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Taxonomic Considerations for Node-and-Link Visualizations

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KEYWORDS *Data visualization, node-and-link, big data, social media, node, link, ground, change agent, annotation*

ABSTRACT

Data visualization models that are intended to depict considerable sets of interrelated data (including systems designed to process and render big data, particularly those that must reveal unexpected correlations) and data-supported massive-communication toolsets (such as social-network media systems) increasingly rely on presentations that depict relationships through node-and-link diagrams. The challenge of combining these kinds of quantitative and qualitative datasets can be well met with node-and-link diagramming — provided an articulate and consistent modelling method is applied to the task. This paper is a primer on what node-and-link diagrams are, and what kinds naming categories may be derived and assigned in order to make node-and-link diagrams articulate and consistent.

This investigation was originally part of research specifically targeting healthcare issues in which the healthcare providers and healthcare recipients were considered "nodes" in the massive paradigm which is the procedural and financial realm of today's healthcare world. Considerations were given to multiple questions: What should constitute a "node" and what should constitute a "link" in a visualization? What other parts are there? How can these elements be placed into dynamic and uncertain context? How can the intrinsic components of such a network be re-arranged to leveraged improvements? Also, how are all the concerns of healthcare providers signified within such as system? These kinds of questions lead to the development of hundreds of "kinds" and "natures." Ultimately a system was devised allowing for comprehensive model building. It was based on these elements: **node(s), link(s), ground(s)**, **change agent(s), and annotations.** This paper provides an overview of how these five elements were considered axiomatic and the nature and variations associated to these core elements

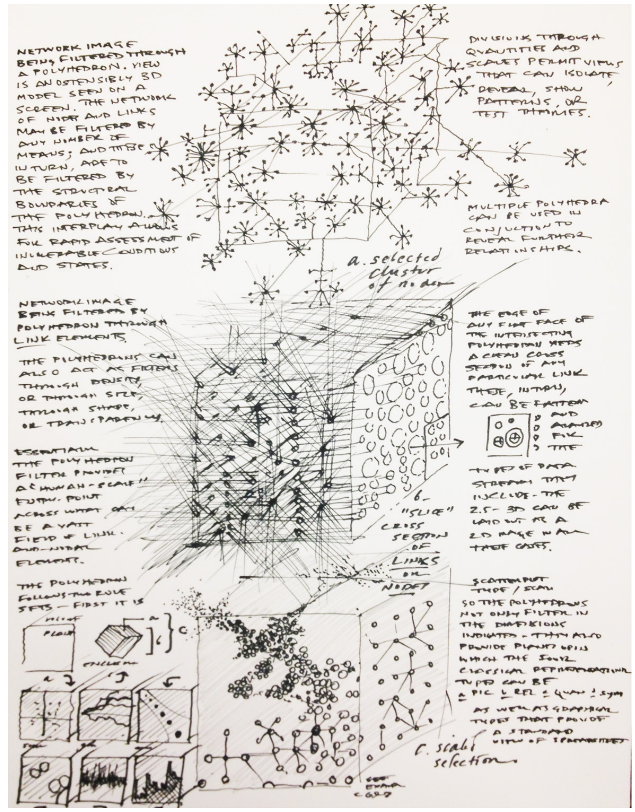


FIGURE 1: *An interface might be thought of as an combination of reveals and controls. The reveals are what are presented to the viewers in terms of presentations, visualizations, renderings, or whatever else they may be termed. Consider, for example, how our senses respond to nature through senses. All the actual presentations of imagery, smells, sounds, movements, etc., have causes and effects behind them — even though such causes may not be sensually "visible." In synthetic interfaces most of what we see visualized have their controls apparent in the forms of buttons, sliders, drop-downs, or non-apprent with gesture based manipulation. Links-and-nodes are always occurring within these interfaces whether or not they are visible. The diagram above shows how node-and-link activity occurs within the polyhedron of possible data within a given system. The choice is whether the associations are presented with visible connections, or not. If so, a logical method to do so is required, or as can be seen, the user will be rapidly overwhelmed by such tangible connectivity.*

INTRODUCTION

A feature-rich, and generally effective, method for displaying interrelational connectivity and like-minded informatics may be achieved through node-and-link visualizations. Social network-style and logic-based modeling become revealed with graphic user interface models and visualizations that deploy node-and-link models.

Node-and-link visualizations are also effectively navigated via touch-screen and gesture-based graphical user interface models. Node-and-link modeling is also a highly proficient approach to "asymmetric" input/output (capture/display) data flow. Massive amounts of data, or data that might be extremely difficult to understand in its more professional and jargon-rich formats, can be displayed in insightful, compact ways via node-and-link methods.

Additionally node-and-link models can seamlessly allow rapid variations within a display which can yield considerable insight into the data being analyzed. Elements within a node-and-link model can provide a targeted delivery of information on one hand, and big data type analytics for analysis on the other. Node-and-link presentations can be approached from simple icon generation to immense presentation and contextual depth. In the last decade network visualization, generally realized through node-and-link presentations, have begun to dominate as a solution to big data requirements.

As information design professionals are looking at new ways to deal with society's insatiable desire for, and generation of, information that reveals context of similar and dissimilar things, the node-and-link modeling method has been in importance.

