THE PARSONS INSTITUTE
FOR INFORMATION MAPPING
68 Fifth Avenue
New York, NY 10011
212 229 6825
piim.newschool.edu

Displaying Healthcare Informatics Through Node-and-Link Visualizations: Can Social Network Modeling Improve Healthcare Provision and Advance Preventive Healthcare Practice More So Than Other GUI Models?

PREPARED FOR:
THE DEFENSE HEALTH INFORMATION MANAGEMENT SYSTEM
SUPPORTING NEXT-GENERATION EFFORTS IN MEDICAL HOME LOGISTICS
PREPARED BY: WILLIAM M BEVINGTON
UNDER PRINCIPLE INVESTIGATOR: CHRISTOPHER GORANSON, JIHOON KANG
THE PARSONS INSTITUTE FOR INFORMATION MAPPING

DELIVERABLE UNDER AWARD NUMBER:
W81XWH1120025

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WILLIAM M. BEVINGTON, PIIM

EXECUTIVE SUMMARY

The Parsons Institute for Information Mapping (PIIM) builds knowledge tools that permit actionable insight from the use of interactive, visual displays. We perform this work on two levels: immediate, practical engagement on tools for next-level deployment, and modeling future tool scenarios and theoretical efforts toward "next-next deployment." This document discusses preparation for such a next-next level. It is divided into four parts: 1) this introductory section; 2) a brief section outlining a taxonomy of components relative to node-and-link diagrams (summarized through a table on page 9); 3) a thorough investigation of extant visual models from which the taxonomy is derived, and; 4) a brief summary discussing the features and underlying deployment concepts and logic that would be combined with the node-and-link structures for a GUI healthcare toolset. The objective is to use this document for general guidance to "visually scope out" a healthcare knowledge toolset that embraces a node-and-link presentation method for healthcare provision and reception. Further, this "network centric" healthcare workflow system will be targeted to support a "medical home" healthcare approach (or other emerging healthcare provider /recipient, models); particularly in respect to preventive health, scenarios.

The principal argument of the paper is that node-and-link presentation logic supports 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 advocated through the techniques of touchscreen, gesture-based interface navigation. Node-and-link models are well leveraged via gesture-based interoperability, and gesture based navigation is made more proficient through the types of scaling, contextualizing, "see-and-replace" sequencing, sliding, etcetera, that node-and-link presentations can readily support. 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 "inefficiency factor" within the presentation; these provide specific details or references, generally through text, when the symbolic, contextual, or structural

OBJECTIVES

Investigate and pursue a "next-level" data visualization "node-and-link" method that can support a: 1) network-centric, 2) healthcare-focused, 3) comparison-driven graphic user interface (GUI).

Lend credence to the argument that such a node-and-link type interface could support healthcare recipients — depicted as "avatar" nodes, or other elements within a healthcare-provider-to-healthcare-recipient documentation GUI — with an aim to permit useful comparison within an individual's history, or, within a "control" group.

Investigate how visual outcomes rendered through node-and-link models and associated "semi-constrained relational" presentations may greatly facilitate healthcare analysis. Discuss how node-and-link models provide strengths via attributes of interconnectedness, scaling, context, and understanding of cause-and-effect supported by the kinds of GUI environments that such node-and-link models portray. Develop a taxonomy of visualization and component elements designed for such a network-based presentation and compare examples of network presentations to support the outcomes of this taxonomy.

Provide the groundwork to begin modeling a prototype example of such a "relationally semi-constrained" GUI for Patient-Centered Medical Home workflow informatics.

aspects of the presentation are not self-informative. Annotations are the last-mile of informativeness and are present in almost all informative visualizations.

Every user-interface toolset has one, or multiple, "core principles" that support its effective deployment (assuming the objective 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. It will be argued here that the core principles for a more effective healthcare informatics knowledge toolset are the use of: 1) semi-constrained relational presentation formats (node-and-link style), 2) the technical attributes of gesture-based navigation methods to leverage the presentations, 3) a capability to integrate the professional language (jargon) of healthcare providers and a non-professional language (vulgate) of the healthcare recipients, 4) a capability to scale and provide healthdata from the one to the many; i.e., from the secure and protected data respecting an individual recipient to the anonymous datapool of the many, 5) the interconnectedness of all these. The challenges to all these are fairly self-evident and are discussed within the greater text.

The oldest model of healthcare: a wise and experienced doctor treating his patient in a direct, case-by-case method is the simplest of node-and-link scenarios: the doctor and patient are nodes and their relationship is a link. This model had slowly, but now is being rapidly, supplemented by myriad interface tools, whereby the healthcare provider interacts through many proxies toward the healthcare recipient. This interface can be understood as a "bundle of links" between the caregiver node and the care-recipient node. These links currently "separate" the healthcare provider from the healthcare recipient; the goal is to make this interface better connect these two entities. Also, as government continually expands its role as the healthcare interface proxy, the need to find efficiencies through scale is amplified; this is a major factor of advocacy for applying a social network informatics logic to the healthcare model, and to support this model through visualizations that render the most effective presentations for social networks: (social) network diagrams.

Indeed, it may be possible to embed such a bundled-link (with a complete and effective language) providing an easy-to-use full picture of the wellness model for both doctor and patient. Through such a richly bundled link system, every single case (and condition) extant would become a visibly and cognitively understood "roadway" between each and every stakeholder node (provider, recipient, infrastructure manager, government payer, manager, etcetera). This would create absolute fluidity of practice through a protocol of analyzed procedure and multiple ways to create high levels of effectiveness with commensurate levels of efficiency in practice. In essence, users could place any node onto a "map" and then compare, reveal, or assign ideal patterns of interactively through selection and analysis of links between such nodes. This kind of toolset may be a perfect presentation compliment to the emerging real-world Medical Home model, and therefore, a potential interface toolset that well supports the vision of an advancing practice such as medical home model (or other future healthcare scenarios).

The term relationals refers to one of four kinds of visual examples. They are described in a visualization taxonomy that focuses on classifying and creating informative imagery. The four are 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 Relational is the focus of the research and development. For more information, see William M. Bevington, "PIIMPAPER01, Part One: A Visualization-based Taxonomy for Information Representation: Introduction and Overview" (New York: Parsons Institute for Information Mapping, 2007); Bevington, "PIIMPAPER01, Part Three: A Visualization-based Taxonomy for Information Representation: Identifying Images with Icon Schematics (New York: Parsons Institute for Information Mapping, 2008).

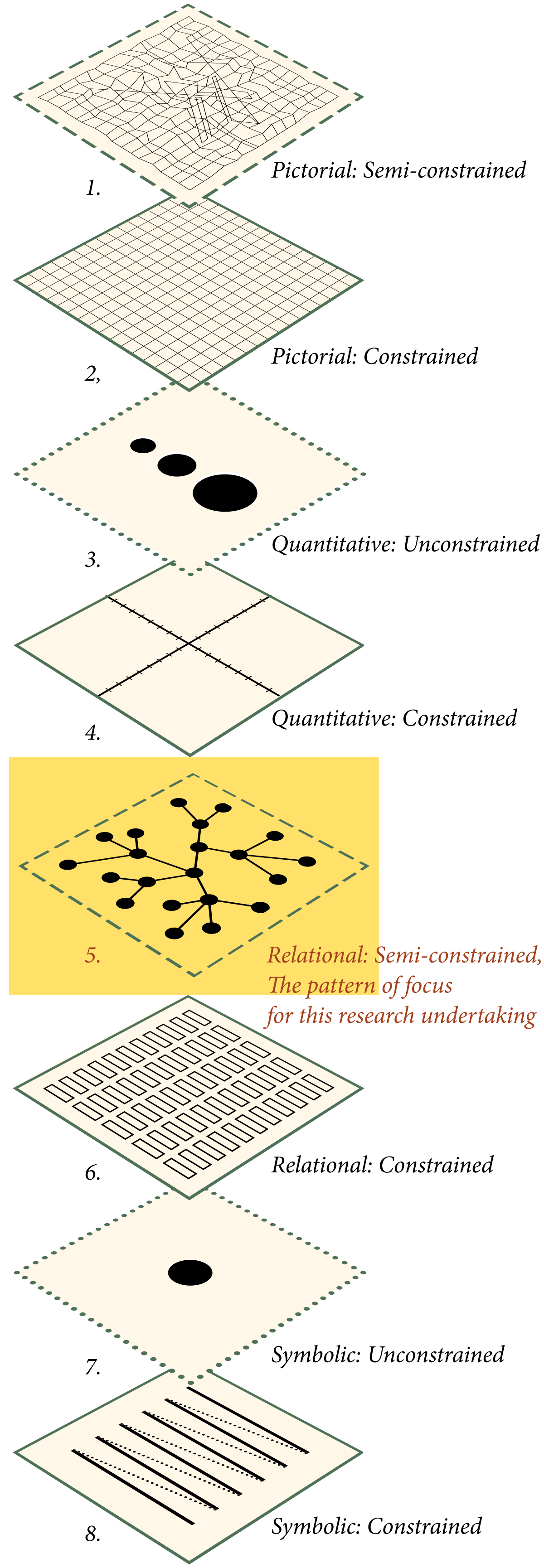
The term basemaps refers to the underlying structure (sometimes visible and sometimes not visible) that locates the visual elements placed upon it. Within informative imagery basemaps support Pictures, Quantities, Relationals, or Symbols.

ASSUMPTIONS

The undertaking involves the consideration of a node-and-link network healthcare toolset. Toolset refers to a graphic user interface that permits communication interactively between healthcare providers and healthcare recipients. Importantly, this network is enhanced through data that provides contextual and comparative health-related data that will inform users of their "status" in relation to change and groups. In order to model such a GUI an underlying taxonomy needs to be developed. This taxonomy is composed of elements that would be part of a node-and-link diagram, as well as a description of their (the elements') characteristics. We refer to these descriptions of the nature of the components as an ontology. In order to investigation and present "building-block" elements of a proposed Social Network system, we first argue that such a node-and-link system is part of a family of visualizations called "Relationals" (see definition on former page). Therefore, we argue that the most effective way to present healthcare data/communications is through a relationally-based visualization; and then specifically through a node-and-link (semi-constrained relational method). A node-and-link visualization scheme is a "Relationals," or "R-type" visualization. This document is concerned with core "provider/recipient" interaction, and how these core elements may later be constructed into full, representative network diagrams, particularly as that modeling method falls under a "Medical Home" model using a network-centric visualization schema. Such diagramming is targeted to assist in revealing the effectiveness in relationships of results-orientated connectivity between all the healthcare stakeholders: healthcare recipients, healthcare providers, and the extensive field of healthcare enablers.

INTRODUCTION

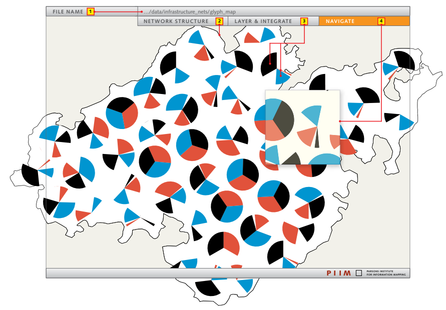
Data visualization tools that handle considerable sets of interrelated data (such as systems designed to handle so-called big data, particularly those that must find unexpected correlations) and data-supported massive-communication tools (such as social-network visualizations) increasingly rely on presentations that depict relationships through nodes-and-link diagrams. These two aspects: truly quantitative data and a highly social network would indicate that node-and-link (relational; specifically: semi-constrained relational) diagramming could be a superior way to navigate and respond to healthcare issues. To pursue this train of investigation we ask how medically-oriented connections relative to healthcare practice are currently understood through visualizations: how might this network be diagrammed? What should constitute "nodes" in such a network diagram; what should constitute "links" in such a diagram? What other parts are there? Can node-and-link diagrams be placed into larger contexts (such as other relational or "locational" types of "basemaps?" [see definition on former page]). How can all the stakeholders be depicted in such diagrams: healthcare recipients (e.g., patients); healthcare providers (e.g., doctors and persons trained and licensed to provide direct [or indirect] care to health-

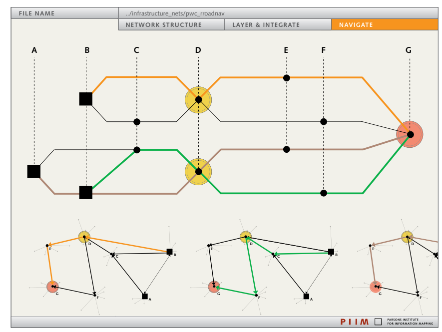


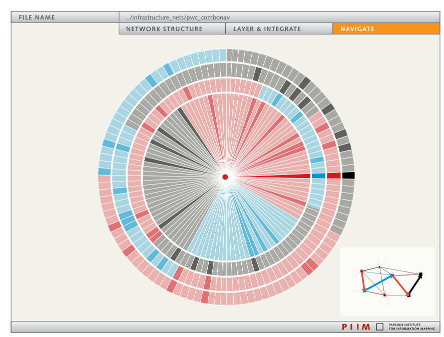
care recipients, etcetera); insurers, other capital resource contributors; administrators; pharmacological providers, medical equipment providers, data collection and medical information technology providers, medical tools contractors and suppliers; medical infrastructure facilities (hospitals, out-patient, clinics, and patient locations, etcetera); and others involved in medical intelligence support entities (all information systems-collection and display, including knowledge capture, storage, and distribution)? How is medical process, and the various types of treatment time frames and visitations to be shown in such connectivity? Importantly, can such a network diagram reveal non-apparent strengths and weaknesses of the current healthcare paradigm? How does the healthcare recipient (as opposed to all the other stakeholders) provide intelligence into the system? And how can the intrinsic components of such a network diagram be re-arranged and thereby leveraged to improve actual healthcare practice? Also, how are all the concerns of healthcare providers signified within such as system?

