chain (such as supervisor-supervisee).
- **Matrix links** include all connections that arose from Cisco's organizational network analysis survey.
- **Brokerage links** include all adjacency links that qualify neither as team links nor as hierarchy links. In other words, brokerage links connect people to those outside their team, and they are a good indicator of people who might connect different teams to one another within the organization.[31]

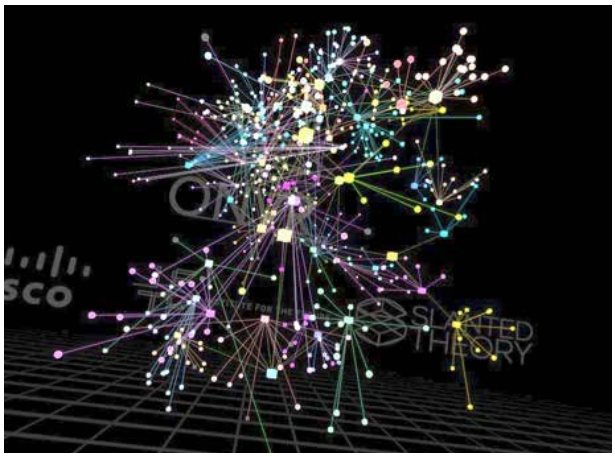


Figure 1. ONVR's 3D network structure is organized by gravitational attraction to denser parts of the network and repulsion from less dense areas.

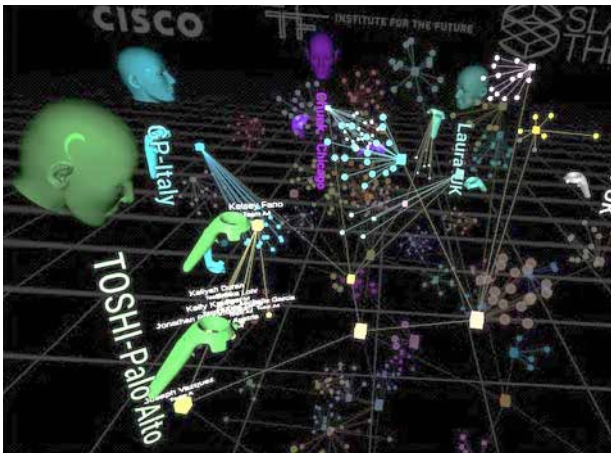


Figure 2. ONVR users temporarily deform the network structure as they grab and reposition individual nodes.

Comparing Informal and Formal Topographies

Hierarchical structures are still the fundamental decision and intervention layer for organizations, as managers and leaders play a critical role in driving change. This makes it important for analysts to be able to visualize traditional hierarchical connections along with the informal network—something ONVR makes possible. Users can switch between viewing the informal topography and the formal org chart, with its hierarchical relationships between individuals organized vertically (Figure 3). And through an animated transformation, users can also visualize the relationship between the two. In both modes, users can choose to color nodes by teams or by "roll-up" (which divides the entire network according to top leaders and the teams that answer to them).

Filtering the Informal Network Graph by Benefit and Value Categories

Comparing the informal and formal network topographies helps ONVR users to identify people and teams that play critical roles in the organization. Once this fundamental social map is understood, a user can then start to investigate the motivation behind particular network connections—for example, why Bob considers Alice one of his most relevant colleagues. People derive benefits and value from their connections, and particular subnetworks propagate them throughout the entire organization. ONVR users can explore this benefit and value layer by filtering connections according to specific categories, such as "innovation" (Figure 4).

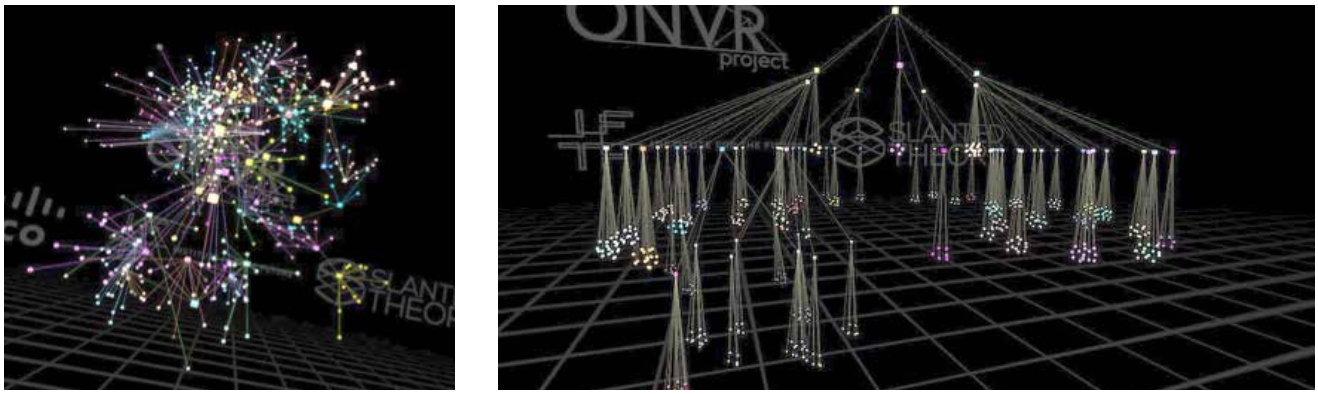


Figure 3. ONVR users can switch between visualizing the informal network structure (left) and the formal organizational hierarchy structure (right).

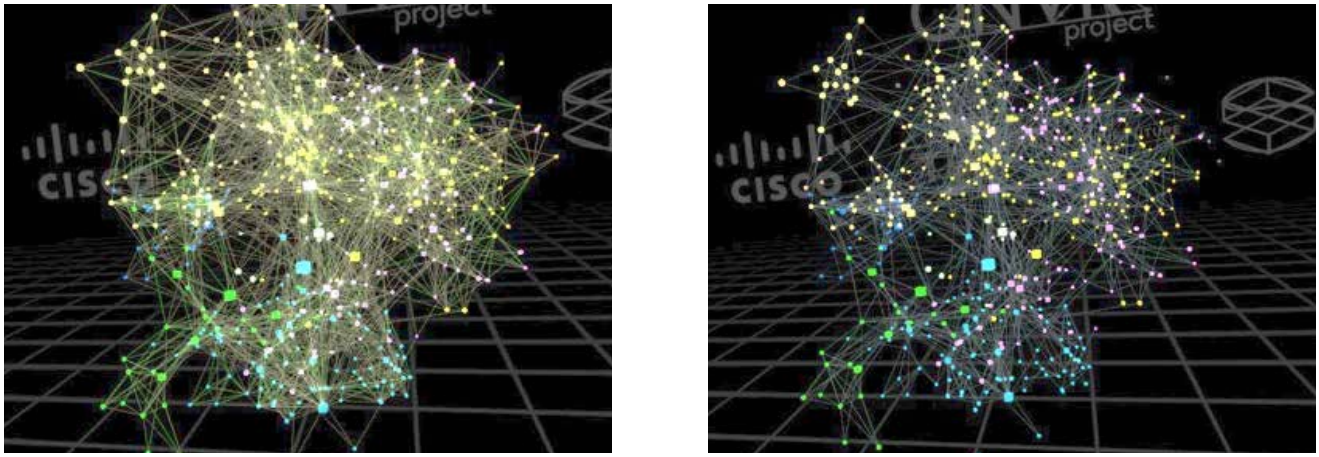


Figure 4. The image on the left shows the ONVR network structure with nodes representing individuals in the network and all possible social connections (edges) visible. The image on the right shows the same ONVR structure filtered for "innovation" edges only.

Highlighting the Directional Flow of Network Connections

The answers to the item in Cisco's questionnaire asking respondents to identify their most important and influential relationships resulted in directional information in the form of "person A considers person B one of the most relevant persons to perform her work." (In this case, the direction of this connection points from B to A, since B is conferring benefits on A.) Translated into a network graph, directionality reveals the number of incoming and outgoing connections for each individual. This information enables an analyst to identify the most influential people in the network and the ones least sought out by others. Combining directionality with the benefit and value layer, we can see how specific benefits and values (such as "decision making," "personal support," or "innovation") flow throughout the entire organization. ONVR represents this information about directional flow in a variety of ways.

On the shared menu panel, users can select directionality to display tapered lines indicating the direction of network flow for each basic connection or benefit/value (Figure 5). This mode enables users to quickly gauge which node is the origin and which node is the destination for a particular connection or benefit/value. Tracer particles can also be activated that start at origination nodes and, over a period of a few seconds, trace along a connection until they reach the destination nodes. This mode enables users to follow the path of information flow along the network so that they can quickly understand the influence of a particular node on its surrounding network.

Making Visible the Power of Teams

Teams are at the core of an organization's life—they are where people engage, performance happens, work is executed, and interventions can gain the most traction. Recognizing this, Cisco HR directed the development of ONVR toward the creation of team-centered visualization and aggregation, introducing for the first time ever a true team-based perspective on organizational network analysis. Demonstrating the role played by teams within the larger organization (a "team of teams"), ONVR lets users switch from a traditional network graph, where nodes represent individuals, to a team view where nodes represent teams.

In team view, the number of outgoing individual connections are aggregated for each team and displayed as spherical bar graphs, with one bar for each benefit/value category (Figure 6). The magnitude of each bar is determined by the number of outgoing individual connections in that category. For example, if the entire network were asked the question "Who do you go to for innovation?" and individuals in team A were listed eight times, the magnitude of the innovation bar for team A would be eight. This provides the user with an immediate picture of how connected each team is within the organization, which benefits/values each team provides, and how to weight these various contributions. In aggregate, the collection of team nodes and benefit/value category dimensions offers a truly innovative "team of teams" perspective on the overall organization.