For all these advantages these is one overwhelming disadvantage — node-and-link diagrams become complex very quickly. It does not take many nodes or links to fill a screen and create considerable "noise." A great deal of the imagery that results is also non-informative, resulting in shapes and patterns from the overlapping devices that provide neither direct knowledge by design, or insight through "collateral shaping." The challenge is to develop a very logical rule set for what each device should, or should not convey; how these devices are designed for the purpose of such conveyance; and how they change when new data (or conditions) must cause them to alter. Let's consider some aspects of these devices and their nature (termed here ontology), and look at how, through a simple taxonomy of five kinds of things (and their sub-divisions), nearly any kind of relational diagram can be constructed. The figure to the right provides a background guide to what a relational pattern is in comparison to the other types of core patterns.

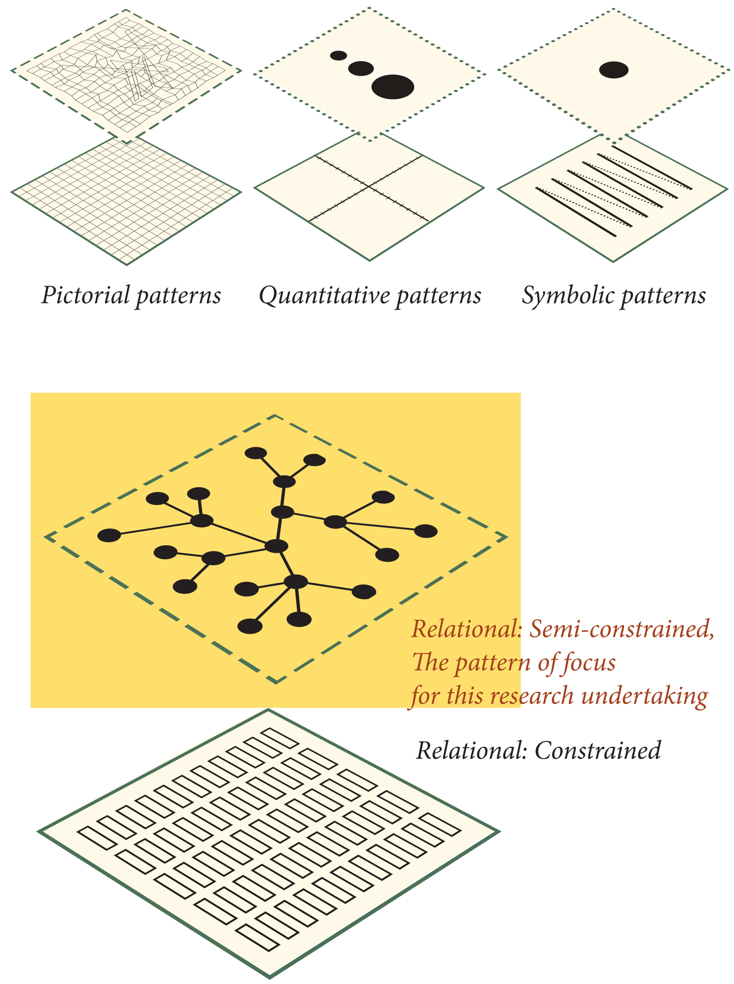


FIGURE 2: *Node-and-link diagrams are a kind of relational pattern. The term relational refers to one of four kinds of visual examples: Pictorials, Quantitatives, Relationals (the kind being investigated here) and, Symbols. Each of the other three will also play a role in the development of a node-and-link presentation, but the "semi-constrained relational" is of our main concern in regard to node-and-link visualizations.*[1] *Our other concern is the "basemap" — The term basemaps refers to the underlying structure (sometimes visible and sometimes not visible) that locates the visual elements placed upon it. All paterns — Pictures, Quantities, Relationals, or Symbols, are either the basemap pattren or are "registered" by the basemap pattern*

THE NODE-AND-LINK AND THE INTERFACE

Node-and-link presentation logic can support improved usability (for both providers and preventive-care-oriented recipients) on two potential levels: the cognitive and the technical. The cognitive aspect is achieved through the resultant presentations themselves; the technical aspects are workflow related and often enhanced through the techniques of touchscreen, gesture-based interface navigation. Also, node-and-link presentations are easily navigated through 3D representations, another potential value of this suggested approach.

It will be argued here that even the most complex node-and-link presentations are composed of only five essential components. These are: *nodes, links, grounds, change-agents, and annotations.* Generally, nodes are entities, and links are connections between those entities. Grounds, when present, provide context. Change agents provide for the dynamic nature of the knowledge tool when such a diagram or presentations is not static. Annotations are a kind of applied "inefficiency factors" within the presentation; and provide specific details or references, generally through text, when the symbolic, contextual, or structural aspects of the presentation are not self-informative. Annotations are the last-mile of informativeness and are present in almost all informative visualizations.

PRINCIPLES AND CHALLENGES

Every user-interface toolset has one, or multiple, "core principles" that support its effective deployment (assuming the objective is to permit actionable insight through the use of interactive visual displays). These are balanced against "core challenges" which would inhibit the effectiveness of the knowledge toolset.