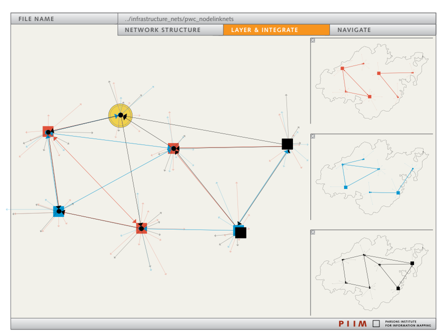
ABSTRACT

The most feature-rich, and effective method for displaying healthcare informatics may be through node-and-link visualizations. Social network-style and logic-based modeling could improve healthcare provision and advance preventive healthcare practice more so than other graphic user interface models and visualizations. Node-and-link visualizations are effectively navigated via touch-screen and gesture-based graphical user interface models; and these could well support preventive healthcare practice by providing the most flexible kind of healthcare provider/healthcare recipient toolset for the near future. Node-and-link modeling is a highly proficient approach to "asymmetric" input/output (capture/display) data flow. This means that 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 healthcare providers and healthcare recipients to access similar data sets with very different visual presentations, both graphically and publishing device wise. Such an interface model can permit targeted delivery of information on one hand, and big data type analytics for analysis on the other, because node-and-link presentations may can be approached from simple icon generation to immense presentation and contextual depth. Just as professionals in medical practice are looking at new ways to administer and manage healthcare through such models as patient-centered medical home — information design professionals are looking at new ways to deal with society's insatiable desire for, and generation of, information. In the last decade network visualization, generally realized through node-and-link presentations, have begun to dominate as a solution to big data requirements. Such visualizations methods should be applied to healthcare toolsets in order to effectively match the new requirement for healthcare and advance the sharing of information through every level of the healthcare enterprise.









Experimental interface concepts utilizing social networks. These kinds of displays reveal insightful patterns and permit opportunities for beneficial change.

PROCEDURE

The preliminary investigation into the diagramming of healthcare node-and-link network model considers contemporary, professional practice, particularly as understood and administered in the United States with an increasing focus on the prevention of illness (versus treatment of illness) in today's healthcare paradigm. Our ideal visualizations/presentations will be based upon the provider workflow of a "Medical Home" model (but this may alter, or be expanded, through research). It became apparent early in the cycle that the diagram should not be "fixed" but rather made up of components, which then could be adjusted to illustrate change overall (current to proposed) and alteration within (condition-by-condition) the diagrams. Essentially, what was needed was a toolkit of both node-and-link elements (the essential visual representatives of a social network diagram) and supporting visual elements that will best express change of design in the paradigm of healthcare. In order to create and build such a taxonomy it node-and-link and network diagrams were first investigated from any field, and then form healthcare fields. This provided the greatest range and opportunities to "cull" creative solutions from a myriad of field-specific challenges.

This concept of "network componentry," specifically designed for the healthcare field, will have multiple benefits: it will allow for evolving research-based updates without major modification to future complex diagrams (or user-interface toolsets); it will allow any part of the diagram to be easily extracted and annotated; it will allow for many alternate diagrams or parts of diagrams to be generated; and it will allow for proposed changes in medical practice to be illustrated step-by-step. Through these means, all kinds of arguments, considerations, and what-if-scenarios can be visually compared with their possible extenuating circumstances. Finally, and perhaps the most beneficial result of developing network-componentry related to a healthcare node-and-link visualized network, may be the ability to lay the groundwork for a next-generation graphic user interface. This could allow an interface application where a (network style) diagram becomes the "control-side, the information input, and the retrieval sides of a healthcare provider and healthcare recipient shared toolset."

As the network components are fully scalable, many levels of information could be understood in relation to one another—allowing components to be modified, re-purposed or, re-linked to generate a highly insightful knowledge tool. A graphic user interface based on a Healthcare Provision Social Network paradigm may be a very promising healthcare tool in-and-of itself, complementing the objectives for healthcare improvement that are envisioned for the (near-future) Medical Home model. The document lays the groundwork for a network "taxonomy" related to the healthcare paradigm. This portion is fairly wide-ranging (generalist) in consideration of network componentry, generated as a typical "first-view" of a suggested interface,and then later to create a storyboard based upon a study of diabetes and obesity.

CONSIDERATIONS OF PRACTITIONERS

During the development of the components under the "Healthcare Provision Social Networks" initiative the following issues are currently considered (column right). Ideally these are to be considered in terms of current practice with an aim toward future practice. They are considered, first, holistically (from the macro view), through the comparison of current practice versus medical home practice. However, this macro view will need to be broken down to the smallest, most clearly definable "requirement/desirement" listings. Through this "smallest multiple" logic different networks can be built up and easily compared one to another.

Enhance a) preventive care; 2) primary care, and 3) secondary care through these considerations:

1. *Increased productivity*
2. *Decreased expense to perform*
3. *More rapid documentation*
4. *More rapid dissemination to others relevant healthcare providers*
5. *Increase in encounter quantity without decrease in quality*
6. *Minimize transcription and chart-pulling expenses*
7. *Improve E & M coding*
8. *Increase legibility and/or consistency of documentation*
9. *Reference to best-practice coding*
10. *Improve communications throughout the immediate healthcare provider group/staff*
11. *Improve communications throughout relevant external healthcare provider group/staff*
12. *Document medical decision making of group*
13. *Document common/uncommon workflow procedures within group*
14. *Track (for later recall if required) communication flow within group*
15. *Improve alert functions of patient to caregiver*
16. *Improve alert functions of urgency to other providers within group*
17. *Document communications that might fall outside of workflow*
18. *Improve follow-up to every encounter*
19. *Create workflow templates for continuous and incremental service improvement*
20. *Create and improve protocols for each area of health (e.g. diabetes, Hypertension, etcetera)*
21. *Develop special templates that assist patients (such as school excuse forms, etcetera)*

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Part One (General Thesis): The Components Supporting Informatics of a Semi-Constrained Relational Network (e.g., Node-and-Link Presentation Logic)

BASE TAXONOMY OF THE NODE AND LINK DIAGRAM

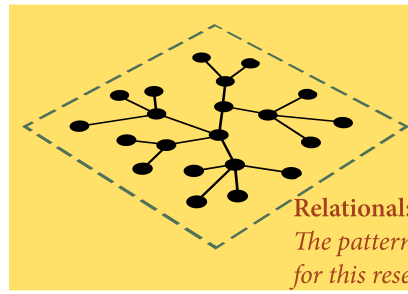
Briefly recapping from the introduction we'll be looking to derive a workable collection of types as seen, and derived from, node-and-link visualizations: The types will be classed within a taxonomy of:

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 in summarized in the table on the following page.

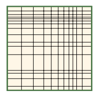
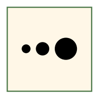
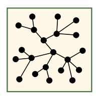
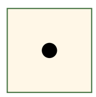
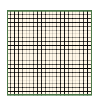
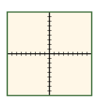
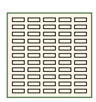
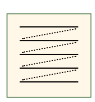
This taxonomy will then provide us with a guide that may be used when we consider what a node-and-link graphic user interface might look like for a healthcare enterprise. The section which follows this provides a compendium of sixty node-and-link examples. The last section of this submission will then address aspects of the link-to-node and node-to-link relationship, and beneficial asymmetry in data collection and display. These will provide a resource for the next stage of the undertaking, the development of a proposed GUI interface for healthcare with multiple kinds of node-and-link logic as it might apply: depending on collection, provider, patient, and data distribution models.



Relational: Semi-constrained:
The pattern of focus for this research undertaking

NODE-AND-LINK DIAGRAMS

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 interrelated spatial (2D or ND) context. Inherent values are determined via location. So, there are at least two informative requirements: cellular elements to contain, and 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.*

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*	**GROUND** *typical/possible visual types — primarily constrained*    	*- 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 *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)*

TAXONOMY TABLE

The table on the preceding 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.

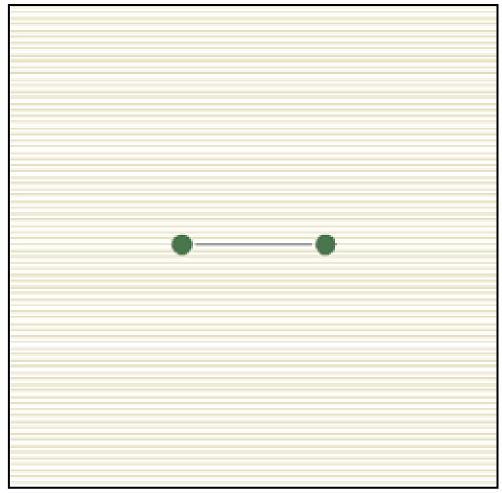
NODE AND LINK: SEMI-CONSTRAINED VS CONSTRAINED

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. A common relational arrangement of nodes may be found in a table format composed of columns and rows. 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 appropriated 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.

NODE AND LINK: ELEMENTARY NATURE

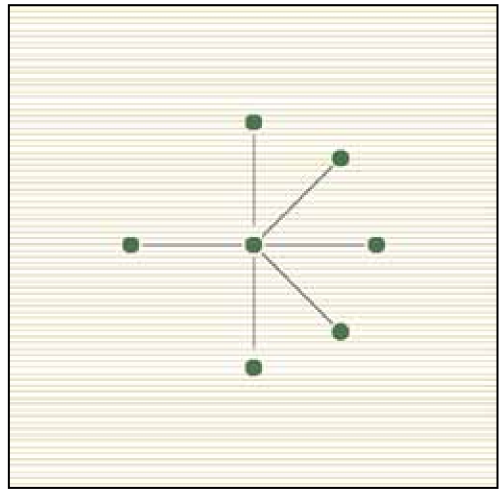
In the simplest kind of node-and-link healthcare visualization models an "a" node, might be the healthcare recipient, and a "b" node, a healthcare provider. Therefore, there would be as many "a" nodes as there are individual patients; however, there would be far fewer "b" nodes, the healthcare provider.

The link between "a" and "b" nodes is to be considered desirable and consensual; that is, the healthcare recipient and healthcare provider are in a relationship that aims to improve or maintain the healthcare recipient's good health. This is true even if there is a mutual goal to minimize the "density and frequency" of such a link, or even virtually eliminate it through prevention. The purpose of the link is to increase the value for the "a" node (through good health) and the "b" node



Two nodes connected by a link: the essence of the matter.

(through effective healthcare provision, as well as payment for service and fulfillment of duties, etcetera). Nodes do not have to represent the patient or the doctor, of course. They can represent any entity to which they are assigned: they could represent a place, such as a hospital or clinic; they could represent a treatment, such as a vaccine or surgical procedure, they can represent an evaluation or a test. A challenge, of course, is that if different nodes are to represent differing things a visual distinction must be applied to establish this fact. If every node is an individual the question arises, "What individual is this" such a question can be handled with a simple textual label. If multiple distinctions 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 distinction. 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 with visually distinctive reference.



A node-and-link cluster. Even this simple image implies that there is a central character within a filed of multiple charcters, and also, that there bay be a kind of distinction between the isolated element on the left compared to the grouping on the right.

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 or projected enhancements proceed from increasingly subtle methods. Ultimately the character of distinction is conveyed by the nodes distinctiveness one-to-another.

NODES: STAGES OF DISTINCTION

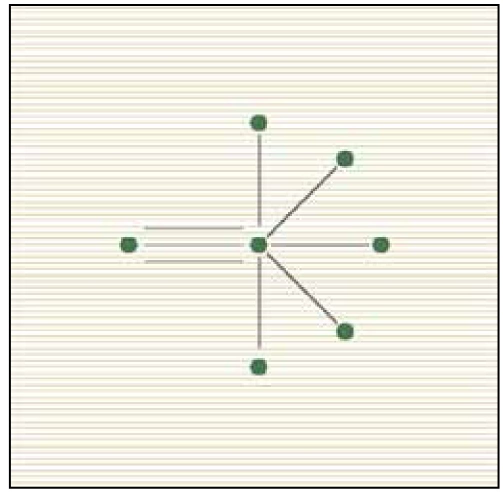
Once on the path of distinction the surface and the form may discrete by stages, or discrete by types. As mentioned, discretion through stages can be handled by shifts in either "color" (i.e., surface) or form. Generally, there are noticeable jumps in the color or shape choices. This helps to establish 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 digital rather that 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 would depend on the application more tan likely, 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. In the examples that follow, section 2, the default design approach of requisite distinction between the nodes is evident. Examples of minor variance within stages is also evident in some examples. Interestingly, these are only apparent when one takes the time for more close viewing. 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

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 non-visual aspect 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.