Figure 5. Users can select directionality and tracer particle options to illuminate the directionality of network connections.

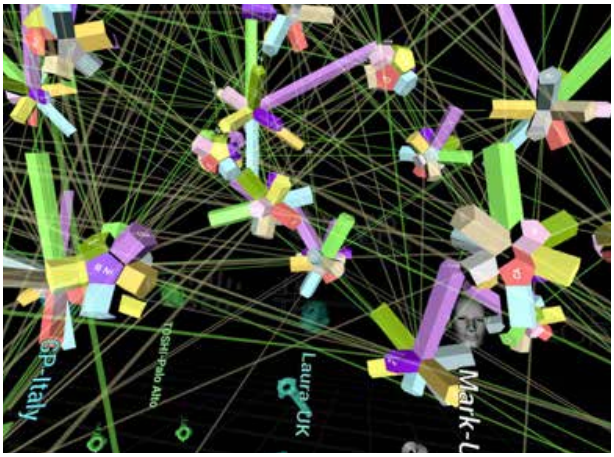


Figure 6. In team view, each node represents an entire team, with one spherical bar for each benefit/value category.

Pulling Apart and Diving Into a Team Node

Shifting the level of analysis from teams to the individuals within each team, ONVR lets users pull apart a team node to reveal a more detailed team tray with a graphical representation of the team's benefit/value scores. Above the tray, the team is now displayed as a network of individual nodes (Figure 7).

From this view, ONVR lets users dive into a particular team to see how individual team members contribute to the team's network characteristics. This perspective allows users to identify key players, critical contributors, and areas where further development could occur. When a user touches one of the benefit/value bars, the team network above is filtered by the selected category. For example, if a user selects "adjacency," only the purple adjacency connections are shown (Figure 8). Arrows show each individual's contributions to the incoming and outgoing team score within that category.

Focusing On Specific Individuals and Ego Networks within Teams

From within team view, ONVR offers users a deeper lens for understanding the role individuals play in connecting teams to other teams. ONVR enables users to select individual team members and highlight connections across teams. In this configuration, users can move from the macro perspective of a "team of teams" view to then drill down into a specific set of member connections or benefit/value layers.

When diving into a team with a team tray open, a user can select a specific member node or nodes. This activates a spherical portal displaying the ego networks of each individual selected—represented as a single node and its direct connections. The portal enables a user to get a micro perspective on a local region of the network while still having the macro context of the wider network visible and accessible. Going a step further, users can also combine multiple ego networks to see

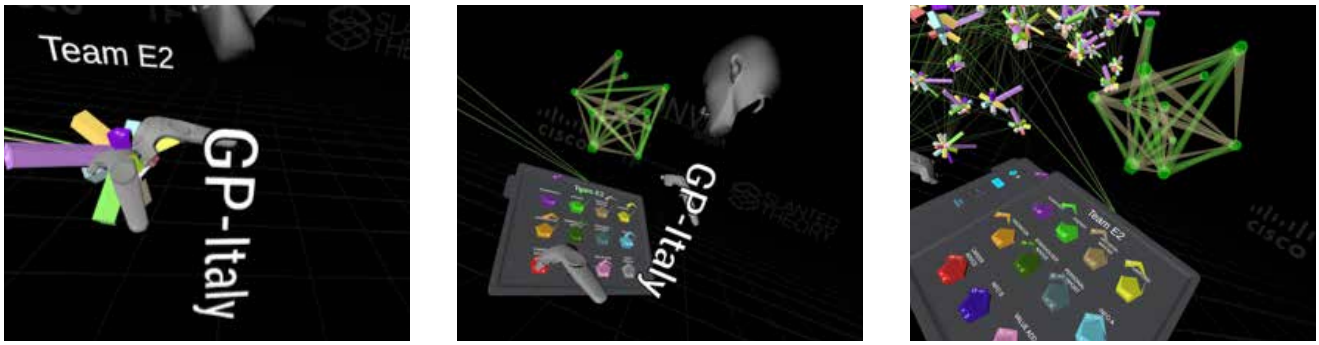


Figure 7. A user pulls apart a team node (left) to reveal the team tray and team member network (center) with the overall team node network structure still visible in the background (right).

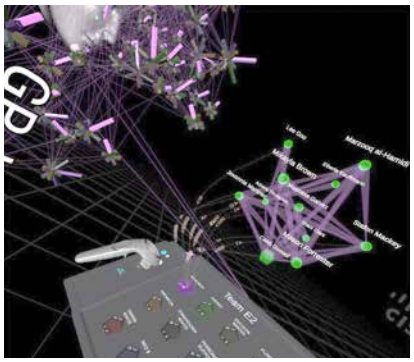


Figure 8. User has selected the adjacency bar on the team tray, which filters the team member network (foreground) and also highlights adjacency bars in the overall team-node network (background).

their interconnections. This enables users to investigate a particular subnetwork.

In Figure 9, the nodes highlighted in white have been selected, and the same nodes appear in the spherical portal along with their ego network links. A single user can transport all users to an isolated view showing only the selected nodes and their ego networks. This dedicated portal then lets users analyze a particular subregion of the network with greater specificity.

Relating Teams to Teams

Taking the analysis and intelligence extraction capabilities even further, ONVR lets users dive into multiple teams simultaneously to explore how the specific team networks relate to one another. In team view, if a user opens multiple team trays, connections are shown between individual nodes in different teams. Likewise, the portal will show all nodes selected from both teams (Figure 10).

In summary, ONVR takes traditional organizational network analysis one step further by integrating team-of-teams and individual network analysis in the same visualization. We believe this integration will make visible and unleash the power of teams.

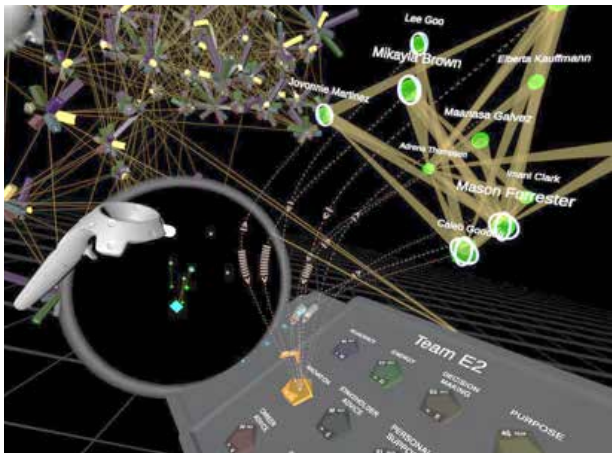


Figure 9. User has selected team member nodes (highlighted in white) making them also appear as ego networks in a spherical portal/overall team-node network (background).

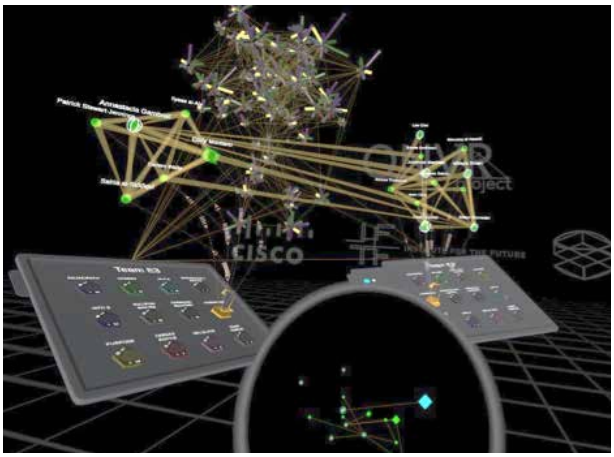


Figure 10. In team view, a user has opened to teams. Their member networks show connections between the teams, and selected members are displayed as integrated ego networks in the portal.

EMBODIED COGNITION IN ONVR

By situating network graph and other data analytics features within an immersive environment, ONVR leverages embodied cognition as a powerful tool for making sense of an organization's networks. The aspects of embodied cognition that ONVR activates include themes of bundling complexity, nested interactions, and spatialization and social organization of data.

Bundling Complexity

One of the ways new media forms reshape embodied metaphors is by enabling new user experience features to stand in for much more complex operations.[32] Several interviewees pointed out how this principle operates at a number of levels in ONVR. For example, the team view (Figure 6) enables users to think about teams as nodes in a network, each with varying contributions to directional network outputs. Thinking about networks at the level of a team of teams enables new kinds of observations about the network flows between teams. And rather than focusing on organizational interventions at an individual level, a team-of-teams view encourages users to see the network as aggregations of agents than can connect to other teams in new ways. For instance, rather than "seeding" an individual connection in the network by encouraging two people to meet, a leader could instead seek to create denser connections between one team and another or could create a new team that occupied a particular position within a team-of-teams network.

Nested Interactions (the "Onion Effect")

Each team node in the network can be opened up to reveal a team-internal network graph (foreground) organized by the same structural principles that also shape the interteam network (background) (Figure 8). Slanted Theory's Laura Smith describes this nested configuration as the "onion effect." VR data visualization expert Angus Forbes also remarked on the novelty of embedding these nested interactions within the data visualization context. For example, by opening a specific team node, users can dive into the team's data to make sense of the ways that the individuals within a team are contributing to its incoming and outgoing contribution to the network.