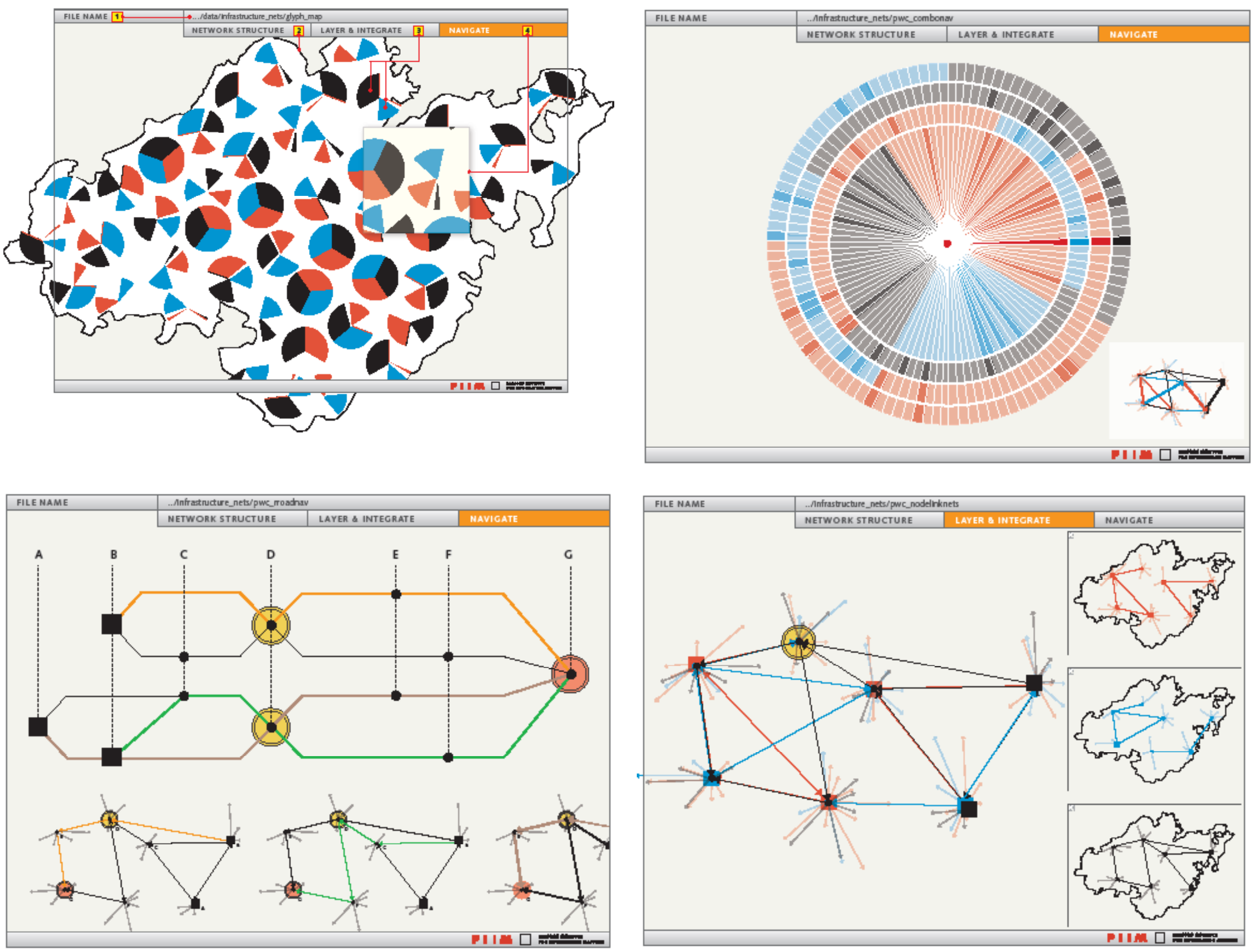


FIGURE 3: *Experimental interface concepts utilizing social networks. They are all relationally based interface designs that rely on a combination of traditional control and gesture-based control—these kinds of displays reveal insightful patterns and permit opportunities for beneficial change.*

THE TAXONOMY

Briefly recapping from the introduction let's look at the deeper attributes that may be applied to node-and-link visualizations:

a) node(s)
(always evident)

b) link(s)
(nearly always evident)

c) ground(s)
(optional context-adding dimension)

d) change agent(s)
(data input/output that renders alternate presentations and sequenced/dynamic representations)

e) annotations
labels, nomenclature, or supporting text, etc.

Beyond merely listing the node, link, ground, and change agent devices we'll consider their nature, or ontology. The ontological aspect permits further distinction respecting the nature of node-and-link diagrams and allows the elements to be understood by the patterns they belong too. From this point we'll consider "kinds" of renderings that the devices may fall under and the attributes that the varying kinds tend to convey. Last, we will look at the structural way in which all these devices may be generally organized. A composed overview of each of these aspects is summarized in the table on the following page.

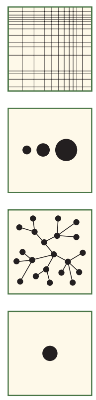
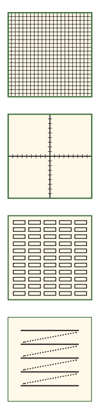
CONTEXT OF SEMI-CONSTRAINING VISUALIZATIONS

Within the eight classes of underlying structural matrices, our focus is on, relational patterns that are semi-constrained. Relational patterns are inherently cellular in nature, they possess points or polygons within an inter-related spatial (2D or ND) context. Inherent values are determined via location. So, there are at least two informative requirements: cellular elements to contain, and the placement of these within a greater context.

The points, or cells, may be visibly or non-visibly evident. Spreadsheets and systems of grids (such as the periodic table of elements) are referred to as "Constrained Relational Patterns"—every element has its meaning established by placement. The "links" are, in a sense, the walls of the touching cells; they are "zero-distance" links. In semi-constrained examples, these cells are not touching, so they must be visibly connected by links that possess length and trajectory. The link connects disjointed cells, hence, semi-constrained. Further, the walls in relational constrained examples (touching) are often non-visible, as the contained elements reveal the pattern of the interrelationship. Conversely, as links in a semi-constrained example are, by their nature, explanatory they are nearly always visible. The pattern of nodes in a semi-constrained relational network is made evident by the links. We'll simply refer to these kinds of semi-constraining networks as node-and-link diagrams for the balance of this paper.