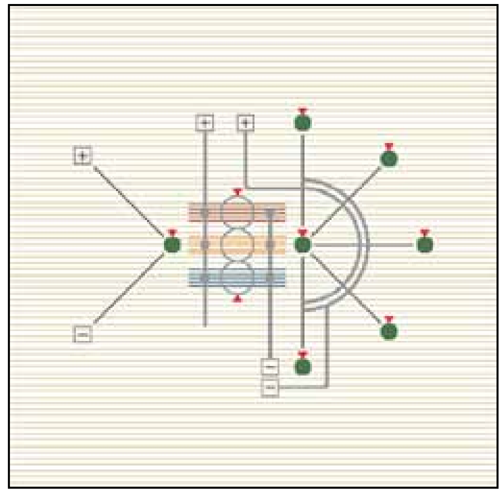


The link is shown divided into multiple paths. This opens up the possibility that any one link can contain as many dimensions as required. An entire EHR could be folded down into an (unpackable) dataset linking two nodes — healthcare provider and recipient. As both nodes and links can be assigned any 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.

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. Again, we direct the reader to the next section to see how this interrelationship reveals itself through the collection of examples.



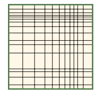
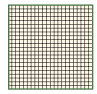
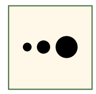
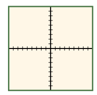
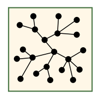
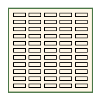
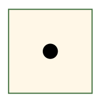
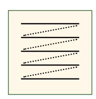
This diagram depicts two ways by which change agents may have a dynamic impact upon a node-and-link composition. The positive/negative indicators speak to a flow of change, thus they would cause a continuous, albeit slowly verifying modification to either the node or link (or ground) devices. The change is modulated and continuous and may be said to be "below the surface." Conversely, the red carrots 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.

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. There is a further subtile of discrete or merged nodes which falls under a structural consideration as well.

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.

	**PICTORIAL** *Semi-constrained*	*— distorted maps, illustrations*
	**PICTORIAL** *Constrained*	*— satellite imagery, photographs,*
	**QUANTITATIVE** *Unconstrained*	*— symbols scaled one to another to reflect quantities (infographic when possessing pictographic information)*
	**QUANTITATIVE** *Constrained*	*— bar charts, line graphs stack graphs*
	**RELATIONAL** *Semi-constrained*	*— node-and-link diagrams, networks*
	**RELATIONAL** *Constrained*	*— spreadsheets, tree maps, tables*
	**SYMBOLIC** *Unconstrained*	*— ideographs, pictographs, infographs (possessing quantigraphic information)*
	**SYMBOLIC** *Constrained*	*— letters, glyphs, Morse code, braille, binary code*

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.

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 GUI sense that it may be clicked upon and information may be accessed through it.

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.

It has been stated how data might be, in some wholesale fashion, switched form node-to-link in order to gain some new insights by a inverted display. 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 none-the-less 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. Or there is the opportunity to bring certain types of characteristics to the less likely to have it (the link becoming pictographic for example). In extreme cases certain types of information may best be portrayed by devices that are modified in a somewhat less-than-natural way. Several examples in the collection that follows display this. As a concluding statement to this discussion of nodes and links 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 healthcare profession so well. If a node is a patient and a link a treatment (in this example) clearly the treatment, irrespective of the known patient, tells me much about the status of that patient. The patient is now somewhat known by the link (treatment) so applied.

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.

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Displaying Healthcare Informatics Through Node-and-Link Visualizations: Can Social Network Modeling Improve Healthcare Provision and Advance Preventive Healthcare Practice More So Than Other GUI Models?

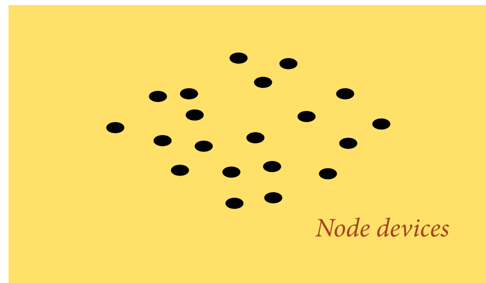
WILLIAM M. BEVINGTON, PIIM

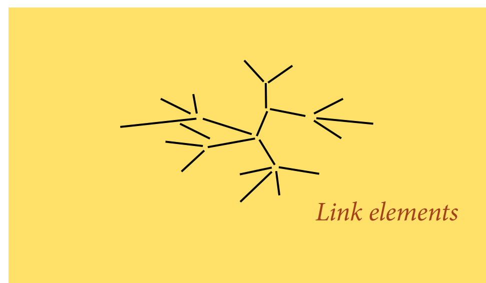
Part Two (Visual Exemplars)
Semi-Constrained Relational Networks: A Compendium of Variously-Purposed and Applied Node-and-Link Presentations

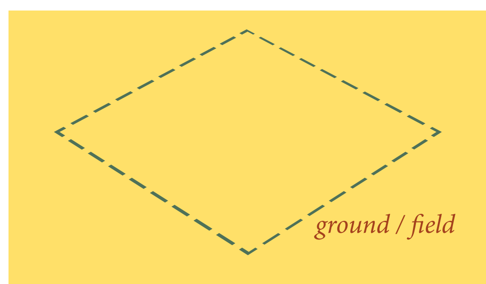
EXHIBITS: NODE-AND-LINK DIAGRAMS

What do **semi-constrained relational network patterns** look like? Approximately how wide is the range of visual presentation that falls within a "node-and-link enterprise." This section addresses these issues, containing sixty image sets of semi-constrained relational network patterns. They are directly, or somewhat indirectly, node-and-link visualizations. The purpose of the collection is two-fold, first it affirms the taxonomy. No element found in this wide collection of node-and-link representations is not either a: **node, link, ground,** or **change agent** all are composed of these four base "radicals". Added to these are **identifiers** (such as text labels), as needed, to address communicative shortcomings. Despite this seeming limitation, the collection of images compiled here are very wide in scope. (As this is a print document the change agents are implied, not actionable, as they would be through dynamic presentations — however, many of these may be accessed through the suppled URL addresses).

This collection will also serves as a reference resource as we move to the next stage of this project: developing the suggested GUI node-and-link visualization approach that can best address a preventative-based healthcare model. No image contained in this set is ideal for that task —however, these sixty images, selected from a much greater set, provides necessary background of *types* toward the task that this paper sets the stage for. The examples are not specifically broken down into subclasses or kinds. However, there is a benefit to generally grouping the exhibits so that viewers and developers (both in design and engineering) can ascertain a sense of secondary ontologies respecting types. The collection is loosely organized from the simpler 2D "flat" examples toward more complex ND models (sometimes called 2.5D models, those that have a suggested additional axis). Complex entries dealing with geography and geographic networking are placed last. Print and noninteractive (many being historical images) come first, and the interactive/electronic versions after these. However, the structural aspects take precedence in the arrangement over interactively aspects.







NODE AND LINK TAXONOMY

All node-and-link presentations are composed of depicted devices and the illustrated connections between them. Optionally, node-and-link presentations may possess a ground that provides a greater context for the devices. (In some cases the ground provides alignment context for the devices and the links, as in a true map where the lines, linking cities, are roads.) In the sixty examples shown within this section only nodes, links, or grounds are present in conjunction with annotation. However, the method in which they are rendered varies considerably depending on the content and the designers understanding of what should be emphasized.

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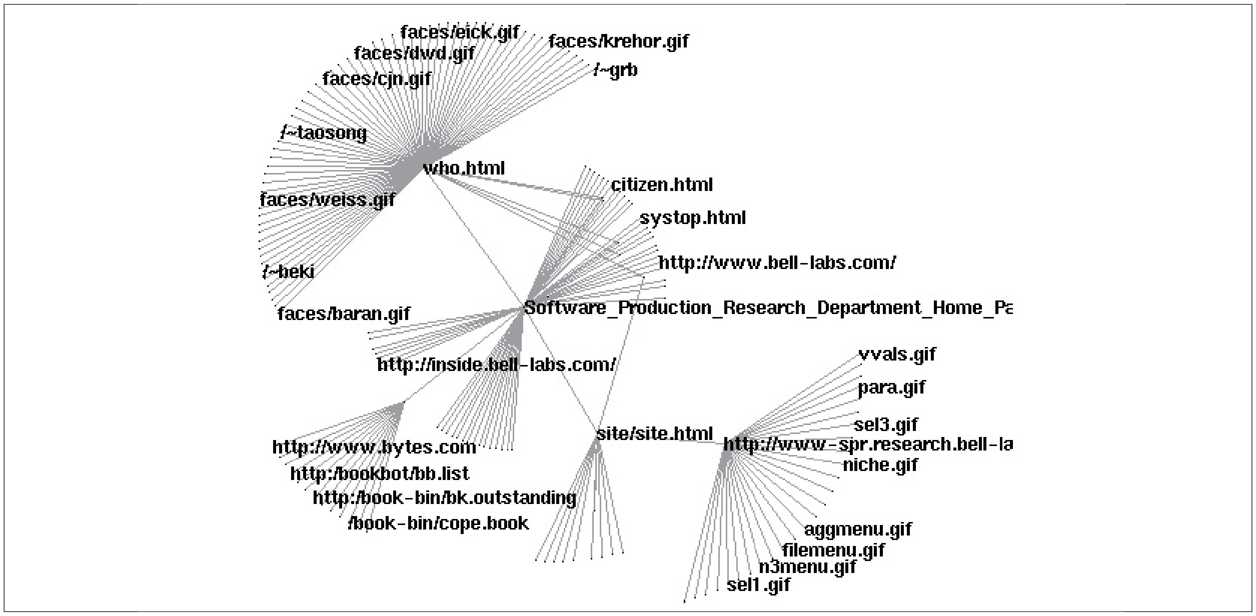
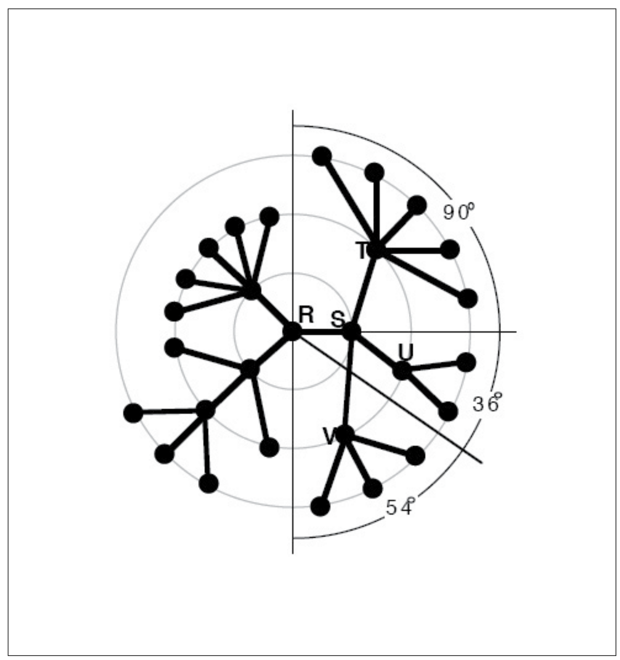
NICHEWORKS



DESCRIPTION:

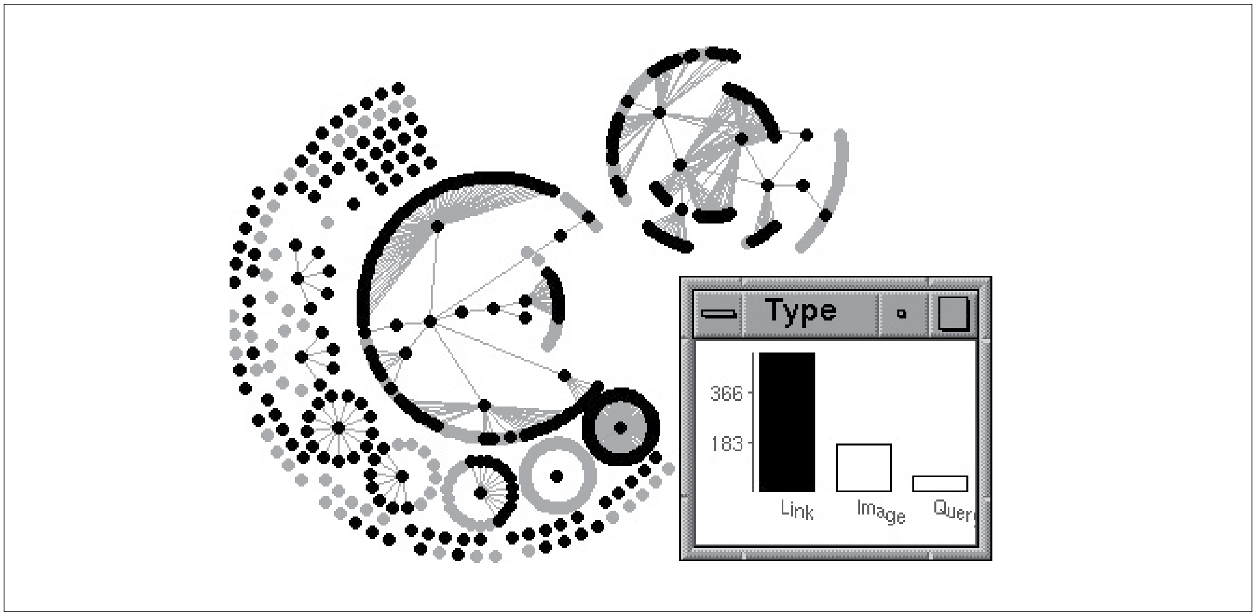
The difference between displaying networks with 100–1,000 nodes and displaying ones with 10,000–100,000 nodes is not merely quantitative, it is qualitative. Layout algorithms suitable for the former are too slow for the latter, requiring new algorithms or modified (often relaxed) versions of existing algorithms to be invented. The density of nodes and edges displayed per inch of screen real estate requires special visual techniques to filter the graphs and focus attention. Compounding the problem is that large real-life networks are often weighted graphs and usually have additional data associated with the nodes and edges. A system for investigating and exploring such large, complex datasets needs to be able to display both graph structure and node and edge attributes so that patterns and information hidden in the data can be seen.