Spatialized Sensemaking and Social Organization of Space

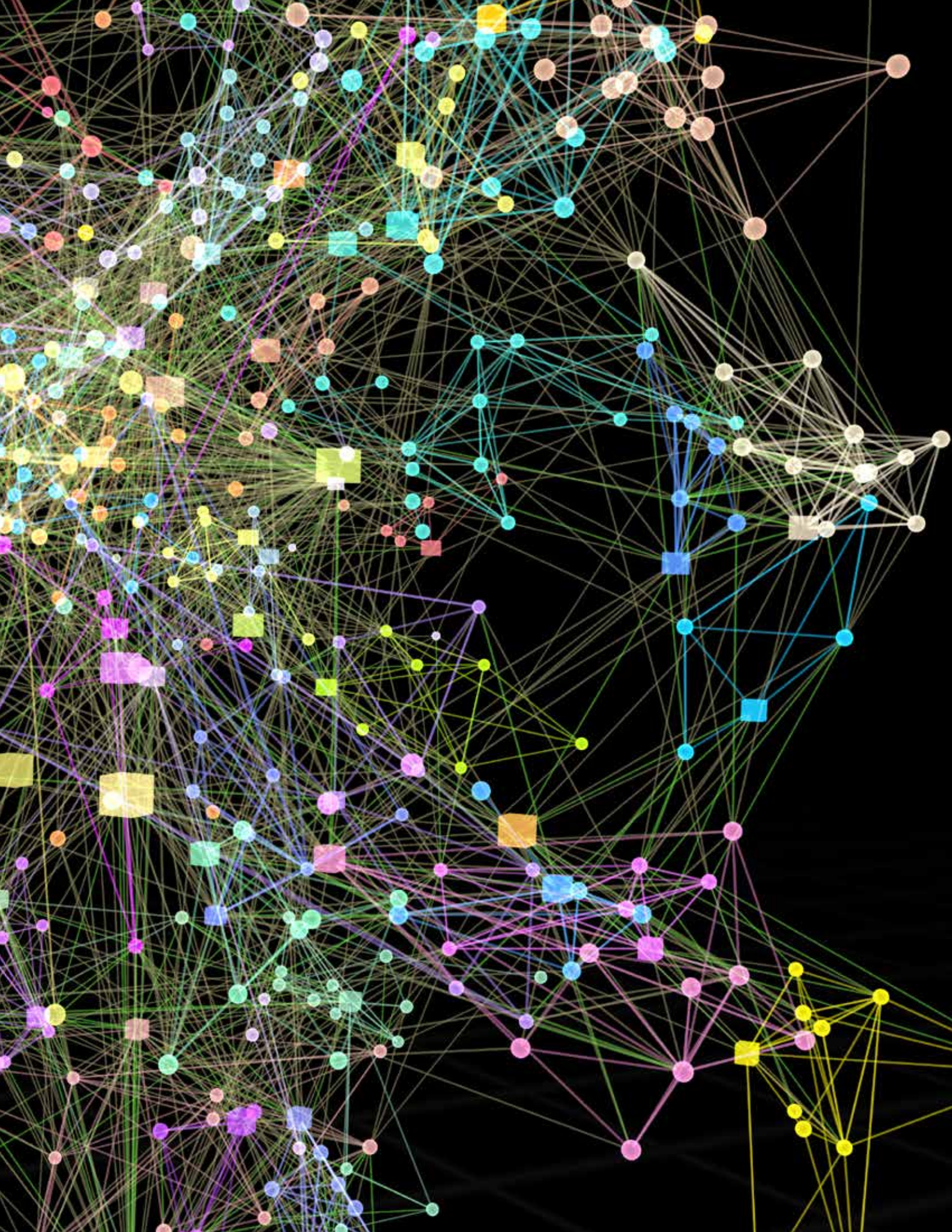
Users might also develop new ways to distribute group cognition by making use of the space around them to organize particular clusters of the network. For example, a group of users might spread out a network into its constituent teams. As each user drags a team into a particular location, they embed meaning in the space around them. As shown in Figure 2, users on their own can examine the relationships of a particular team's component members. In the same space, they can communicate with each other about particular hypotheses or propose movement of members across various teams. And, like the analysts who spread out files on a physical desktop, users might remember insights surfaced during this conversation in relation to a particular social constellation of bodies and team graphs. In this sense, the social space overlaps with the spatial aspect of the network in meaningful ways that may contribute to higher-level thinking.

Another unique way ONVR leverages spatiality is by enabling interactions to cascade throughout multiple interface elements in the foreground, midground, and background. For example, selecting local features like the benefit/value bar graphs on the team tray has a cascading impact on the overall network graph in that the particular category selected by the user is also highlighted throughout the larger network.

ONVR AS A SANDBOX

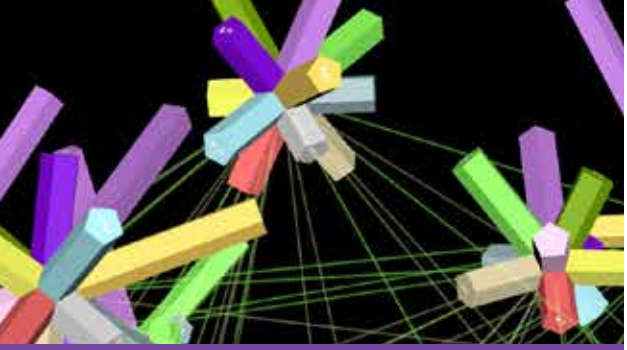
ONVR certainly leverages aspects of data visualization as a communication device, but it might also be characterized as a sandbox for data analytics. Weidong Yang, CEO of Kineviz, who has developed similar volumetric network graph tools for his GraphXR project, describes the distinction this way: “Do you have a conclusion already or are you seeking to make a discovery?” The latter demands a more exploratory approach. He points out that whereas in the Tufte model, data visualization is done in print form to display information that is already known, “today the visualization we’re interested in is a discovery. Because of that, the requirements are different. Yes, you want to reduce noise, but you also want to amplify the signals (especially multidimensional signals). Most of the time you’re telegraphing what your intuition tells you and then after the fact you rationalize your decision. How do you build subconscious understanding of complex data inside of data, so that you may not realize what’s on the tip of your tongue but you’ll start to feel it?” By activating embodied cognition, a sandbox approach helps analysts to “feel” the data before they can even articulate the patterns they are seeing.

Reflecting this exploratory sensibility, the first version of the 2D human network platform designed by the Cisco LTI Digitalization Office team was presented to their leadership as “an answer looking for a question.” One of the ways ONVR builds on this approach to exploration and discovery is by enabling engagement at multiple scales simultaneously (a key feature identified by Chris North). For example, users can dive into a particular team to better understand the role of individual members and then shift focus to consider the role of the team in the overall organization. Specific arrangements of ego networks can also be isolated to explore unique substructures within the network. Future generations of ONVR can reflect discoveries made in the initial prototype and incorporate new features that further leverage embodied cognition as a tool for exploration.

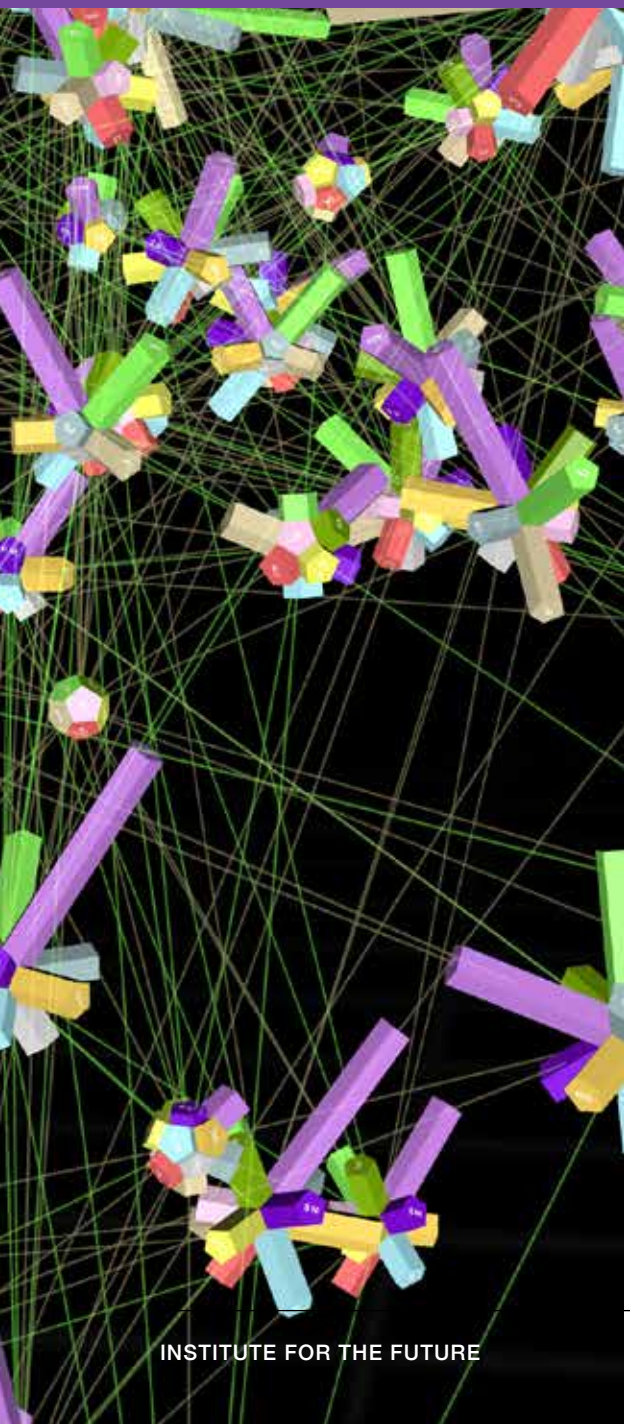


Future Possibilities Signaled by ONVR

ONVR signals a future where immersive sensemaking tools unlock transformative possibilities for organizations. In particular, multiuser VR network analysis can drive innovations in how network data is visualized, in the kinds of organizational interventions that can be designed and the actors who can design them, and in how the collective intelligence of an organization can be tapped to help it continuously evolve to meet new challenges. This section considers work that has already been done and is being done to conceptualize future methods of visualizing data in a multidimensional immersive environment, organizational intervention by way of ritual design, and practicing biomimicry in organizations to leverage human network intelligence. We pose questions to guide further reflection about how multiuser VR network analysis might play an enabling role.