NODE-AND-LINK DIAGRAMS

The table on the following page contains a comprehensive overview of all the possible elements within a node-and-link diagram (except for the annotations). The components (device types) can be categorized under their qualities of node, link, ground, or change agent. Each of these, in turn, can be defined by its essential nature, its level of pattern fluidity (the constrained, semi-constrained, or unconstrained quality), the kinds of sub-types into which it falls, general attributes that may be associated with these kinds, and last, what types of structures are usually associated with the four visible device types. The text which follows elaborates on the table and provides some deeper discussions on the ontology, or nature, of the key device types.

DEVICE TYPE *within network*	**NATURE**	**VIS. TYPE** *VT-CAD* options*	**KINDS** *visual composition*	**ATTRIBUTES** *variables*	**STRUCTURE** *composition*
NODE — 'O' *open node: available to new connections or diconnections within the greater network through links*	*nodes are tasked with the function of identifying the character of any specific entity, one-from-another — conversely, there may be many like nodes that establish their collective distinction within the greater network, nodes carry this possible range of signifying attributes within the context of the greater network — with similar differences or different similarities*	**NODE AND LINKS** *typical/possible visual types — primarily unconstrained, sometimes semi-constrained* 	*- as pictograph* *- as ideograph* *- as quantigraph* *- as infograph*	*-toward accuracy vs. emphasis* *-as base element vs. composed elem.* *-toward figurative vs. symbolic* *-toward singular vs. collective* *-toward intelligence vs. static* *- within schema or self-identified (e.g., as avatar)* *-self signified or as proxy*	*-single component* *-multiple component* *-discrete component* *-merged component*
NODE — 'C' *closed node: fixed within network and not available to new connections or disconnections.*					*-single component* *-discrete component*
LINK — 'O' *open link: connecting device within network open to modification of characteristics*	*links indicate the connections between nodes — links may be "intelligent" or passive, or control: intelligent links carry information (this can be data that is shared by both nodes, or supplementary data to the nodes; passive links illustrate connection aspects only between the nodes, showing relationships but not necessarily defining them; control links feature temporal characteristics that modify nodes*		*- connecting* *- non-connecting* *- direct* *-non-direct* *-discrete* *- branching* *- manifest* *-iconographic*	*- singular* *- multiple* *- clustered* *- multi-clustered* *- composite* *- composite-cluster* *- multi-composite-clustered*	*- thinness / thickness* *- straightness / curvedness* *- monotonal / colorful* *- unbroken / broken* *- opaqueness / transparency*
LINK — 'C' *closed link: restricted connecting device within network, not open to modification of characteristics*		**GROUND** *typical/possible visual types — primarily constrained* 			
GROUND *basemap providing contextual reference for all node-and-link devices*	*ground (when present) provides contextual information for the network it is supporting — geospatial data, or relational data in cells, or for other fields*		*- pictorial ground (e.g., map)* *- as mathematical plane (x,y,z coord)* *- as cellular structure (e.g., columns/rows)*	*-polygon* *-line* *-dot* *-composite*	*- contiguous* *-extracted* *-layered*
CHANGE AGENT *causes (visible or non-visible) that result in the modification of the network*	*temporal data aspects: by supplying data to node, link, or ground elements within the network change agents generate the next iteration of the network*	*non-applicable*	*-updated* *-pulsed* *-continuous*	*- manual* *- passive*	*(variable sources)*

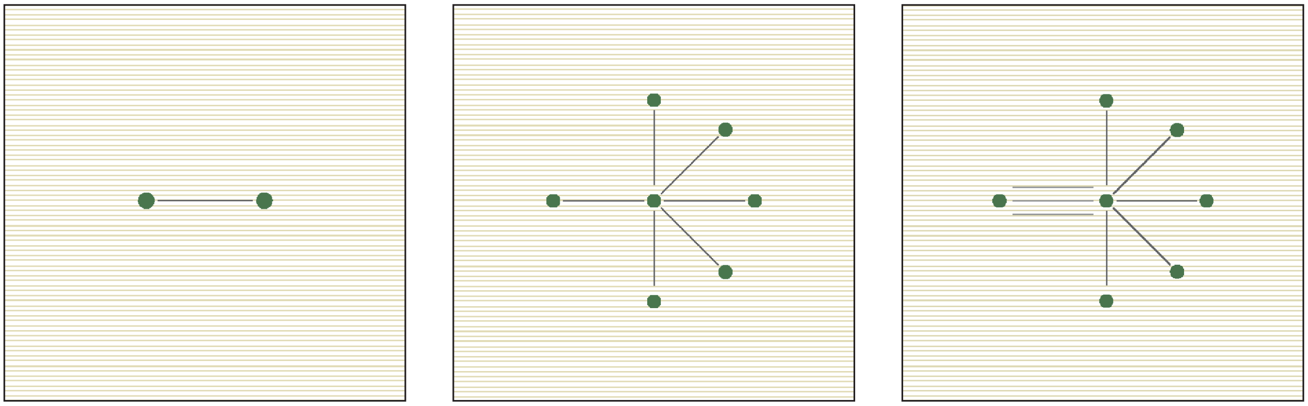


FIGURE 4: *Two nodes connected by a link are the essence of the matter, this is shown by the left-hand diagram — one link, two nodes. If the link were not there the viewer might assume, but not be certain if there was "connectivity" or interrelationality between the two points. Most links, when shown are thoroughly conceptual. The center image goes beyond the one-to-one relationship, it may be referred to as a node-and-link cluster. Even this simple image implies that there is a central character within a field of multiple characters, and also, that there may be a kind of distinction between the isolated element on the left compared to the grouping on the right. The diagram on the right shows a "multi-link" pathway. What might this mean? This opens up the possibility that any one link can contain as many dimensions as required. As both nodes and links can be assigned any level of information, yet remain distinct of each other, particularly useful comparisons can be derived from analysis of such comparatives. This is akin to the quantitative/qualitative value difference between numbers and letters — few other visualization inherently possess this kind of valuable co-distinction.*