SOURCE:

Wills, Graham J. "NicheWorks — Interactive Visualization of Very Large Graphs." *Lecture Notes in Computer Science, Volume* 1353 (1997): 403-414.

NICHEWORKS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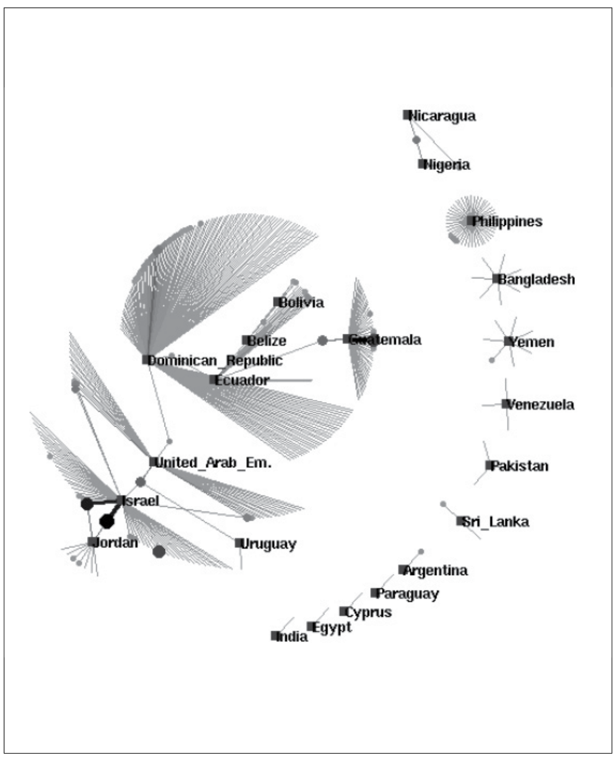
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Israel
Sri_Lanka
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Argentina
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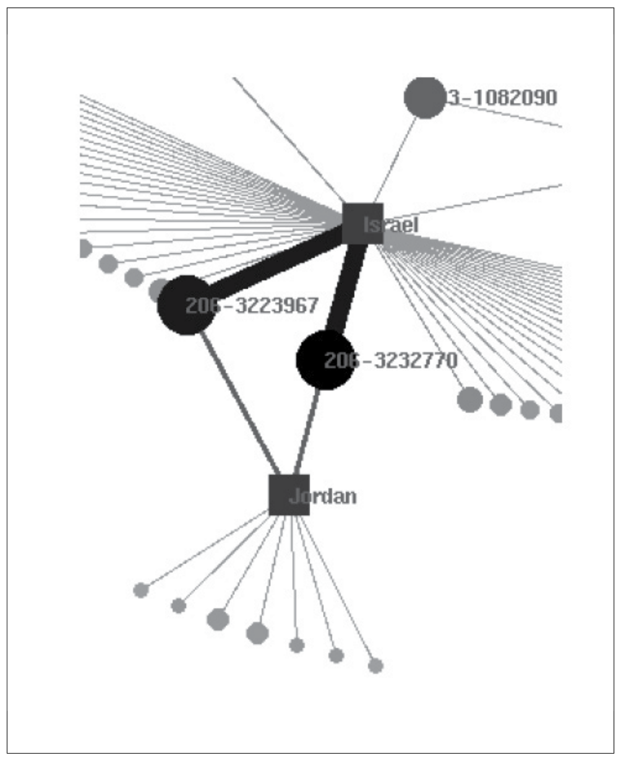
Cyprus
Egypt
India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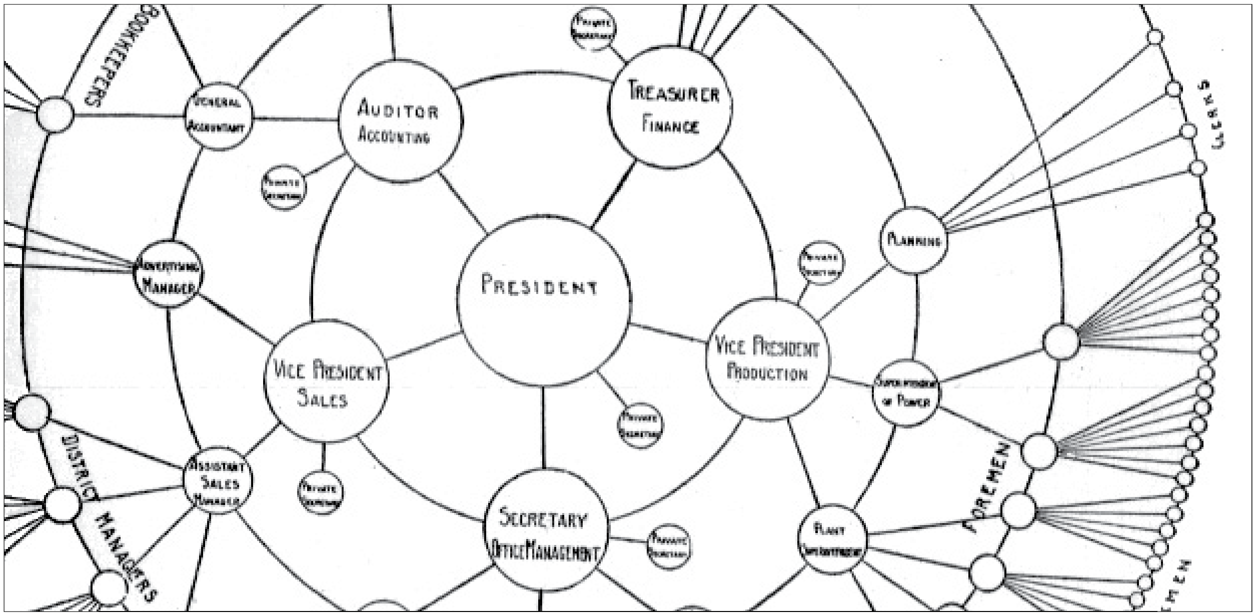
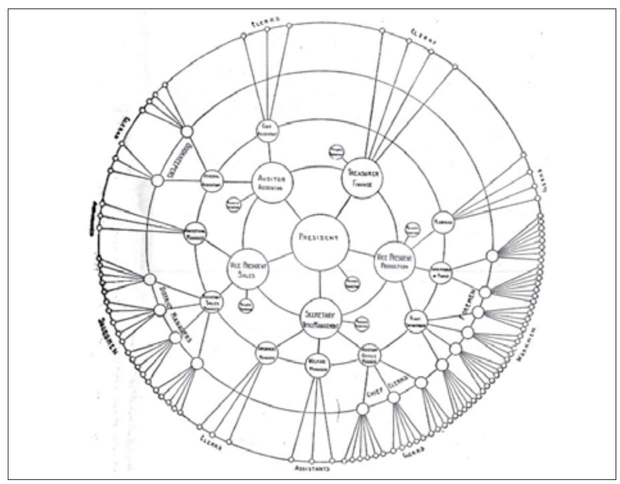
206-3232770
Jordan

RADIAL FORM OF ORGANIZATION CHART (1924)



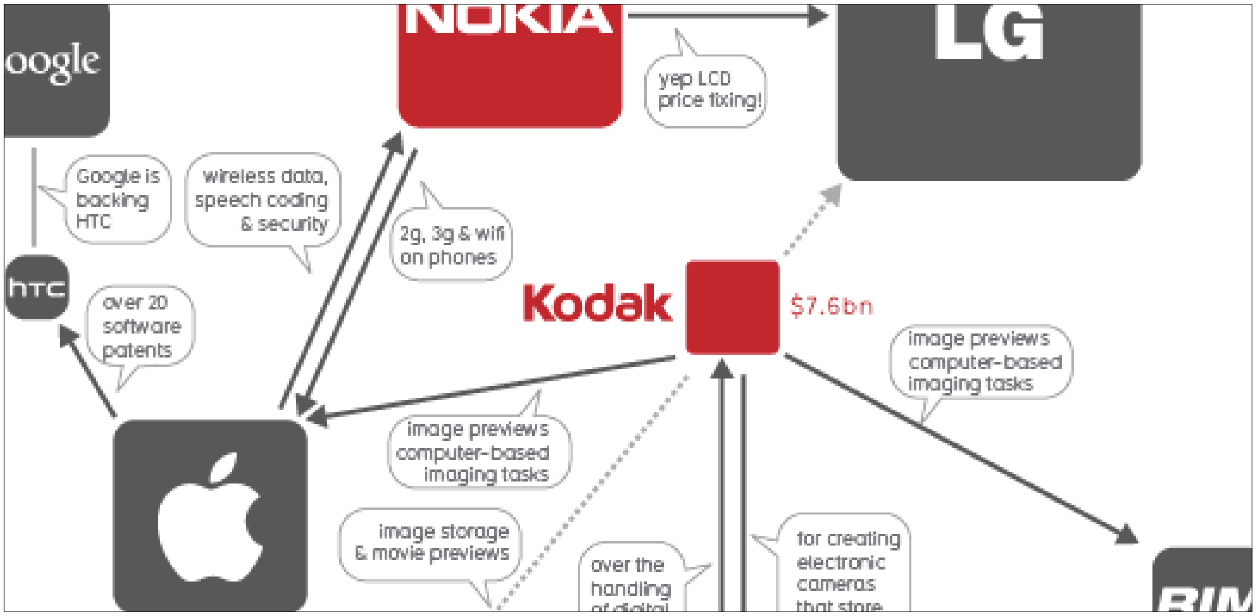
DESCRIPTION:

The radial form of organization chart, showed in the image, has not so much to recommend it as the block and line system. In the first place it is difficult to draw it so as to show lines of authority. It places the emphasis on the central authority, while making it difficult to ascertain the relations of the subordinate divisons to each other.



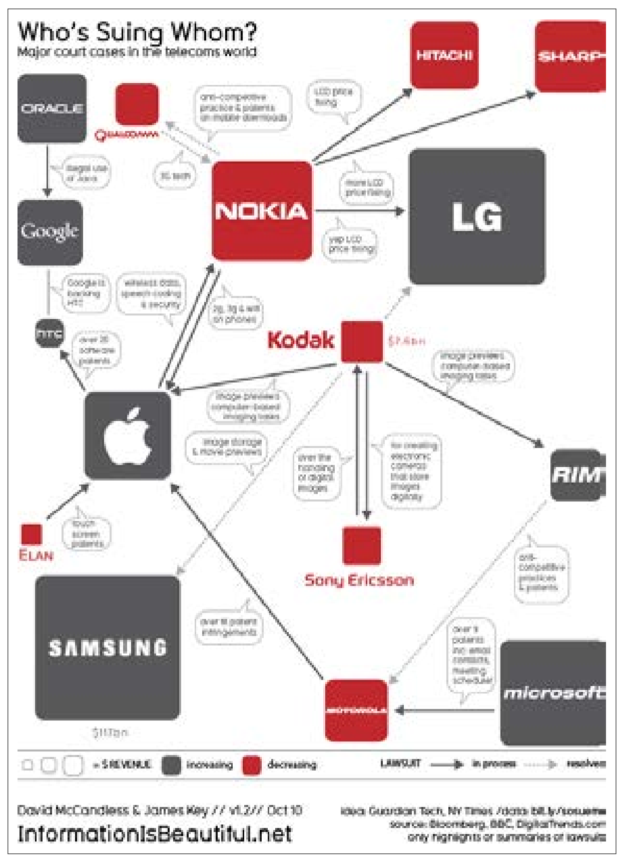
SOURCE:
W. H. Smith., Graphic Statistics in Management (McGraw-Hill Book Company, New York, ed. First, 1924).

MOBILE PATENT LAWSUITS 550 x 771



DESCRIPTION:

An observation of the different patent lawsuits being filed between major mobile device companies.



SOURCE:

Key, James and McCandless. "Who's Suing Whom in the Telecoms Trade?" *Information is Beautiful*, 6 October 2012, http://www.informationisbeautiful.net/2010/whos-suing-whom-in-the-telecoms-trade/ (26 June 2012).