INNOVATIONS IN 3D DATA VISUALIZATION



As mentioned earlier, the field of data visualization has traditionally used 3D approaches sparingly in screen-based and print-based media. But this is changing as virtual reality (VR) and augmented reality (AR) leverage stereoscopic vision and self-motion parallax to enable users to understand information structures more richly without suffering from the kind of occlusion and noise issues associated with 3D representations in 2D media. In addition, the field of virtual analytics has emerged to support analytic reasoning facilitated by immersive forms of interactive visual interfaces.[33] Virtual analytics has been applied in a range of contexts, including the life sciences, climate science, emergency management, archaeology, air traffic control, social network visualization, and work management.[34] Virtual analytics has also seen recent success in commercial big data applications. For example, Pasadena start-up Virtualitics recently raised significant funds to support its VR and AR data analytics platform for analyzing e-commerce sales data (Figure 11).[35]

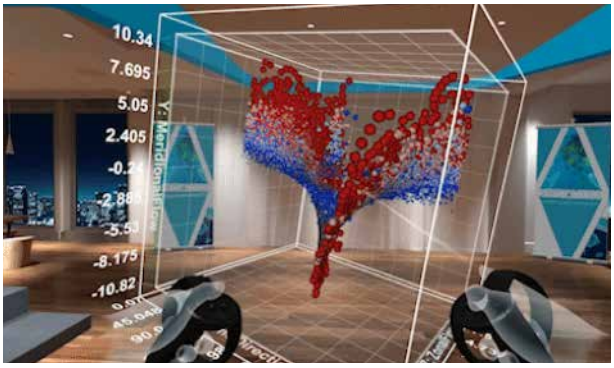


Figure 11. Virtualitics is developing a VR and AR data analytics platform for analyzing e-commerce sales data.

Within this emerging sector, several start-ups have focused in particular on visualizing and interacting with network graph data in VR. San Francisco–based Kineviz, founded by Weidong Yang and Travis Bennett, has developed 3D network graph explorations in a range of contexts, including workplace collaboration data and visualizations of social media (Figure 12). They describe their GraphXR platform as a low-friction interface for 3D link analysis and data science. GraphXR earned news coverage for helping to identify Russian troll activity on social media (Figure 13).[36]

In addition, AR research efforts are being undertaken by larger players such as IBM, with its Immersive Insights demo. Alfredo Ruiz, design lead at IBM Design, describes the opportunity as one of efficiency of pattern discovery. "By visualizing data in 3D and viewing data from new angles and perspectives, we help data scientists identify key patterns, relationships, and outliers in seconds, where it would normally take hours of work."[37]

The future of 3D data visualization and analytics in VR is likely to be shaped by innovation opportunities in the areas of collaboration and emerging interface techniques, such as new approaches to filtering and comparison.

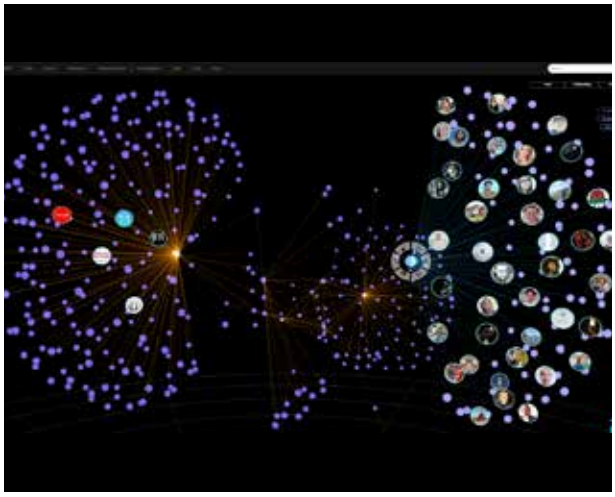


Figure 12. Kineviz's GraphXR platform is a network graph tool for analyzing social media.

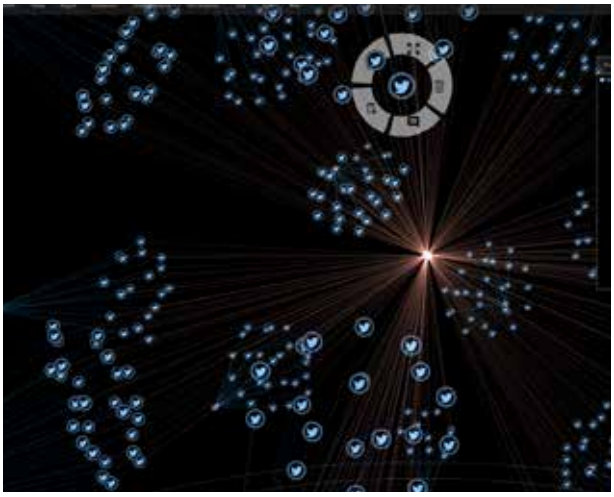


Figure 13. GraphXR was used to help identify Russian troll activity.

Virtual Analytics and Collaboration

Multiuser VR analytics environments can make possible collaborations that draw on the power of teams and collective intelligence. One of the academic trailblazers in this area is the Immersive Analytics Lab at Monash University in Australia, a research group that has explored how VR, AR, and CAVE (cave automatic virtual environment) media can support visual analytics. Its research has demonstrated, for example, the important role that collaboration can play in enabling users to share different points of view on the same information structure and make pattern discoveries together. While they have worked with a range of media forms, much of their research in this area uses CAVE displays (Figure 14).[38]

Figure 14. The Immersive Analytics Lab at Monash University explores collaboration using CAVE displays.

Another research lab at the forefront of collaborative data analytics is the Electronic Visualization Laboratory (EVL) at the University of Illinois. Their work has included a number of CAVE-based projects, including a multiuser analytics platform for exploring lake data in a CAVE2 environment (Figure 15).[39]

Up until the release of consumer-grade head-mounted displays (HMDs), a CAVE was one of the few affordable multiuser environments. The availability of high-quality consumer HMDs have now unlocked new research avenues for multiuser, immersive interfaces beyond earlier exploration in CAVE displays. Not only do HMD's lower the cost for building multiuser immersive systems, but they also allow for remote collaboration of participants and richer forms of volumetric interaction.

In terms of commercial applications, companies that have specialized in HMD-supported multiuser VR analytics environments include Slanted Theory and Austin-based start-up DatavizVR. DatavizVR has created a custom enterprise virtual analytics platform called 3Data, earning support from Microsoft for Startups and from BoostVC. Based on its own description of 3Data, DatavizVR focuses more on multiuser VR as an environment for sharing presentation-ready data visualizations than as a sandbox for sensemaking and insight discovery: "Team members can work together; supervisors and CEO's can contribute and/or leave notes; clients can make changes and give their

Figure 15. Andy Johnson's Electronic Visualization Laboratory at UIC created a multiuser analytics platform to explore lake data in a CAVE2 environment.

input—all in the same 3D space, and in real time."[40] This approach contrasts with ONVR's emphasis on data exploration within a sandboxlike environment, but it also signals a future where the boundaries between specialized analytics tools and generalized communication environments start to blur.

Comparing the Same Dataset as Seen Through Different Filters

A number of our interviewees who work at the vanguard of 3D visualization and analytics emphasized the importance of being able to compare multiple configurations of the same dataset. UC Santa Cruz assistant professor Angus Forbes, runs Creative Coding, a research lab that explores data visualization and analytics techniques in immersive media. Forbes has developed a platform called NeuroCave to visualize the human brain as a network graph.[41] In this work he has found a great deal of value in providing neuroscientists with the ability to compare the anatomical network structure of the brain to the intrinsic structure (structured by the connection topography) in order to explore various hypotheses (Figure 16).

Other interviewees echoed this interest in side-by-side comparison of the same dataset with different filters applied. For example, Weidong Yang of Kineviz described a way to visualize two 3D scatter plots side by side in VR, an approach he calls a 6D data sandbox. This approach enables users to test mini-hypotheses about whether apparent clusters are consistent across multiple variables. This goal is a familiar objective for data scientists, among them cancer genomics scientists who need to compare multiple 2D scatter plots to assess tumor affinity clusters. Yang's approach accelerates this sensemaking process by enabling users to think and interact in six dimensions simultaneously.