SEMI-CONSTRAINED VS CONSTRAINED

The essential elements of a node-and-link diagram are obviously the namesake components of such a presentation: the nodes and the links. As a comparative, consider what nodes look like without links. As noted earlier, a common relational arrangement of nodes may be found in a table format composed of columns and rows — let's discuss this a bit further as it has many implications respecting how a naming protocol can be developed for node-and-link applications.

As the elements are defined by their position in columns and rows, links are not required. As stated previously, the borders in tables serve as direct links and the table is merely full of entries, or nodes. The structure is cellular. If one imagines a table with all the elements now free to be moved according to whatever logic applies, then a new need arises — the need for links. In one case the cells are fitted within a table, in the other they are free to move toward a new logical arrangement — yet both *require visible or implied connections.* This also addresses the reason why columns and rows, seemingly more appropriate to contain a collection of cells, might fail to be effective. What occurs to demand that the constrained diagram should fragment into a semi-constrained display? It is usually a function of radically uneven distribution. Many nodes would need to be packed into one area of the table, while another area might have no nodes over hundreds of potential columns and rows. Generally the spatial advantages of order dictated by columns and rows fail to be of use, the nodes simply need space and cannot all crowd into equally distributed housing.

Yet, another consideration is paramount, there are only so many dimensions that can be assigned when a node, or cell, is in a particular place — x, y, z, perhaps more. This is applied dimensionality; a free floating node may have n-number of implied dimensions. As indicated by the links that identify them. The ultimate level of attributes would leverage all three aspects: placement, node design, node associations.

NODE AND LINK: ELEMENTARY NATURE

In the simplest kind of node-and-link visualization models there are only "a" nodes. All the elements carry the same meaning, or merely identify connectedness.

Next, each node may have a unique identifying quality — the nodes now stand in for something far more complex. Beyond modifying the apparent character of any particular node to any particular level — to what ever number of types is desired, annotation may be applied. (Of course each distinction is a new weight on the cognitive scale, and at x-point [about seven distinctions +/- 2] the difficulty of reading becomes very elevated."What individual is this?" such a question can be handled with a simple textual label applied to the node in question. If multiple distinctions (beyond what is shown within the character of the node) begin to arise the label can be extended to include more information.

Ultimately, it would be possible to have an unlimited number of exactly similar nodes with very extensive references around each to establish their respective distinctiveness. However, all this annotation would be ridiculous from a visually coherent standpoint and the advantage of the node-and-link diagram would be lost in a sea of annotation. The links would then serve their base purpose of simply establishing connectedness. In practice one generally wants to "fold-up" annotation by imbuing the nodes (or the links) with visually distinctive reference.

NODES: SURFACE AND SHAPE

By modifying the surface of the node through color or shading or by altering the shape of the node, or by doing both, a near endless level of distinctions can be made. As these distinctions are made textual supporting information is implied. In most cases such implications must be taught through a key or familiarity through intuition (former experience, insight), training, or new experience. In order for nodes to reveal character they must possess, or be assigned character. As they are visual elements character is applied at the aesthetic level. Once certain levels of primary distinction are set, projected "enhancements"may proceed from increasingly subtle methods. Users need to identify contextually and then be trained respecting these enhancements. Ultimately the character of distinction is conveyed by the nodes distinctiveness one-to-another.

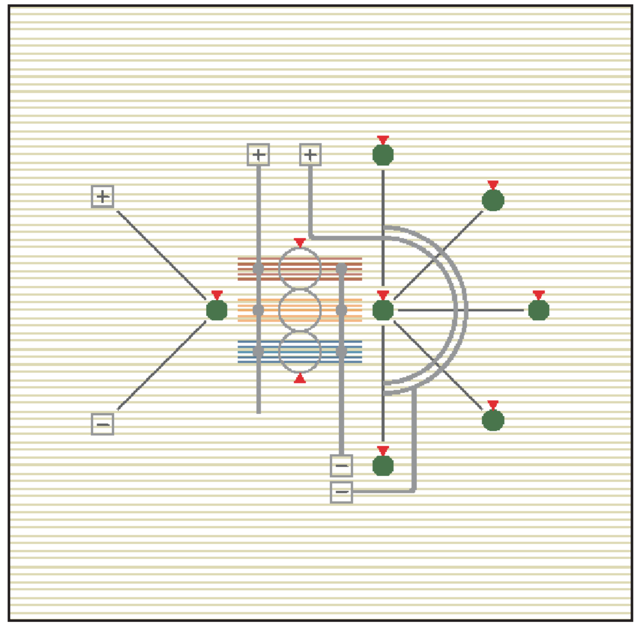


FIGURE 5: *This diagram depicts two ways by which change agents may have a dynamic impact upon a node-and-link composition. The positive/negative indicators speak to a flow of change, thus they would cause a continuous, albeit slowly verifying modification to either the node or link (or ground) devices. The change is modulated and continuous and may be said to be "below the surface." Conversely, the red triangles indicate the possibility of a rapid shift in the nodes (links, or grounds) presence or composition—we'll refer to this as a "surface" alteration. In this manner a dynamic node-and-link representation may be undergoing continual change as the data which supports the presentation is being updated in real-time (even though all the essential node-and-link relationships are not being altered.) Or, elements may be seen to be added, subtracted, or reorganized. These surface changes alter the relationship of the node-and-link composition itself. These are the two major ways change agents impact the visual (and therefore meaningful) nature of the informative visualization.*