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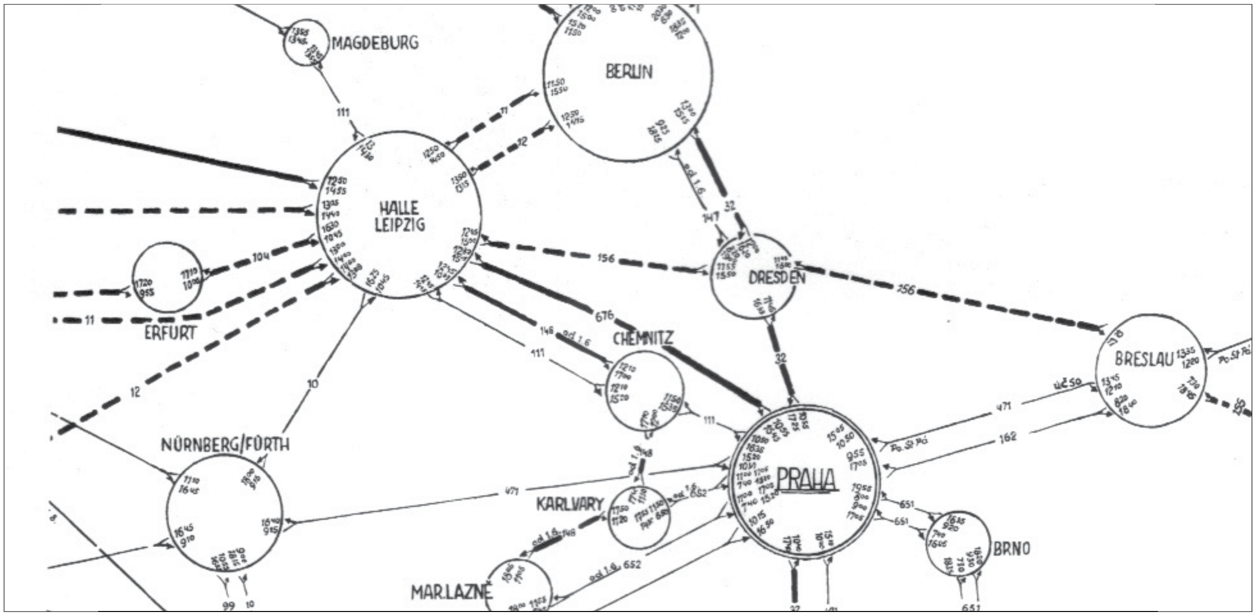
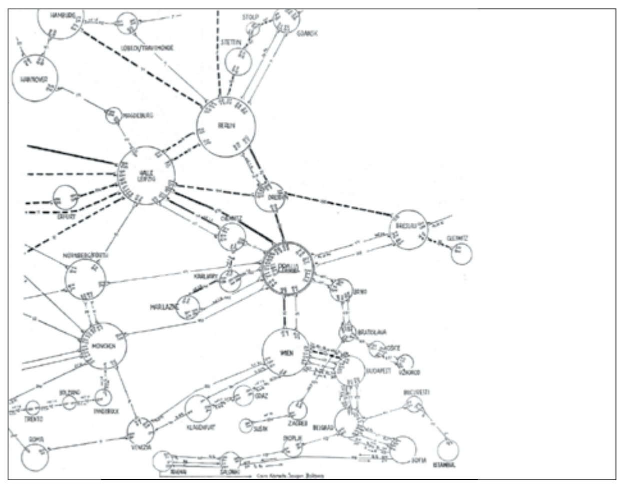
CZECHOSLOVAKIA AIR ROUTE MAP (1933)



DESCRIPTION:

“A comprehensive narrative description of a transport system requires a record of both time and spatial experiences. Here a complex network of routes is brought together with flight times and identification numbers in a brilliant map/schedule for the Czechoslovakia Air Transport Company in 1933.”



SOURCE:

E. R. Tufte., *Envisioning Information* (Graphics Press, , May 1, 1990).

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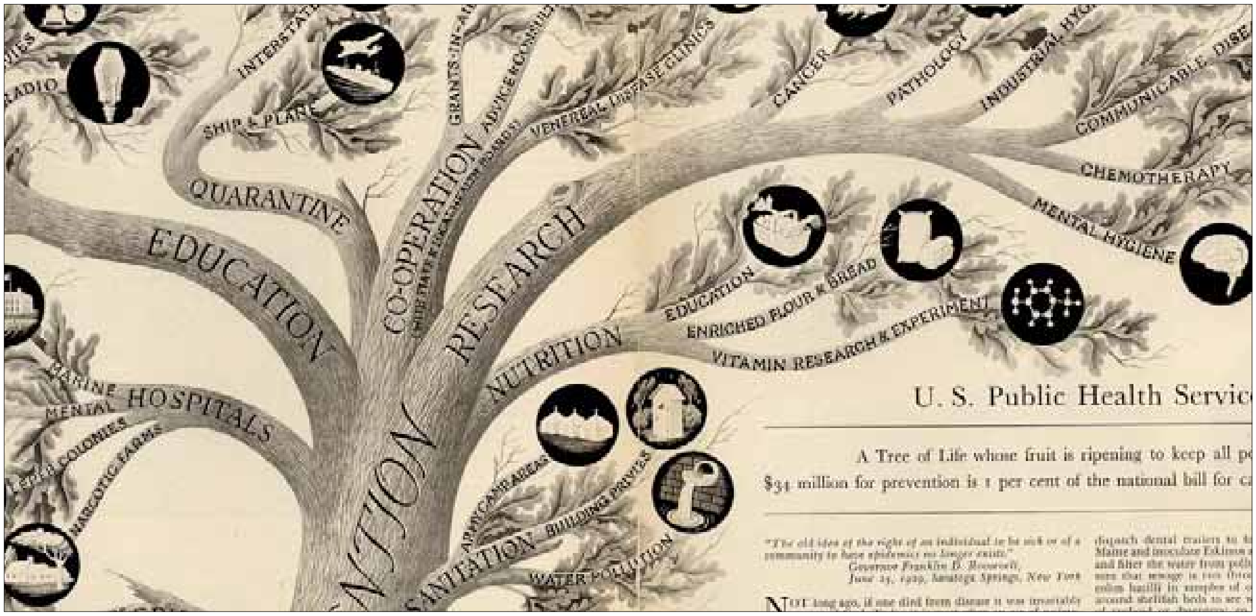
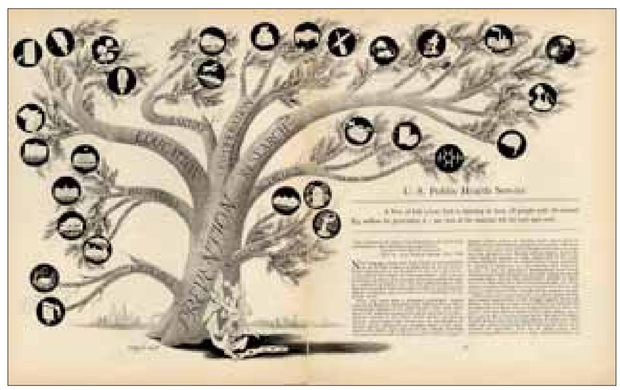
U.S. PUBLIC HEALTH SERVICE 1282 x 1159



DESCRIPTION:

"A Tree of Life whose fruit is ripening to keep all people well. Its annual $34 million for prevention is 1 per cent of the national bill for care and cure.

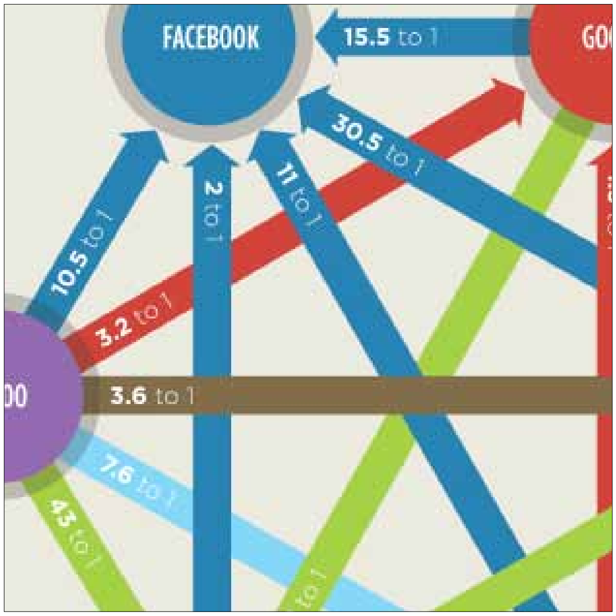
Not long ago, if one died from disease it was invariably an act of God. Today it is most often an act of society: either medical care is not available or one can't pay for it— or the disease has simply not been prevented. And if to an individual an ounce of prevention is worth a pound of cure, to a nation it is worth a ton. For the public health is even less of an accident than individual health; it is nothing but infinite precaution and the swift use of knowledge for the benefit of all."

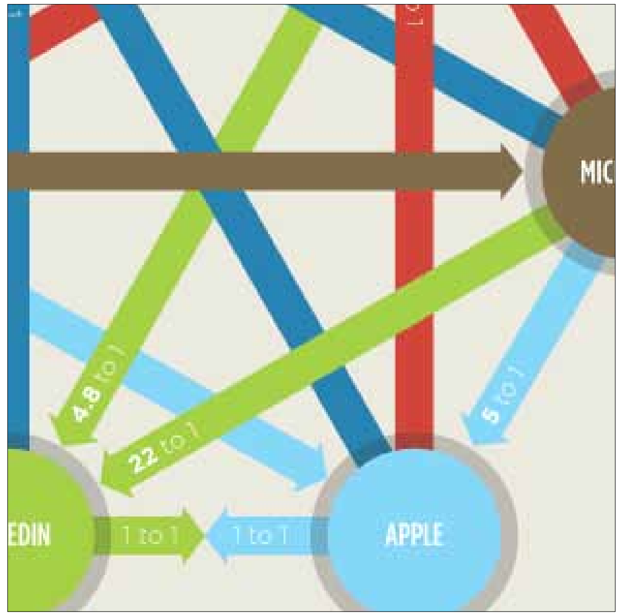


SOURCE:

"U.S. Public Healthcare Service Infographic Infographic," *LoveInfographics*, 29 December 2011, http://www.loveinfographics.com/categories/health-and-diet-infographics/u-s-public-healthcare-service-infographic-infographic#!prettyPhoto-7939/1/ (26 June 2012).

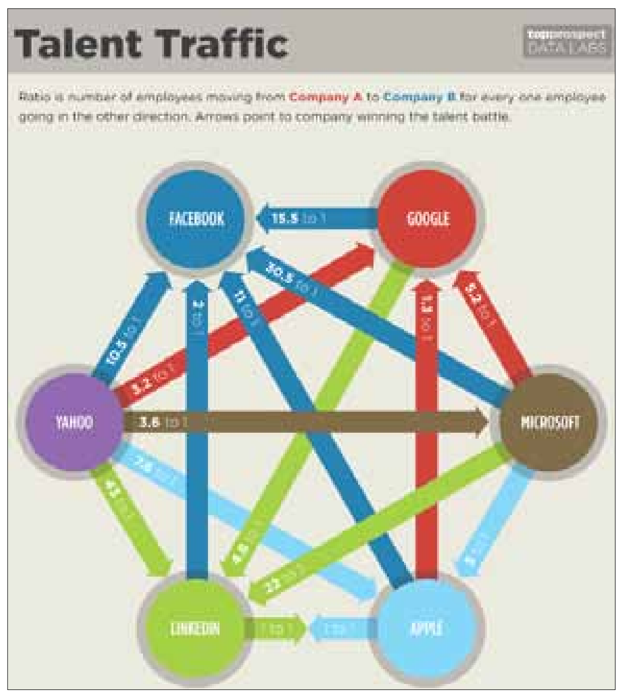
TALENT TRAFFIC 558 x 620





DESCRIPTION:

Ratio is number of employees moving from Company A to Company B for every one employee going in the other direction. Arrows point to company winning the talent battle.



SOURCE:

Cohen, Jackie. “Infographic: Facebook Winning War for Talent.” *AllFacebook*, 10 June 2011, http://allfacebook.com/infographic-facebook-winning-war-for-best-talent_b46481 (26 Jun 2012).