After experiencing ONVR, sociologist Marc Smith was also interested in comparing the same dataset through different filters. Smith is the chief social scientist for the Connected Action Consulting Group and one of the leading experts in 2D network graph visualization of social media. Despite his grounding in 2D visualization (with its skepticism of 3D), he quickly grasped the transformative opportunity of stereoscopic 3D in VR. He suggested that it would be valuable to compare an organizational network filtered by the incentives that

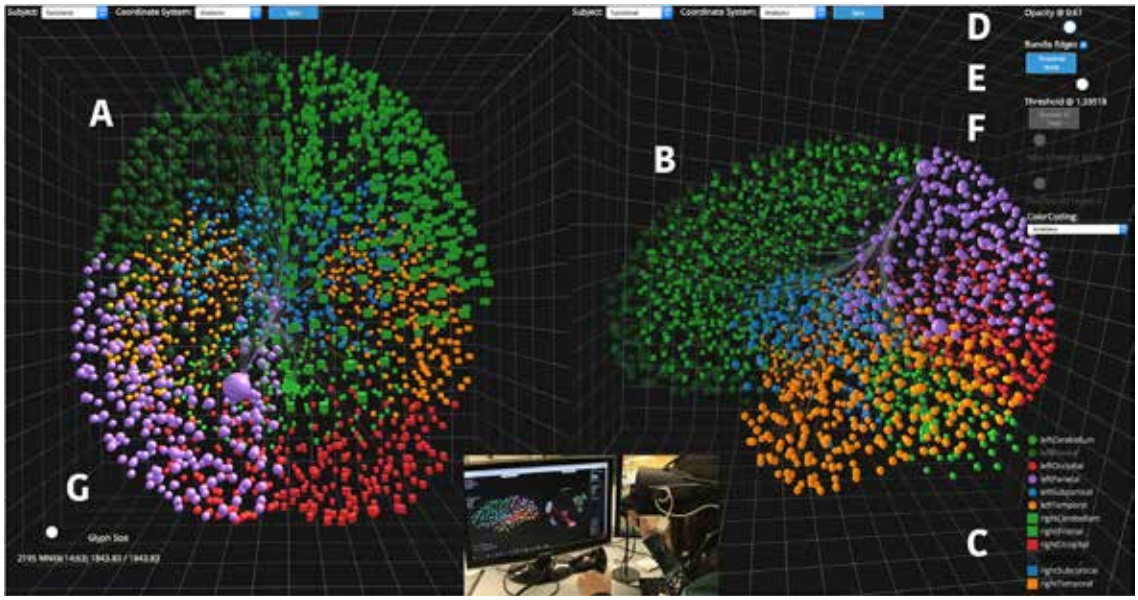


Figure 16. NeuroCave is a VR platform for visualizing the brain neural network that lets users compare the anatomical structure (left) to the intrinsic structure (right).

drive performance—for example, comparing people whose performance improves more after a raise with those whose performance improves more when given additional time off—and commented that "not everyone is motivated by the same things." Smith also made a striking suggestion about rethinking the interface for filtering data by embedding the filter itself in an object that attracts certain kinds of nodes and not others. If you moved the filter object through the network, the perturbations could reveal meaningful patterns.

Melissa Hui, an innovation strategist at Idean with deep expertise in both user experience design and organizational management, also commented on the importance of advanced filtering and comparison features. While using ONVR, she wanted to be able to select the upper and lower bounds of a filter envelope so that it would, for instance, show only the people or teams who have outgoing innovation connection scores greater than 3 but less than 7. This kind of feature might help leaders identify individuals or teams with promise in a particular value category that has yet to be optimized.

Innovative Interface Techniques

Perhaps the most transformative area of future innovation for 3D data visualization and analytics in VR involves breakthroughs in interface techniques.

The Immersive Analytics Lab's workshop at IEEE VIS 2017 posed questions about new affordances and interaction techniques for virtual analytics. For example, it called attention to the value of hybrid 2D and 3D interfaces but also asked participants to go further in rethinking the basic assumptions of analytics in VR. "Traditional information visualization supports open-ended exploration based on Shneiderman's information mantra: overview first, zoom and filter, then details on demand." Contrasting with this classic approach, the workshop pointed to a new model where "analytical applications [are] grounded in the physical world . . . [and] objects in the physical environment provide the immediate and primary focus." Similarly in immersive contexts, an effective approach is "to provide detailed information about these objects [in the foreground] and only provide contextual information on demand."[42] This notion of focusing on the foreground first and only filling in context on demand is an approach echoed by big data research using VR and AR.[43]

Slanted Theory's Laura Smith and Mark Burkitt echoed some of this sensibility, but their work on ONVR has helped them hone their approach in several unique ways. In response to calls to embed interface choices in content, Smith and Burkitt note the importance of balancing familiar user expectations with innovative departures. For example, in certain cases they deliberately leveraged well-established patterns of 2D GUI-based literacy (such as shared menu panels and toggle selection buttons). The shared menu, in fact, was an important feature for enabling collaboration. Because the shared menu panel is both familiar and visible to all parties, it became an important anchor for attention and a vehicle for expert users to teach novices about the system's capabilities. In other areas, however, Smith and Burkitt wanted to innovate by making content like the team tray graphs interactive—these graphs not only convey information but also serve as a selection mechanism when a user touches one of the value category bars, revealing additional team-score contribution information as well as causing the entire network to highlight that category.

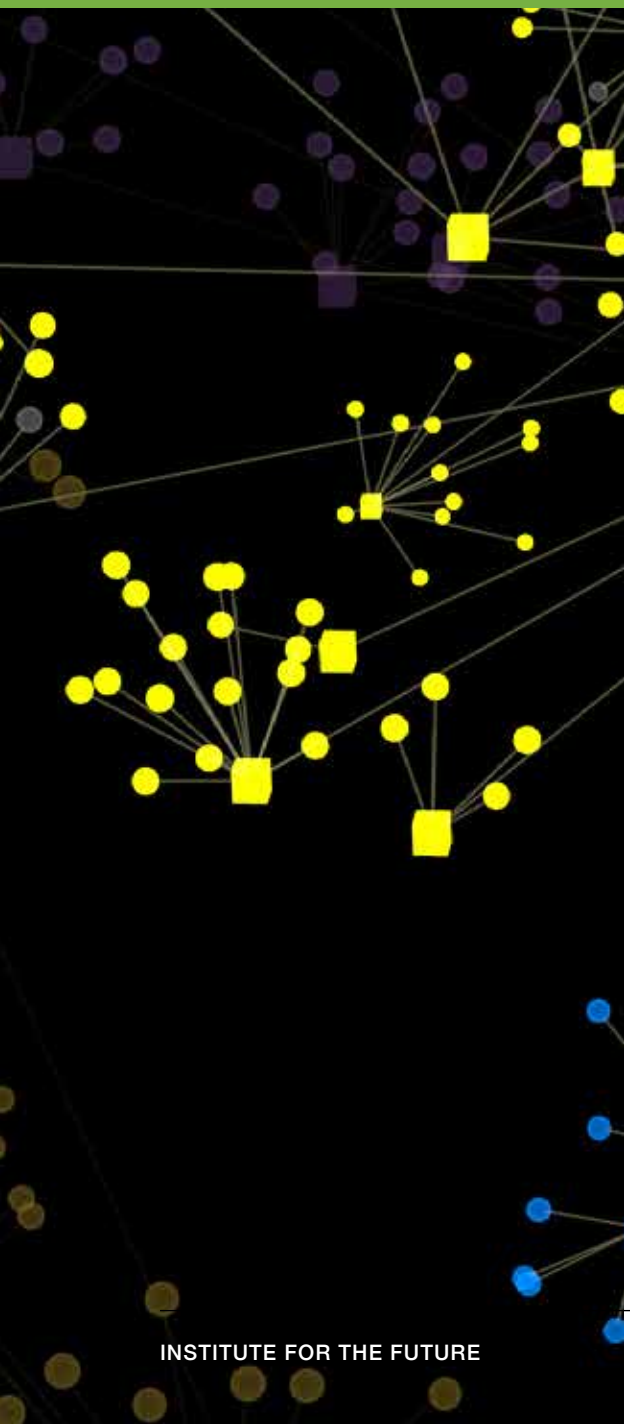
In the team tray case, users trigger this effect by "touching" the bars with their controllers (a relatively familiar interaction); but in other cases, more innovative choices demand entirely new gesture-based interaction literacies. For example, users can "pull apart" a team node to reveal the team tray, but this "pulling apart" interaction is hidden—users must be told it exists since the interface itself does not communicate this affordance. That said, user testers remarked that the interaction itself was fairly intuitive and satisfying once it was known. Slanted Theory's Smith likened this gesture-based interaction modality to the pinch-and-zoom gesture introduced by the iPhone. At one time, people had to develop this gesture literacy, but now it feels

intuitive and natural. Like pinch-and-zoom, the "pull apart" gesture in ONVR could be used more broadly—for interacting with all nodes in the network (not just team nodes), for instance.

Questions for Further Reflection

- What new data visualization possibilities are opened up by features of higher-end VR systems with volumetric tracking (stereoscopic vision and self-motion parallax)? In what contexts is 3D data visualization superior to the 2D visualization of the past?
- What kinds of new discoveries might be made possible by emerging approaches to data filtering and comparison in VR network analytics?
- How might the affordances of 3D data visualization and analytics unlock new collaborative powers for teams?
- How might tools like ONVR make it possible for groups to collaborate seamlessly in real time to advance organizational agendas?
- What kinds of interface features would draw on embodied cognition to make collaboration in VR more intuitive and natural?
- How might new gesture-based interaction literacies impact how people engage with data? What new embodied metaphors might be available for people to think with?