NODE: STAGES OF DISTINCTION

Once on the path of distinction, the surface and the form may be discrete by stages, or discrete by types. As mentioned, discretion through stages can be handled by shifts in either "color" (i.e., surface) or form. Generally, there are noticeable jumps in the color or shape choices. This helps to establish the requisite distinction. A deep blood orange for one node element and a red for another might not provide ready distinction between the two. An eleven sided form and a twelve sided form would obviously not provide the requisite distinction unless the viewer was a very close reader.

Therefore, one would usually design with a "gapped" rather than an analog-kind of logic. Having said this there is the possibility that a node might be in the family of what we refer to as "intelligent icons." These are devices that are constantly being modified, according to some algorithm or collection of algorithms. In such cases change could be continuous but miniscule—nearly analog— across a range of nodes. So discretion by stages can be through easily recognizable variance, or less-than-easily recognizable variance.

This, more than likely, would depend on the application, it is also likely that in instances where variations may be in very small increments, the users of such tools could probably be very aware of such changes. Distinction may also be established by position — this is not to bring us back to the argument of columns and rows (though possible). Positional distinction in semi-constrained context is usually due to a noticeable pattern shift and other aspects of a particular outlier aspect of one (or more) nodes compared to the others.

NODES: INHERENT PATTERN

Because Nodes are inherently nonconstrained and nonconstraining they are like a symbol on a sign for a men's or women's room. The sign can be carried around, it is not affixed somewhere by its inherent nature. Instead, once affixed upon a door it describes the nature of the room that lies beyond that door. In that respect the nature of a node as a symbol becomes very important. It carries intelligence that must first be applied by the language of the presentation it inhabits. This adds to its unconstrained nature — if a user is not first familiarized with the meaning of an unconstrained devices such meanings may be lost or ineffective. Unconstrained (and to a lesser degree) semi-constrained devices are not understood through pattern, but more often through learned familiarization.

NODES: KINDS (VISUAL COMPOSITION)

Distinction of types (in the table under the column, kinds) applies to an essentially hyper-visual aspects of nodal distinction. Instead of merely applying visual variation (surface or shape) to indicate discretion, the nodes may have underlying logical variation. These variations are derived from meaning. The nodes may be formed as little (generally highly simplified) pictures, which we refer to as pictograph. The node may be an ideograph (such as a skull-and-cross-bones, depicting poison, pirates, or death). The node may be sized (quantitative) to indicate value, it thus may be referred to as a quantigraph (a node of say, 2 mm diameter representing 100 individuals and of 4 mm diameter representing 500, etc.).

Or the node may possess some composite of these type/kinds distinction — say both pictorial and sized. In this case we use the term infograph as a descriptor. We see then, that nodes are tasked with identifying the character of something, usually an entity, but quite easily an idea or condition as well. Also, nodes usually need to have applied (or generated) distinction. In practice patterns and sub-patterns can be projected by how the nodes are arranged globally across a presentation. In this manner the meaning of a node can be altered by quantity or position of other nodes irrespective of links.

NODES: ATTRIBUTES

We use the term attribute to indicate what characteristics a node is trying to convey. How is the device communicating? After reviewing many hundreds of node-and-link diagrams, it was generally seen that, when there was comparative variance from node to node, this variance was dichotomous. Some nodes were more one way, and some were more another. These variations often touched upon aspects best covered under other categories within the taxonomy. For example, if one node was tending larger, and another was tending smaller, this was usually to define a quantitative state—we would therefore list this variation under "kinds." Similarly, a node could have a more ideographic than pictographic quality, also as aspect of kinds. So the category of attribute may serve as a modulation to kinds. However, this was certainly not always the case. An attribute could stand on its own, independent of the kinds categorization.

Even at the small scale of a node, some nodes were designed to convey accuracy, while others were designed to convey emphasis. (This dichotomy of accuracy and emphasis is a fundamental principal of design: the choice to move away from uniform accuracy of elements so that a critical point, at the expense of accuracy, may be conveyed. The balance of applied accuracy/emphasis becomes an important subtlety of effective communication design that is very difficult to achieve through algorithms alone.)

Another dichotomy is whether a node is signifying something directly, or as a proxy element. The node could appear as a pictorial avatar, say being anthropomorphic, or representative, as when someone chooses an animal to represent characteristic traits. A node, in itself, can be singular, or it may represent a collective. In conclusion the kinds/attributes characteristics can be seen to work together modulating the precise nature of the node within its greater nature as a device.

NODES: STRUCTURE AND COMPOSITION

Nodes are generally singular devices that are organized in a array of the collective. There are many cases, however, where subgroupings occur. Sometimes these subgroups are merely understood, and sometimes they are conscientiously designed. For example, when one views the heavens in darkness and sees the plethora of stars, each star can be considered a node in its own right. A constellation is merely assigned, with certain nodes selectively brought into the desired portrayal. In some cases multiple nodes are always collected by design as multiple component devices.