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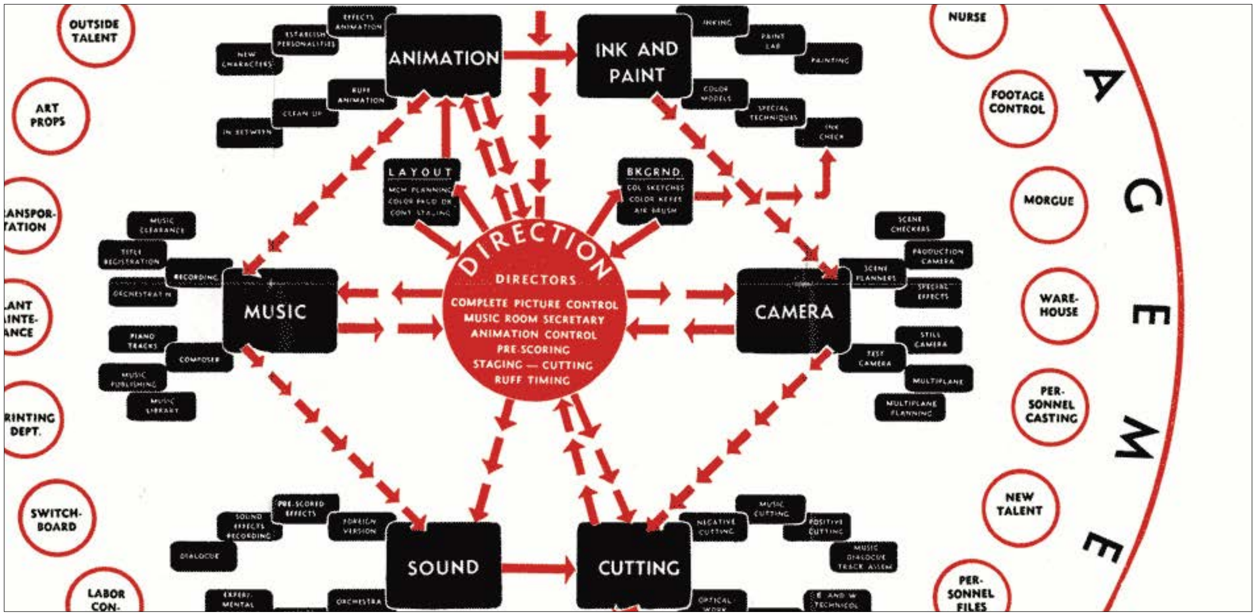
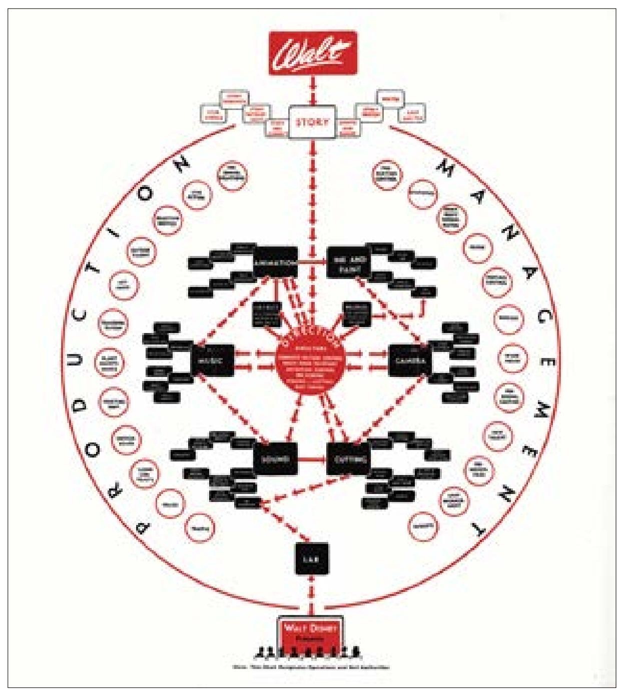
CREATION OF ANIMATION 1200 x 1340



DESCRIPTION:

Walt Disney Presents: How an Animation is made. From the mind of Walt to the story to the direction in which the story is presented, with the processes involving aspects of influence from production and management, among other factors, the path is eventually traced to a screen near you.



SOURCE:

"Walt Disney Presents – How an Animation is Made." *Infographics Depot of Information Graphics*, 1 February 2012, http://infographics.w3ec.com/path-infographics/walt-disney-presents-how-an-animation-is-made (3 July 2012).

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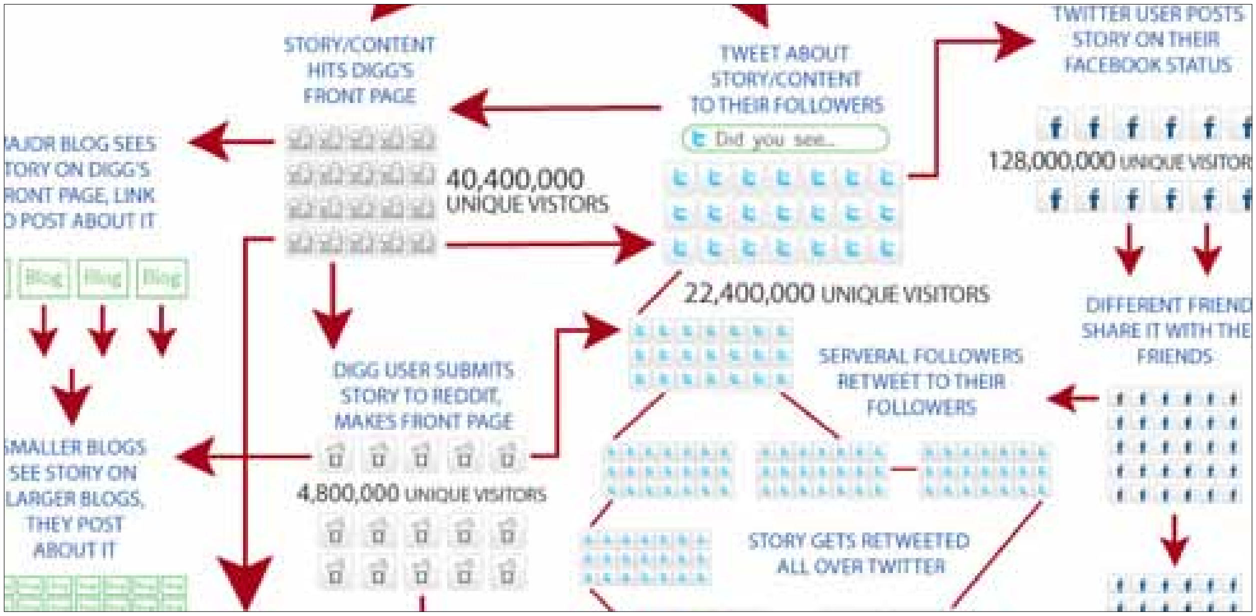
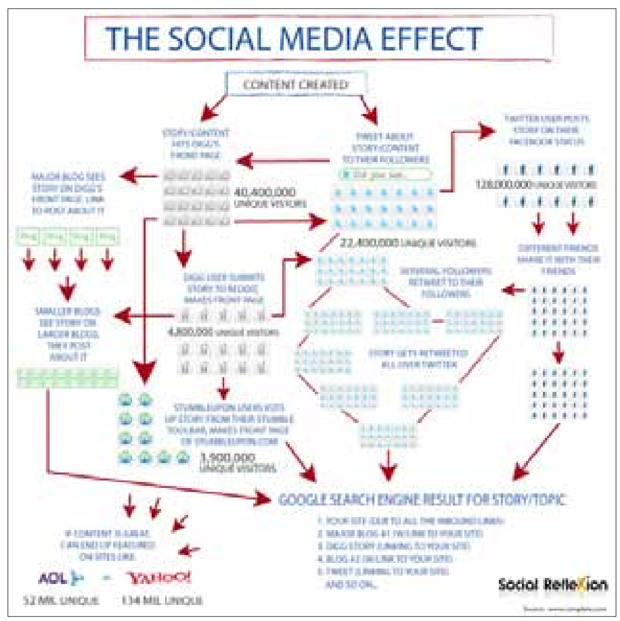
SOCIAL MEDIA EFFECT 536 x 536



DESCRIPTION:

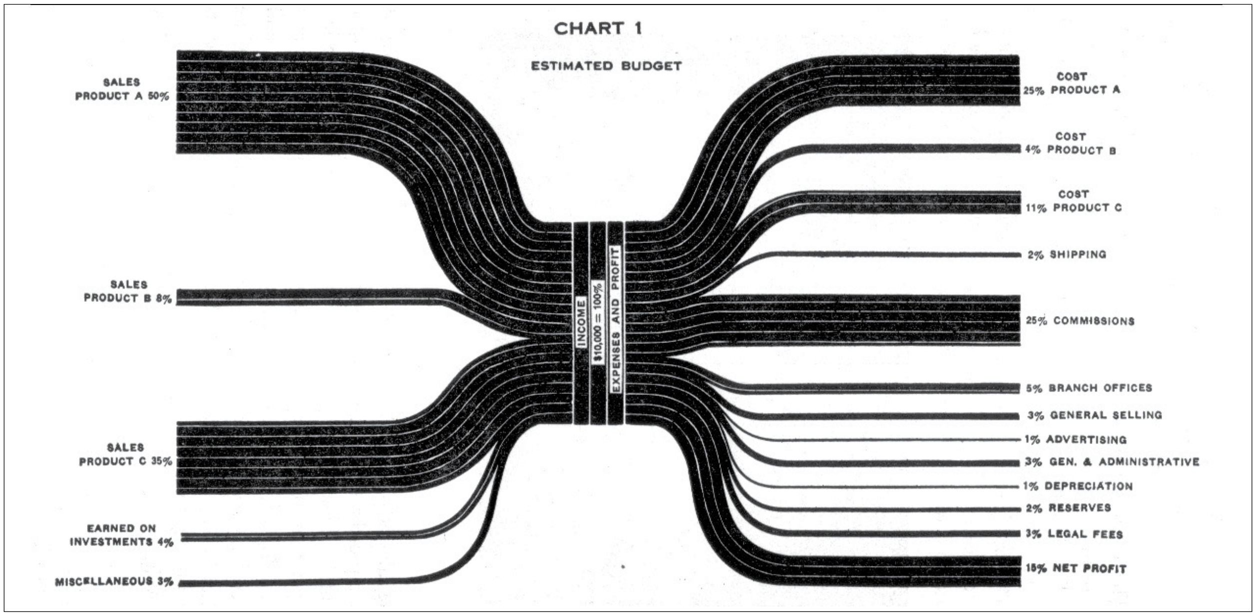
This infographic is a great way of looking at the way content development is used to create all sorts of goodness for your brand inside (and out of) social networks.



SOURCE:

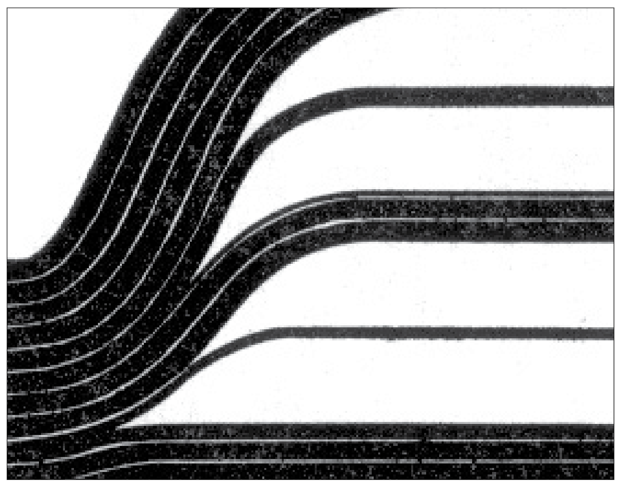
Hepburn, Aden. "Inforgraphic: The Social Media Effect." *Digital Buzz*, 4 April 2010, http://www.digitalbuzzblog.com/infographic-the-social-media-effect/ (28 June 2012).

ESTIMATED BUDGET CHART (1940)



DESCRIPTION:

A graph of a Budget prepared on a Cosmograph.



SOURCE:
H. Arkin., Graphs: How to make and use them (Harper & Brothers Publishers, New York, ed. Revised, 1940).

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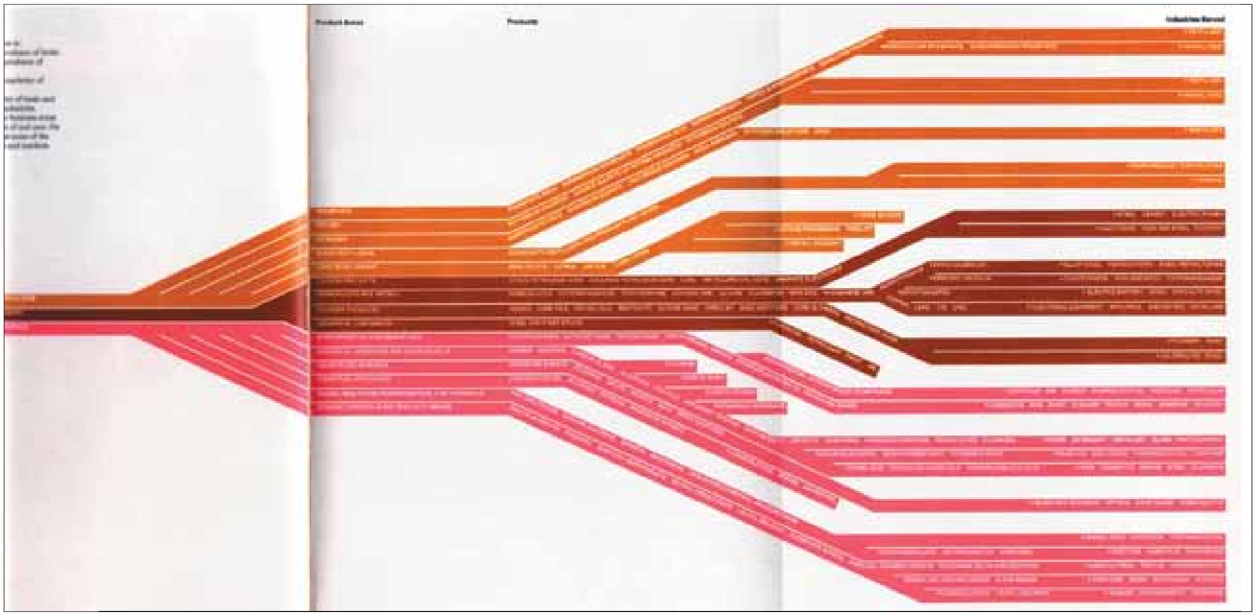
PRODUCTS AND MARKETS