NEW KINDS OF ORGANIZATIONAL INTERVENTIONS



Just as ONVR signals a future where the rules of network data visualization can be rethought, it also points to the opportunity to rethink rituals of interaction that take place inside organizations. As companies struggle with disengagement, lack of resilience, and instability due to the changing nature of work, they need new ways of intervening to act on the insights they gather from network analysis. Traditionally, managers are the only ones authorized to act on those insights, and they have done so through the usual suspects of hiring, promoting, reassigning, laying off, and forming new teams, as well as through more subtle interventions associated with seeding new network connections or integrating across networks during a merger.

But growing interest in organizational ritual design points toward a future in which VR network analysis tools like ONVR can play a part in democratizing workplace culture and decentralizing network interventions. If such tools can be made available to all members of an organization, each member can also be empowered to redesign the routines, rituals, and processes through which his or her network operates and transforms. Cisco HR is on the path to introducing such a network-based culture and perspective in its workforce and leadership by seeking to share organizational network intelligence at all levels.

The Emergence of Organizational Ritual Design

Organizational ritual design is a method for interacting with the tacit beliefs, values, and assumptions of a workplace culture. This emerging field suggests new pathways of intervention for shaping the informal structure of organizational networks. Designers have demonstrated surprising results by working with organizations to develop new workplace rituals to promote cohesion, resilience, creativity, well-being, and engagement.[44] Rituals in the workplace are not necessarily new as a concept, since events like retreats, retirement parties, and culture-building events have long

been a feature of organizational life.[45] But conscious ritual design can vastly improve upon these traditional—and at times stale—rituals by leveraging the creativity of local actors and empowering them to be agents of cultural transformation.

Kursat Ozenc, an expert in organizational ritual design and a strategic design consultant at SAP Labs, describes a range of ritual "flavors" and domains—"personal rituals, team rituals, rituals with robots or artificial intelligence, and other untapped territories"—and notes that workplace rituals "can be grand, dramatic things, or they can be tiny, personal ones." Along with Margaret Hagan, Ozenc runs the Stanford Ritual Design Lab. He points out that regardless of the context, "the core question is how do we bring meaning and purpose to these different domains?" This question of how to create meaning is particularly salient in areas of emerging media. Ozenc notes that "when designing for VR/AR/AI and robots, we don't know how people will be creating meaning in those contexts, and ritual design helps ground you and have something to hang on. It's how we are wired."

The process of organizational ritual design begins by collaborating with participants to identify key contexts for rituals to be deliberately (re)designed and articulating these opportunities as a simple design brief, such as this one:

> **Onboarding New Employees:** How do we help a creative team . . . effectively welcome a new team member—and help this new employee to feel part of the team more quickly and seamlessly?

This brief resulted in the following ritual design:

> **Crash the Desk,** to welcome new hires with a surprise treasure hunt on their first day at work. When the employee is distracted away from the desk, their team-mates fill up their sad, empty new desk with their own personal objects. Then the employee must go on a hunt, talking to all their new co-workers to try to find the objects' owners, and hearing stories about why they're special. The goal is to build more personal one-to-one connections, and reinforce the new bonds being made.[46]

Ozenc notes that this approach requires buy-in from the participants—a ritual won't be as effective or sustainable if it is merely imposed from the outside. The process of ritual design has to address the authentic experience of those on the ground, which means that participants have to be willing to reflect on their own practices and be ready to creatively reimagine them. Ozenc and Hagan propose that organizational ritual design can "allow for employees to design the rituals, and thus the culture, that they want to see in their organization. Rather than only central management imposing rituals to define culture, could we democratize culture building through design sessions in which all kinds of stakeholders can propose and implement new rituals?"[47] According to Ozenc, ritual design approaches work best when leaders cede responsibility to local actors.

"...when designing for VR/AR/AI and robots, we don't know how people will be creating meaning in those contexts, and ritual design helps ground you and have something to hang on."

In May 2018, the Ritual Design Lab hosted a first summit on organizational ritual design at Stanford University (Figure 17). Ozenc notes that the summit strongly validated the emerging sense of interest in this approach from a wide range of practitioners, researchers, and industry partners. “We see a potential of an emergence of ritual design as a field, and it might have a practical angle, a research angle, or a business angle, [but] people have been approaching us from different channels/domains. [Participants from] Airbnb, Adobe, anthropology professors, business schools, design researchers, primatologists, [all came together] and validated the emergence of this interest.”

Summit participant Lillian Tong practices organizational ritual design as a co-founder of the Matter-Mind Studio. Her work focuses in particular on rituals in the workplace that support the processing of difficult emotions. Like Ozenc, she notes the importance of local actors having autonomy and being able to take ownership of the rituals they co-design. “It takes a person in the community, who understands the pain of the community, to design and sustain the ritual.”

Organizational Rituals and Team-Based Interventions

Teams have a unique power to shape aspects of organizational culture by designing and sustaining rituals that are customized for their local needs. Embracing workplace rituals as a key to building successful teams, Cisco is well positioned to capitalize on ritual design as an area of innovation. In particular, Cisco’s LTI group seeks to empower teams to create their own collective rituals as a way to enhance engagement, accelerate performance, and effectively leverage strengths and aspirations. This approach is reflected in Team Space, a dedicated platform for creating and working with teams at Cisco.

While ONVR offers an innovative new approach to network analytics, the issue of how organizations can and should make strategic interventions at the level of the team remains an evolving question for the

Figure 17. The first Ritual Design Summit was held at Stanford University in May 2018.

future. Traditional management interventions tend to be oriented to the individual whereas organizational ritual design suggests opportunities for intervention at the level of the team. Introducing a new team ritual in one area of a network may provide a valuable test bed for the organization overall or suggest alternative experiments that could be explored by other teams in the wider organizational network.

The Promise of Using VR Network Analysis Tools in Organizational Ritual Design

Tools like ONVR can contribute to grounding organizational rituals within teams and decentralizing the power to shape organizational culture. Organizational ritual design in VR is an emerging area with few real-world examples,[48] but we can imagine a variety of ways in which multiuser VR network analysis tools might be employed to change workplace culture through strategic interventions. These possibilities focus on intervening at the level of teams and on democratizing organizational sensemaking by making VR tools broadly accessible and transparent.

First, network analysis itself can become a collaborative sensemaking ritual when practiced by multiple users in an immersive VR environment. Exploring together how such an environment activates and leverages embodied cognition in a way that's not possible with more traditional 2D network graph tools might be an interesting team exercise in awakening to new potentials. A new sense of empowerment and curiosity might also result from putting VR network analysis tools into the hands of teams of local actors.

Second, as new rituals are invented, revised, or proliferated throughout a network, tools like ONVR can help analysts make sense of the impact these interventions have on the organizational network as a complex living phenomenon. VR tools can help analysts evaluate the impact of team rituals designed, for example, to overcome a difficult period of change or connect to other teams in the organization.

Third, rituals as organizational interventions can be suggested through an AI-supported recommendation system in VR. The next generation of ONVR could analyze existing teams' rituals and make recommendations about which successful team practices should be experimentally extended into new contexts within the organization. For example, if a team wanted to design a ritual to build internal cohesion or if a leader wanted to bridge the cultures of two teams, a recommendation system could suggest ritual templates that have worked within similar network configurations in other contexts. The specific teams could then adapt these templates to their own local needs.

Questions for Further Reflection

- What would it mean to democratize organizational sensemaking by making tools like VR network analysis and other human network intelligence platforms broadly accessible and transparent?
- What might happen to an organization that adopts tools like these? What new strategic interventions might be possible?
- What new kinds of collaborative sensemaking rituals can occur inside an environment like ONVR?
- How might tools like ONVR help people make sense of the impact of new team rituals on an organization and its networks?
- How might the interface of a tool like ONVR suggest new team rituals as part of a strategic recommendation system supported by AI?
- If new sensemaking technologies support new kinds of insights, how might we channel insight into action in new ways?
- What are most important kinds of ritual interventions for a team-of-teams network perspective?

NEW MODELS FOR LEVERAGING HUMAN NETWORK INTELLIGENCE

Tools like ONVR promise to democratize organizational sensemaking, and they also make possible collaborations that draw on the power of collective intelligence. This is right in line with what the field of biology can teach organizations that want to become more agile. Evolutionary biologist Tamsin Woolley-Barker uses analogies between human networks and what she calls superorganisms (such as mycelial networks or ant colonies) in the natural world. For her, the superorganism offers a model for thinking through how organizations can transform themselves to take advantage of distributed leadership, swarm creativity, reciprocity, and regenerative value.[49]

Woolley-Barker makes the case that successful human organizations will increasingly reflect the decentralized self-organizing complexity of biological superorganisms. In other words, organizations will need to empower decentralized leadership so that teams can take on and respond to challenges autonomously and rapidly. During her interview, Woolley-Barker was shown the ONVR tool and responded by emphasizing the importance of enabling more avenues to represent dynamic data, noting: "Leaders need to understand that we need to be building living systems. You don't optimize a species behavior for each season, or each stage of a superorganism's lifecycle." With new sensemaking capabilities such as those offered by VR network analysis tools, organizations can be intentional about harnessing the power of the human superorganism.

From Centralized to Decentralized Power, as in Nature

Tamsin Woolley-Barker points out that we have hierarchies in the workplace because at one time they served an important purpose of enabling scale, but that now the centralized, hierarchical, command-and-control structures of traditional organizations are increasingly not up to the task of supporting modern work. "We've defaulted to the hierarchical model because we have to be able to 'scale up.' Now we have the technological abilities and

infrastructure (communication networks) to support the way humans actually like to work. We are flipping back and forth between these hierarchical structures and more distributed biological models which are self-organized. Much of the struggles are because of the mismatch. When you use naturally occurring human patterns you get a lot of productivity and efficiency for free."