NODES: TYPE "O" OPEN; TYPE "C" CLOSED

A major distinction, and a distinction that formulates an entry at the top of the hierarchy, is the notion of an open or closed node. Although this would appear to be minor, it has a significant impact on the entire node-and-link presentation model. Most nodes are "open" in that they can accept new links, or they can have links deleted. An open node works within a social network the way in the commonly perceived way. New "friends" are added and nodes may be "unfriended." The world of nodes and links is ever open to growth, shrinkage, and change. Closed nodes are those that are never vary in their connections or lack of them. Certain types of node-and-link diagrams have these relationships. A simple wiring diagram possesses this attribute; every component is interconnected one way and altering that relationship is detrimental to the organism. Closed nodes within a network often establish a baseline of structure.

LINKS

Links indicate connections between nodes — links may be "intelligent," passive, or controlling. Intelligent links carry information that is directly connected to a dynamic database. The link, therefore, may somehow portray this information, or more likely it serves as a "link" in the Graphic User Interface sense that it may be clicked upon and information may be accessed through it. Links may also possess "speed," (*see following section).*

Passive links show interconnectedness only (showing relationships but not necessarily defining these relationships). The implication beyond mere association must be ascertained by other means, as the connection is implied visually and value-added information is not supplied. Controlling links modify nodes through the mere aspect of being so connected. The link being present means the node will appear in one state. If the link is removed the node will be altered in some manner.

In some manner, too, connectivity through a link also means that some data must be shared by both connected nodes. The link can reflect a single activity, or multiple activities. Additionally, it may be used to represent varying temporal conditions, and varying quality conditions.

If one looks at the chart on page 5, under "kinds" it is possible to see how certain characteristics can be applied to either nodes, or links, In this manner one could allow certain kinds of data to drive nodes in one case, and links in another. Such a process could yield some facinating insights.In one critical area there would be likely difficulty in doing this. That area is respective to "kinds" of links. The table supplied in this section shows that the taxonomic aspects of nodes versus links possess similar classes and qualities. Under kinds nodes take forms such as pictographs and quantigraphs. Nodes vary here dramatically and possess kinds that are determined mostly through the sub-nature of connectedness. These kinds include: *connecting, non-connecting, direct, non-direct, discrete, branching,* and *manifest*. It is possible, however, that links do possess iconographic characteristics — portraying quantitative or qualitative information by design. These are rarely found in examples but are nonetheless a possibility.

The Kinds, Attributes, and Structures of links are "naturally" distinctive between nodes and links. As stated, kinds is primarily reflected through aspects of connectedness; attributes is primarily reflected through the composition of the links — how they are clustered or arranged. Structurally, links vary in thickness, straightness and curvedness, opaqueness and density, and whether they are continuous, or dotted, or broken, etc.

One way to look at the classic idea of a node-and-link diagram is as a map of dots (cities and points of interest), lines (roads), and polygons (areas). These same types of differences exist in typical displays of node-and-link diagrams. The table shows a direct relationship of categories and sub-categories for nodes or links. The nature and the applied characteristics for each can be understood as highly discrete, specifically unique aspects.

In extreme cases certain types of information may best be portrayed by devices that are modified in a somewhat less-than-natural way. The argument that nodes are places and roads are the means to get to these places serves well. The added notion that the road tells you a great deal about the place before you get there may provide further clarification. A node is about itself — a link is often about the node. This type of extra-intellignce respecting design is why such a type of representation can serve the health-care profession so well.

Concluding here, the parallel of categories for nodes and links also applies to the concept of an open link or a closed link. A closed link cannot ostensibly be removed or alter its connectivity from the node or nodes to which it is connected.

LINKS: INTRODUCING THE IDEA OF SPEED

One of the challenges of portraying connectivity via node-and-link diagrams is simultaneously conveying aspects of time and duration. Multiple means have been visually applied to both nodes and links for this purpose. One means is the use of thickness of line weight (denser links implying more time or duration between nodes).

Another, fairly effective, albeit visually dense displays, is by increasing distance beyond a straight line. Through the use of lengthening the links into spirals of varying degrees of concentric frequencies a rapid sense of time is conveyed. The figure and caption on this page provides additional detail.

GROUND AND CHANGE AGENT

In a great number of node-and-link visualization, the ground is simply space: it serves only as an available region upon, or through, which the node-and-link universe is dispersed. Otherwise it provides context and requires that the node-and-link environment must configure to its spatial constraints–it is the physical reference that remodifies a node-and-link environment. The idea of ground is most easily conveyed by referring back to the basemap patterns upon which all the other patterns reference themselves. The table to the right is a reiteration of these structures. It can thus be seen that the node-and-link

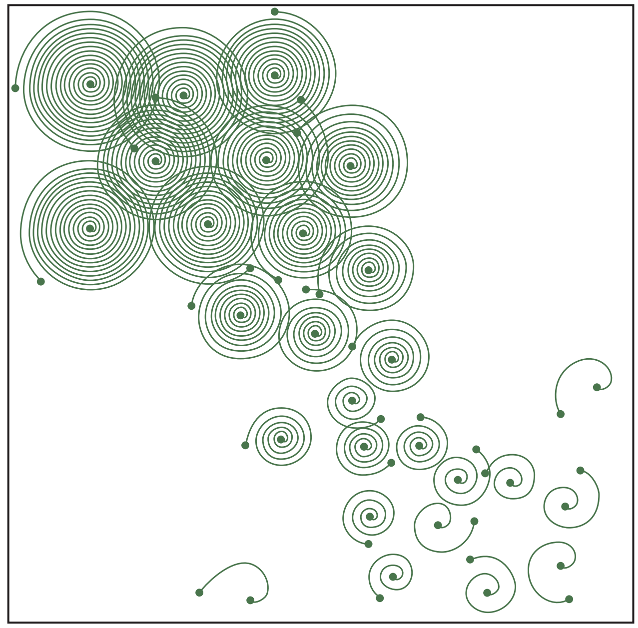


FIGURE 6:*In this illustration the links between the nodes are of varying length based not merely on the “actual” distance from node-to-node. Instead, the links are “lengthed” by the idea of time or other aspects of duration. In the extreme upper right, the dense spirals indicate a “longest” durartion associated regarding the node-to-node relationship. As one moves diagonally downward and tightward less duration is implied. The node-to-node connections are closer and closer. This is one method of viually overcomming a common difficulty—conveying time through link-and-node visualizations.*