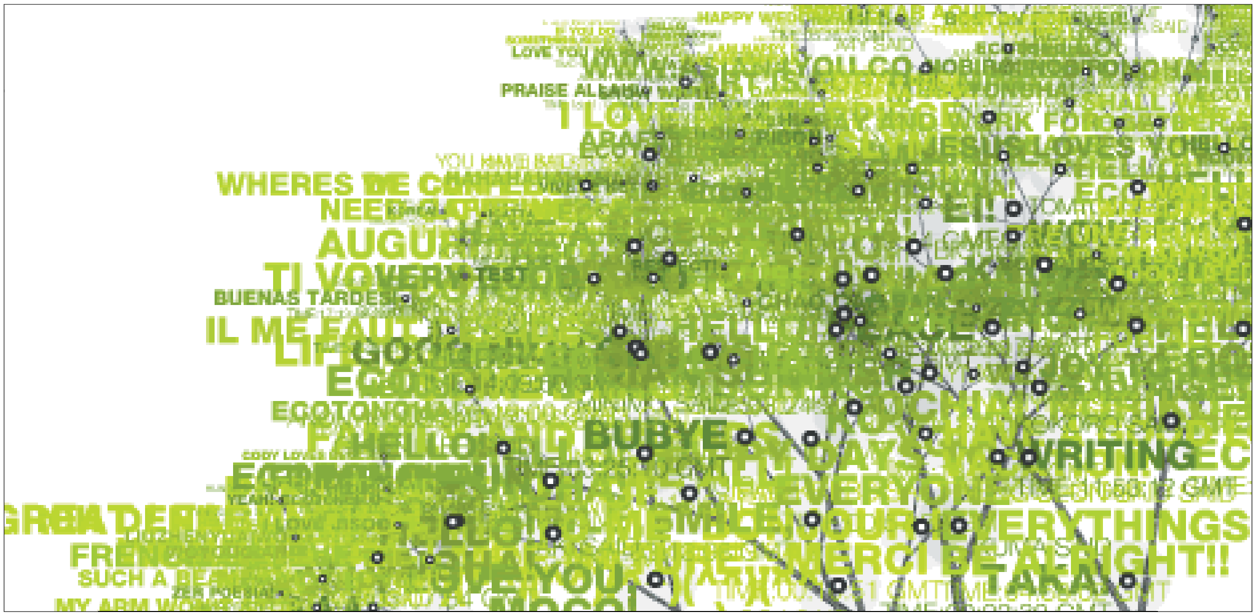
DESCRIPTION:

Products and markets of International Minerals and Chemical Corp. (gatefold from a report)

SOURCE:

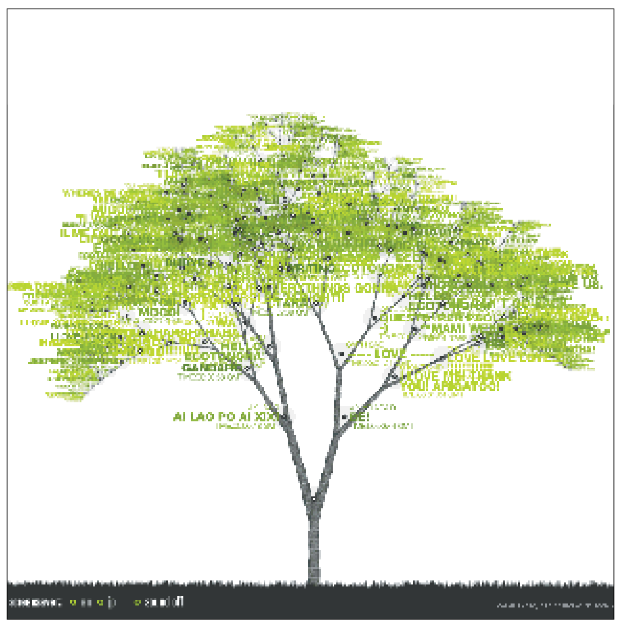
Herdeg, Walter. *Graphis Diagrams*. 4th Expanded ed. Zurich, Switzerland: Graphics Press Corp., 1981.

ECOTONOHA



DESCRIPTION:

"Ecotonoha is a project to nurture a virtual tree collaboratively, and at the same time contribute to the actual environment to cope with global warming. As you make Ecotonoha's leaves, the virtual tree will grow. And as Ecotonoha grows, real trees will be planted by NEC."



SOURCE:

Nakamura, Yugo. "Ecotonoha." *Visual Complexity*, 2004, http://www.visualcomplexity.com/vc/project.cfm?id=201.

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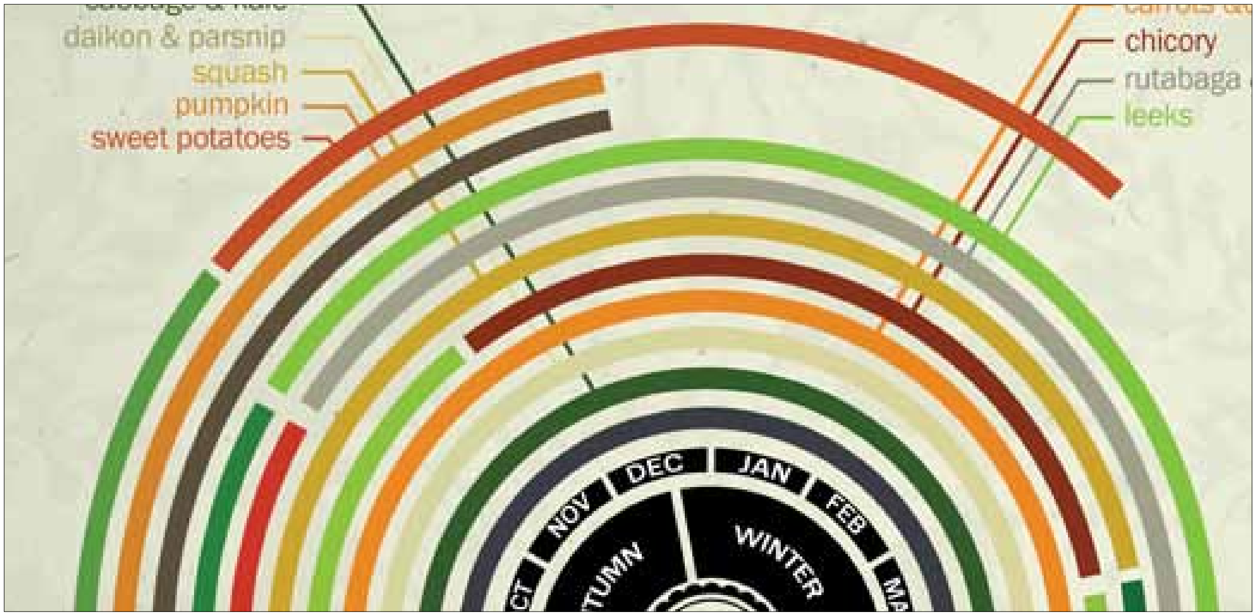
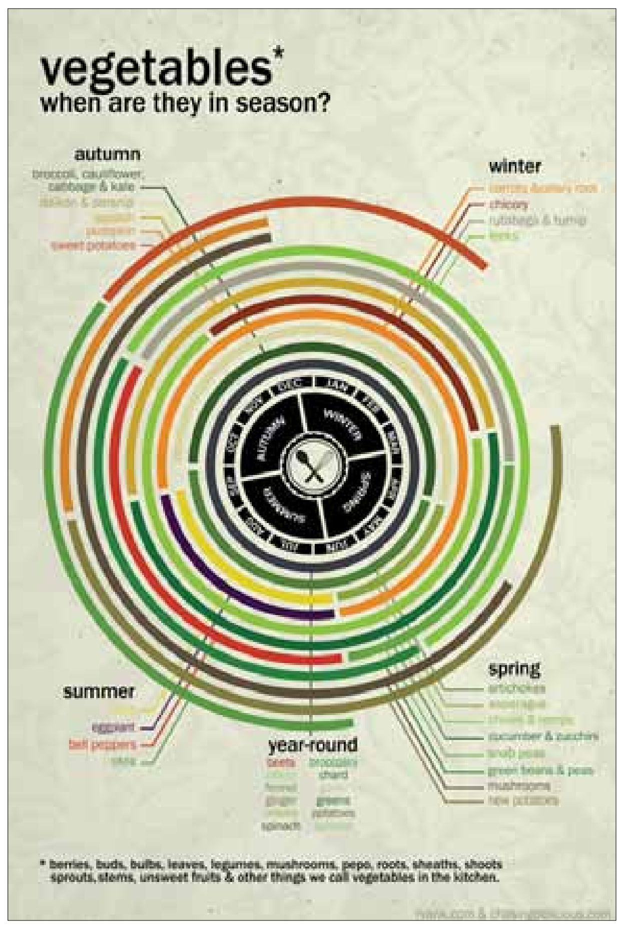
CROPS IN SEASON 600 x 900



DESCRIPTION:

Whether you are a strict seasonal-only shopper or not, knowing what produce is in season when can be very advantageous to successful cooking and baking. Not only will you notice fresher taste and stronger flavors but you will see a marked increase in savings, and a heightened sense of anticipation and appreciation for each season.



SOURCE:

van Kraayenburd, Russell. "Kitchen 101: Fruits, Vegetables, & Herbs." *Chasing Delicious*, 28 May 2012, http://chasing-delicious.com/kitchen-101-produce/ (3 July 2012).

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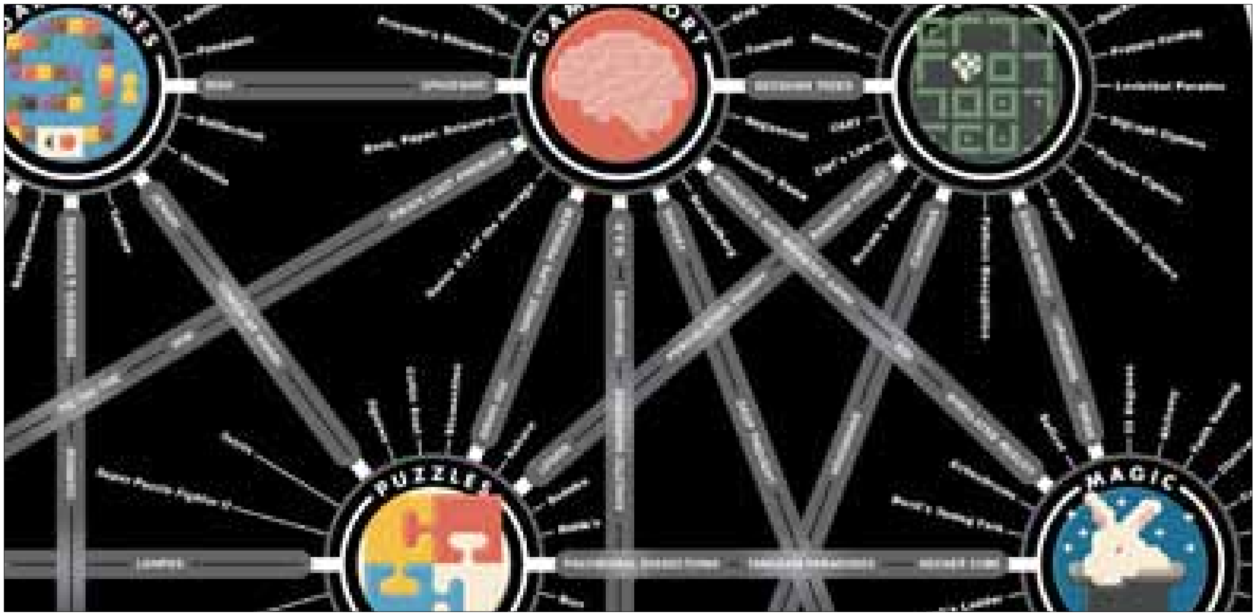
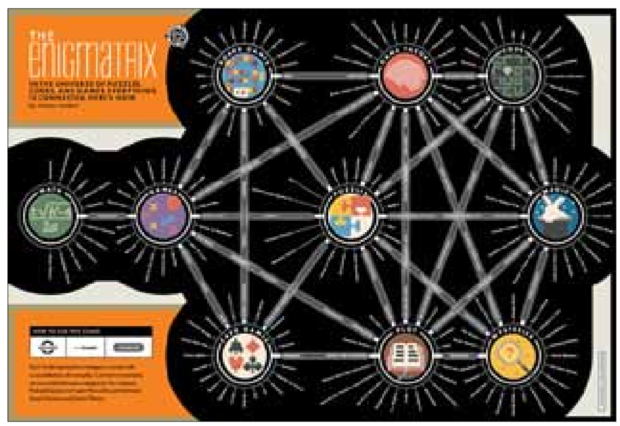
PUZZLE TAXONOMY 653 x 444



DESCRIPTION:

This infographic based on the mythical sephirot shows all the various influences and connections in the world of puzzles and games.