Echoing Woolley-Barker and practitioners of organizational ritual design, researchers in a range of fields have identified a profound shift away from traditional top-down structures of hierarchical power toward more flexible, decentralized phenomena. Jeremy Heimans and Henry Timms describe this shift in their book *New Power*, which articulates a vision of new kinds of movements and organizations driven by "crowd leaders" who combine the tactics of crowd engagement with an eagerness to share power.[50] As David Brooks writes in the *New York Times*, "Heimans and Timms emphasize that the best organizations try to blend old and new power structures. These organizations are often founded by what you might call disappearing organizers. Somebody comes up with a compelling concept, like TED or Black Lives Matter. The concept gives people a sticky group identity; many people think of themselves as Tedsters. The core idea is spreadable, actionable and connected—it allows participants to subcreate in local and flexible ways. Tedsters organize and attend over 20,000 local TEDx events. The founder doesn't dominate the network so much as manage the community."[51]

Also writing on the topic of self-organizing movements and organizations, Ori Brafman and Rod Beckstrom describe this distinction between old and new power as a metaphorical contrast between the spider, which has a head that serves as command-and-control for its legs, and the starfish, with legs that operate semi-independently and can regenerate if separated from the whole.[52] As organizations increasingly morph from spiders to starfish in order to survive, the value of immersive tools like ONVR for visualizing the network flows behind hierarchical structures will become more and more apparent.

Further Lessons from Biology

Aside from studying the decentralized complexity of superorganisms, organizations can draw a variety of other lessons from biology. For example, sociologist and physician Nicholas Christakis points to epidemiological frameworks of contagion to better understand how patterns of human behavior and emotion flow through a network. Intelligence can also operate as an outcome of network flows. Geoff Mulgan, chief executive of Nesta, the UK's National Endowment for Science, illustrates this point in his book *Big Mind,* which makes the case for an understanding of collective intelligence beyond the wisdom of the crowd. Instead, his interest is in understanding how societies, institutions, and other governing systems can leverage more complex assemblages of human-machine networks to solve complex collective problems.[53]

> "It's the difference between being in traffic [as a driver] versus watching it go by."

Biological systems often rely on emergent properties in which the whole demonstrates behavior that is more complex than that of its component parts. Craig Reynolds, a software engineer known for developing the first flocking algorithm for artificial birds (known as boids) points out that the complex behavior of a flock arises from the local interactions of individual agents—in this case, driven by three simple mathematical rules: separation, alignment, and cohesion. Reynolds describes the inspiration that sparked the invention of his algorithm: "One of the things that made a difference was imagining myself as a bird in the flock. [This was a] transformative shift in perspective."[54] Now Reynolds works as an engineer modeling the emergent properties of traffic systems. He still notes the importance of taking on this perspective as an individual within an emergent system: "It's the difference between being in traffic [as a

driver] versus watching it go by." The ONVR application offers a similarly transformative shift in perspective as users begin to immerse themselves in an embodied sense of network data connections. Pointing to future opportunities, Reynolds and Woolley-Barker both expressed interest in seeing an ONVR-like environment capable of representing dynamic data and reflecting how organizations change over time. Reynolds notes "someone may stop seeming influential over time . . . people come and go . . . how do you design for higher-order perception? [As with boids] you need to perceive the flock of birds as a superorganism."

New Avenues for Signaling

To support the organization as a living system, the human network needs not only new tools for sensemaking and analysis but also new pathways for individuals and groups closest to a problem to send signals back into the organizational network model itself. In biology, the concept of stigmergy describes how organisms coordinate by leaving signals in their environment. Kathi Vian, distinguished fellow at the Institute for the Future, has researched several human examples of stigmergy, including the Depression-era technique of "warchalking," a hobo-symbol system for communicating about the habitability of transient environments (later used as a reference point during the invention of WiFi). She notes that stigmergic systems like warchalking operate as a meta-language for the environment. "What it does is create a secret code or vocabulary for people to comment on things in the environment that aren't necessarily visible in the environment."

Responding to the Emerging Media Lab's goals, Vian notes: "We are literally creating different surfaces . . . and VR becomes [a digital] surface" to embed social signals into. Thinking about a tool like ONVR as a surface to annotate opens up new questions, however. Is the network graph itself a surface that can be annotated? In the future, could ONVR be better positioned as a tool for making sense of signals left in some other environment? Widening our perspective to include ubiquitous augmented reality in the workplace, for instance, we can imagine a world in which social annotations of communication are collected in real time to serve as the data inputs for an ONVR-like tool.

With an AR "surface," everyday interactions become an opportunity to annotate/generate collective intelligence that shapes how we understand the patterns and interactions both within and between teams. In the next generation of ONVR, we might imagine pulling apart team nodes not only to reveal network-value contribution scores but also to reveal annotations based on collective input from team members who leave social signals as they interact with one another. We could also imagine an AR version of ONVR as an interface for accessing these annotations left behind in physical space as digital traces of the rituals and routines of everyday work interactions.

Questions for Further Reflection

- How can VR network analysis tools help organizations be intentional about harnessing the power of the human superorganism?
- How can tools like ONVR help remind leaders and employees alike that an organization is a living system?
- How might an ONVR-like environment represent dynamic data and real-time organizational change? What lessons from the biology of flocking could inform the design?
- How can people collaborate in immersive spaces to activate and leverage their collective intelligence?
- How might new forms of social augmentation enable new kinds of human superorganisms?
- What new "surfaces" can annotated and what new communicative signals can be leveraged to support stigmergic interaction in the workplace?

Conclusions

This report has offered a glimpse of the ways network sensemaking may change when it shifts into 3D environments. ONVR presents a proof of concept of an immersive, collaborative organizational network graph set in VR. In particular, ONVR demonstrates the important role that embodied cognition can play in shaping how we make sense of organizational network data.

As we look to the future, new questions emerge around how new literacies native to immersive interaction will shape the ways that we engage with network data structures and recognize patterns in volumetric data. As we shift from a 2D window–based paradigm of GUI interaction to a stereoscopic 3D interaction paradigm, new user expectations will emerge and new kinds of gesture input will become intuitive, eventually reshaping the embodied metaphors we use to think with. The affordances of collaboration will expand to incorporate new social superpowers opened up by immersive VR sensemaking.

One of the promises of ONVR is to point the way from network insights to new kinds of organizational interventions. The emerging field of organizational ritual design signals opportunities for decentralization in the crafting of culture. Empowered by VR network analysis tools, everyone in an organization—not only leadership—can have an opportunity to derive insights from a network intelligence perspective. Similarly, each member of an organization can be empowered to act on those insights by reinventing the routines, rituals, and processes through which the network operates and transforms at the local scale. Teams can become the new locus of intervention as environments like ONVR make it possible for human network intelligence itself to evolve as a collaborative sensemaking ritual. The future of ONVR could enable analysts to make sense of the impact that team interventions have on the organizational network as a complex living system, and new rituals could be suggested through an AI-supported recommendation system.

ONVR offers a lens for thinking about the kinds of interventions that might be possible as organizations shift their leadership perspective from a hierarchical command-and-control model to one that seeks to facilitate those closest to a problem or opportunity area.

This approach to decentralized intelligence and leadership fits nicely with a vision of organizations as superorganisms. Organizations can draw inspiration from the ways that information flows within biological networks. For example, VR and AR “surfaces” can be annotated as a way for individuals and groups closest to a problem to send signals back into the organizational network model itself.

VR network analysis tools like ONVR are potentially transformative. They can help organizations harness new forms of collective intelligence. They can nurture the capacities of individuals and teams to make sense of changing network flows. And by enabling more autonomous forms of distributed leadership and decentralized cultural intervention, they can help organizations become more agile in the face of disruptive change.

Appendix: About the Research

The information presented in this report was gathered through a variety of methods: research through design, expert interviews, and a literature and landscape review.

Research through design (or RtD) is an approach that focuses on insights surfaced through the process of prototyping.[55] The insights generated by RtD are not universal, nor are they so specific that they only apply to a single design. Instead RtD insights tend to point to patterns that occupy the middle ground between general theory and a particular instance.[56]

The interviews included experts in a range of fields, including organizational design, strategic foresight, sociology, AI, biology, virtual reality design, data visualization, and social networking. Interviews also included members of the partner teams, including an in-depth interview of Slanted Theory's co-founders as well as interviews of several of the key members of the Cisco team. Interviews were semi-structured and open ended, and often involved a demo of ONVR to provoke feedback (Figure 18). We analyzed the interviews to pull out insights about new network analysis approaches and provide context for the future possibilities we outline in the last section of the report.

Figure 18. Users test ONVR during expert interviews.