model is one of the eight potential patterns that can then be referenced back into any of the other patterns. Change agents are the non-physical, temporal, "causes" They fall under the technical or physical computing side of the design equation Change agents modify the node-and-link environments. As with node-and-link elements, both grounds and change agents have their respective natures, types, kinds, attributes, structures. These are increasingly proprietary to the specificity of the system in which they are used. As such they are about as endless as topics and datasets themselves may be. The essence is that grounds generally modify placement, while change agents modify composition of node-and-link diagrams.

CONCLUSION

Node-and-link visualization is a form of relational representation. The form allows for considerable flexibility due to its unconstrained nature. Node-and-link models are fairly fluid patterns that can be applied (or referenced) against the other seven major patterns yielding highly informative outcomes. Node-and-link models are particularly useful for gesture-based, graphic user interface systems. By considering core components of a node-and-link model: node, link, change agent, ground, and annotation *against* aspects of nature, type, attribute, kind, and structure highly effective models can be devised.

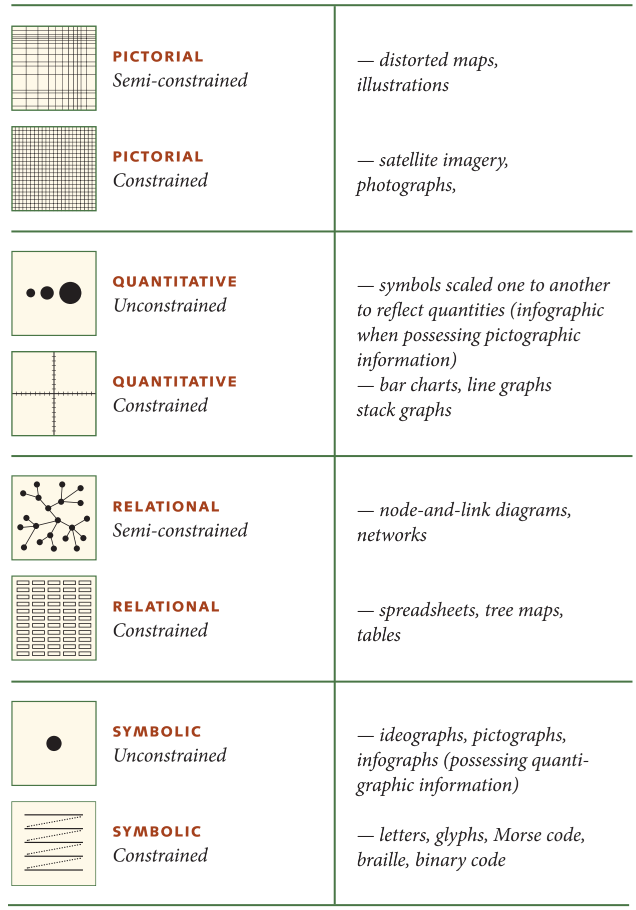


FIGURE 6: *One can see how the Quantitative/Unconstrained, and the Symbolic/Unconstrained entries work independently as nodes within the Relational/Semi-constrained category. This demonstrates how patterns nest within patterns. Of the eight principal patterns the node-and-link pattern is perhaps the most complex from a standard of predictability. Also, note a very critical attribute that is easily seen due to the simplified nature of the diagrams above. In every pattern there is a figure/ground relationship. In a simplified way this figure/ground relationship can be understood through the black (object/figure) versus cream (non-object/ground) relationship. Note, however, that the node-and-link entry has both nodes as figures and links as figures. This double-figure quality makes node-and-link diagrams unique. When the logic of this is applied to toolsets such as that proposed for healthcare informatics it provides an opportunity for language and counter-language — similar to figures and letters within language, or quantitative vs. qualitative distinctions. Complexities within content (such as is the case with healthcare data) can be better clarified vis the node-and-link model because there are multiple opportunities to portray rapid distinction at the visual, pre-drill-down, level.*

BIOGRAPHY

William M. Bevington currently serves Senior Information Theorist for PIIM. He also serves as Associate Professor of Information Mapping in the School of Art, Media, and Technology at Parsons The New School for Design, The New School, New York. He formerly served as the Executive Director for Parsons Institute of Information Mapping, Chairman of the Communication Design department at Parsons School of Design, and various professorial and instructional roles at his Alma Mater, The Cooper Union for the Advancement of Science and Art. He is an Information Designer and Information Theorist specializing in creating tools for the rapid assessment of complex data. Mr. Bevington has developed toolsets for transit systems applications, stock trading applications, and health management tools as a principal designer at Spire Integrated Design, New York.

NOTES

1 William M. Bevington, "PIIMPAPER01, Part One: A Visualization-based Taxonomy for Information Representation: Introduction and Overview," New York: Parsons Institute for Information Mapping, 2007).