PARTNER TEAMS WERE AS FOLLOWS:

Cisco, Leadership and Team Intelligence Digitalization Office

- Gianpaolo Barozzi, senior director HR and team leader
- Bill Jackson, architect and experience designer
- Chuck Shipman, digital alchemist and experience designer
- Jack Wilson, senior manager, leadership and team intelligence
- Tom Lamberty, consultant, leadership and team intelligence

Institute for the Future, Emerging Media Lab

- Joshua McVeigh-Schultz, research manager and primary report author
- Toshi Hoo, director
- Susanne Forchheimer, program manager

Slanted Theory (ONVR design and development)

- Laura Smith, co-founder
- Mark Burkitt, co-founder

Interview participants, in addition to members of the partner teams above, included the following experts:

Experts on data visualization in VR

- Weidong Yang, CEO of Kineviz
- Travis Bennett, co-founder of Kineviz, director of R&D
- Angus G. Forbes, assistant professor of computational media, UC Santa Cruz

Experts on social networks, network visualization, and organizational networks

- Howard Rheingold, writer, critic, and theorist of social networks and cooperation
- Marc Smith, chief social scientist for the Connected Action Consulting Group
- Bob Johansen, distinguished fellow, Institute for the Future

Experts on organizational culture and organizational ritual design

- Kursat Ozenc, strategic design consultant, SAP
- Lillian Tong, co-founder of Matter-Mind Studio
- Melissa Hui, innovation strategist with expertise on mapping culture, director of customer experience, Idean
- Linda Couwenberg, design researcher, behavioral scientist, Idean
- Kate Judson, program manager, global workplace strategy, Adobe Systems

Experts on biomimicry

- Tamsin Woolley-Barker, evolutionary biologist
- Kathi Vian, distinguished fellow, Institute for the Future
- Craig Reynolds, expert in modeling autonomous agents in flocking behaviors, software engineer at RightHook
- Radha Mistry, foresight strategist in emerging technologies, Autodesk

The literature and landscape review surveyed academic research and state-of-the-art projects in the fields of organizational management, biomimicry, network analysis, data visualization, virtual reality, computer supported cooperative work (CSCW), and human-computer interaction (HCI).

We enlisted Anthony Weeks, a graphic facilitator and real-time information designer, to create graphics that helped organize our conversation on the topics of social sensemaking, immersive network data visualization, and creative new ways that organizations can intervene to shape their networks and their culture (Figures 19 and 20). Central questions explored in this work included: How do we enable people to creatively act? How might metaphors from biology enable us to think differently about dynamic network data? And what new kinds of social superpowers might new sensemaking and social augmentation media unlock?

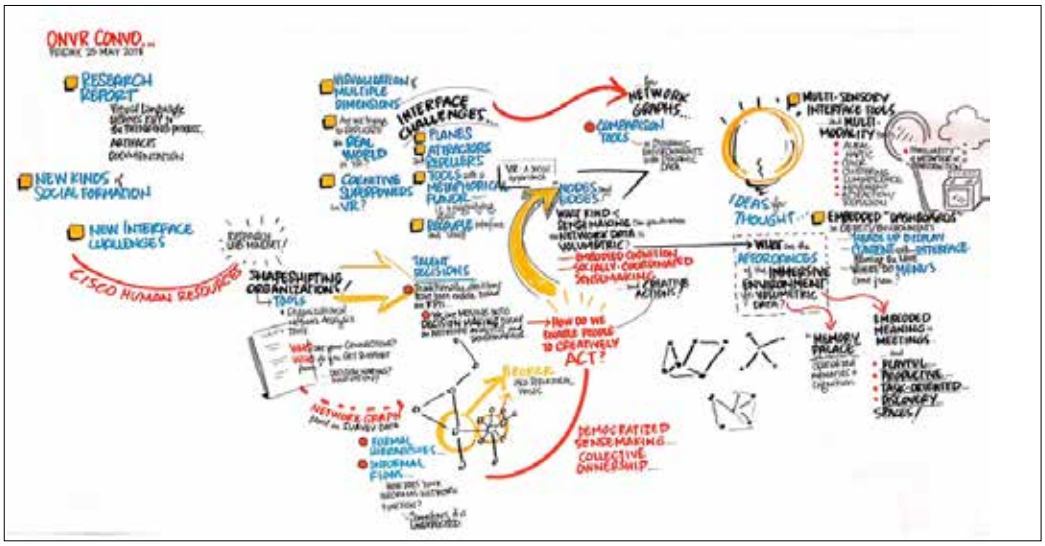


Figure 19. Anthony Weeks created this visualization of the initial conversation focusing on the context and design problem space for ONVR.

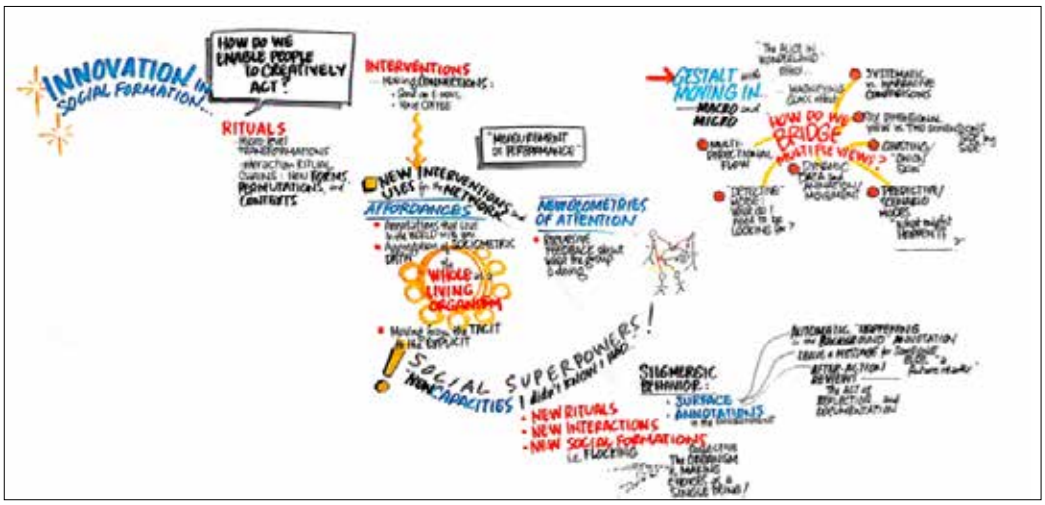


Figure 20. Weeks created this visualization of an ideation conversation that explored possible democratized approaches to network analysis, new capacities and social superpowers, and new approaches to representing dynamic data.

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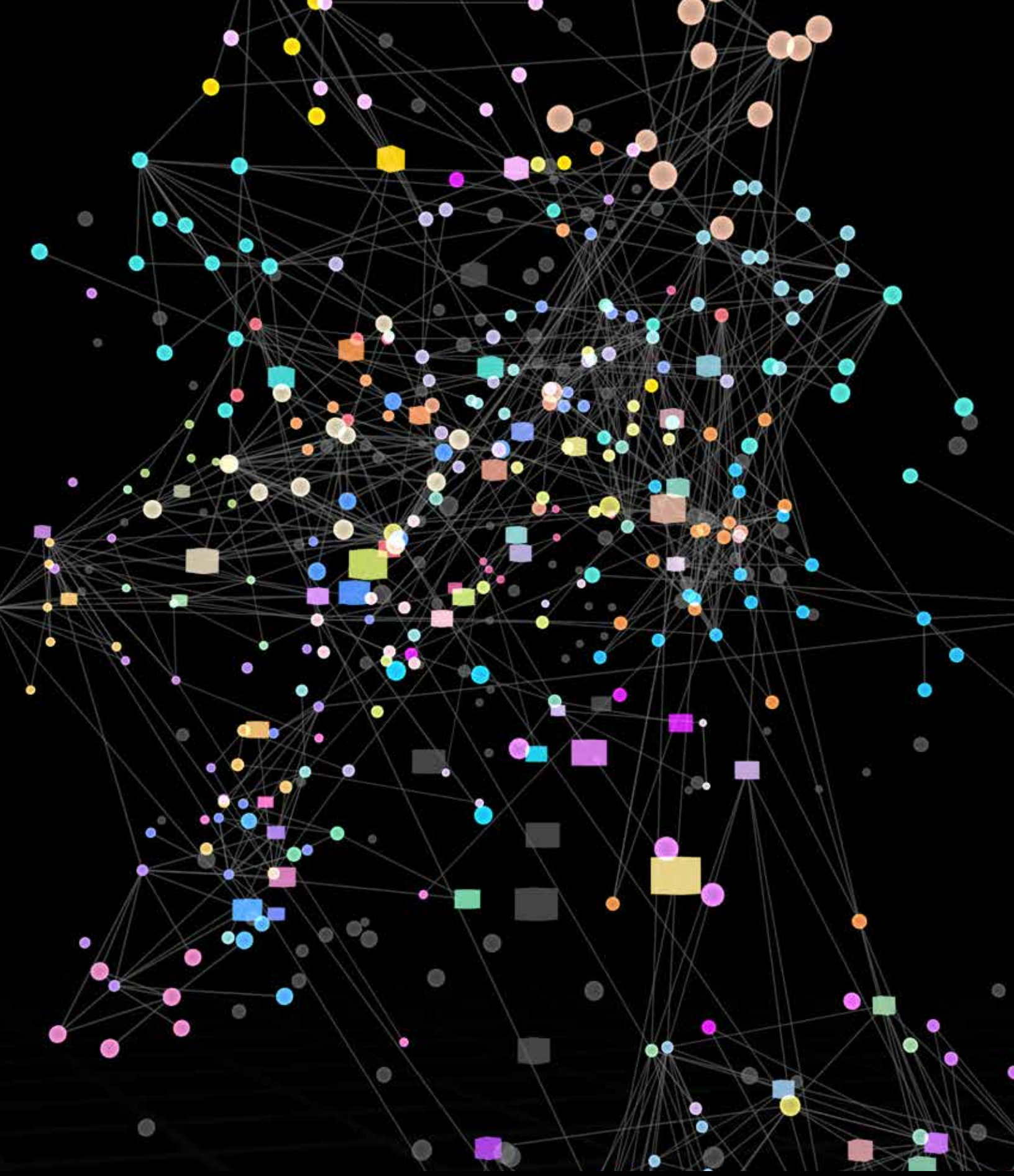

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