SOURCE:

Leckart, Steven. "The Complex Universe of Games and Puzzles, Simplified." *Wired*, 20 April 2009, http://www.wired.com/special_multimedia/2009/mf_enigmatrix (28 June 2012).

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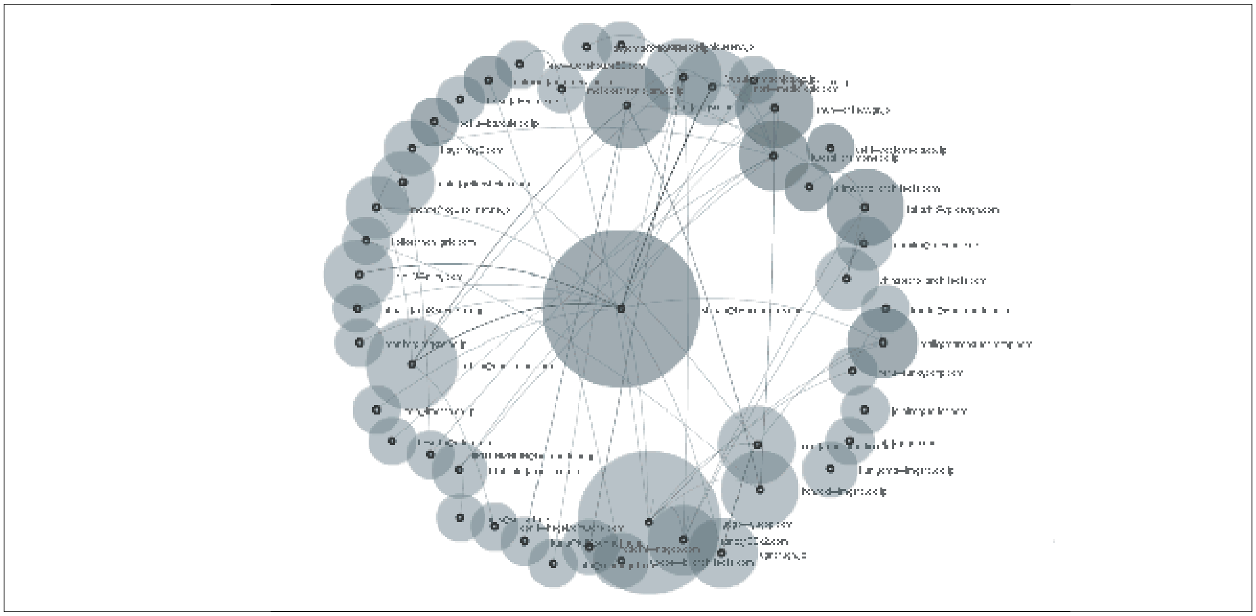
SOCIAL CIRCLES



DESCRIPTION:

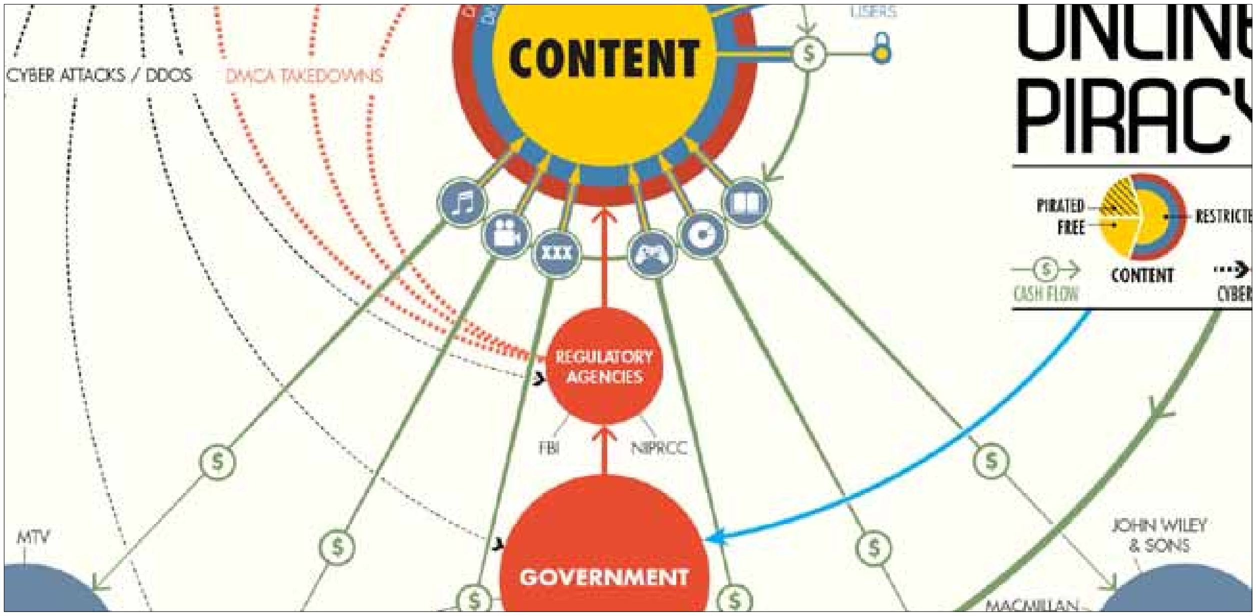
"The idea for Social Circles started a day I was in a meeting, where I noticed how hierarchical and structured the conversation was. Besides conversation protocols and the actual spoken words there's always loads of information that we perceive on body language, dress codes, the position of each person in the room, and the relative position to each other - all meta-data for the human psyche and which helps a lot in telling what is being talked about there.

On the other hand, very informative online discussion forums, mailing lists or chats are not really expressive of those qualities. The sociable media group at MIT has done a great deal in researching on different ways to represent those lost signs. Social Circles then approaches the same problem in a similar way, but focusing only on mailing lists and feeding them live data, so as it can display near realtime snapshots of the current states of the mailing lists it is being pointed to. It also ironically inverts the paradigm that sets that mailing lists are closed discussion places, as it presents those conversation patterns in an open way. Even in unmoderated lists there's always a natural moderator, no one elects it, they simply arise naturally. That is the person who starts and participates in most threads. It was very interesting to see when the people on the lists where first presented with these graphs. I also saw big discussions starting up. Some people liked it a lot, others suddenly restructured themselves. Others hated it as they felt it was an invasion to their private space, others simply died. Some people would 'fight', sending more emails and participating in most threads, so as to stand in the center of the graph, while others, when they realized they where the center of the list, may have felt shy and slowly faded away."

SOURCE:

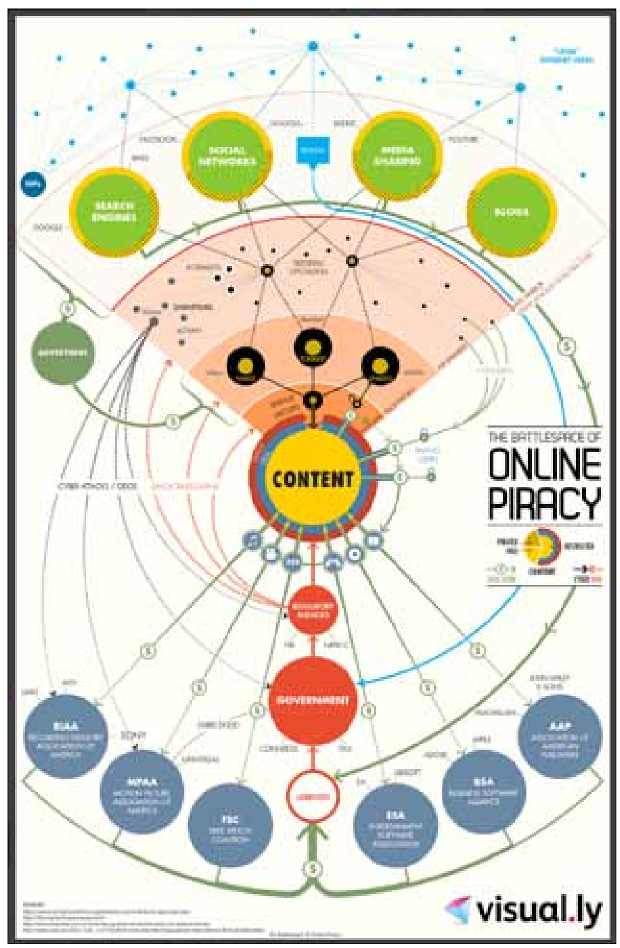
Weskamp, Marcos; text by Fukushi, Naoko. "Marcos Weskamp." *Shift*, Fbruary 2005, http://www.shift.jp.org/en/archives/2005/02/marcos_weskamp.html .

ONLINE PIRACY 1771 x 2723



DESCRIPTION:

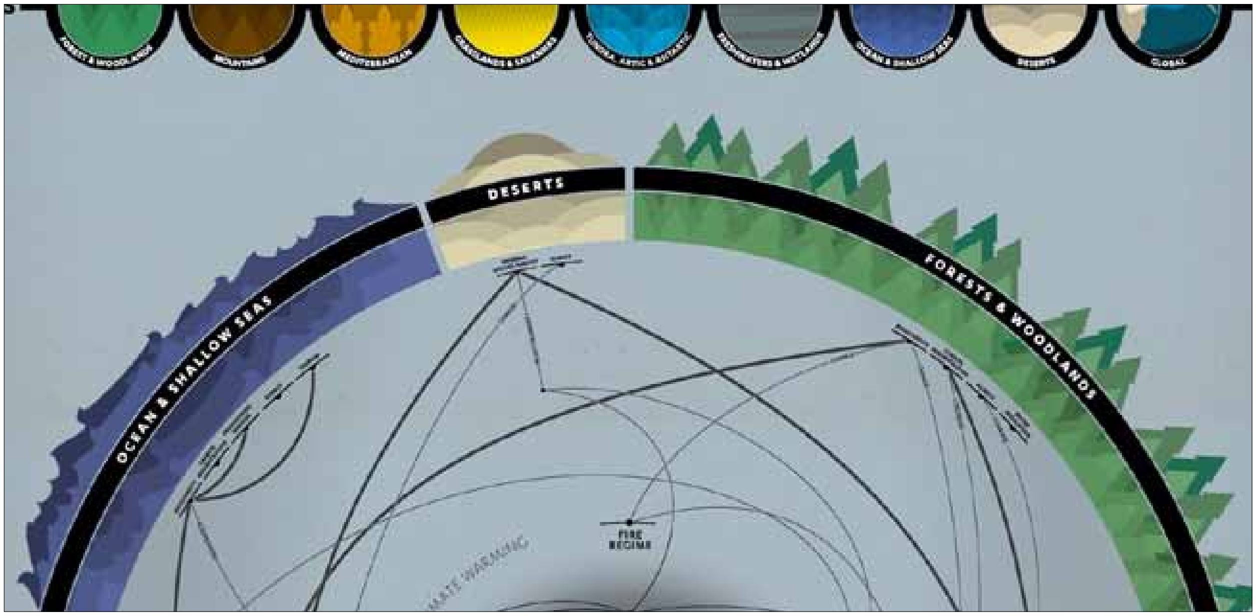
Online piracy has become an unfortunate reality to the entertainment industry as peer-to-peer technology has grown. Check out the battlefield that is online piracy.



SOURCE:

Kessler, Sarah and Sigler, Nick. "The Interconnected World of Tech Companies [Inforgraphic]." *Mashable Tech*, 19 July 2011, http://mashable.com/2011/07/19/tech-companies-infographic/ (2 July 2012).

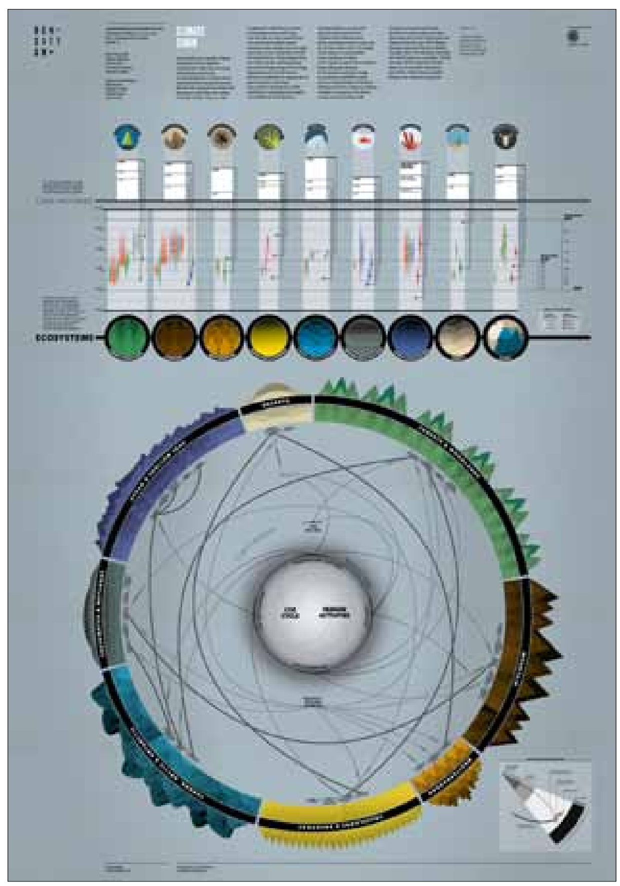
CLIMATE CHAIN 2066 x 2956



DESCRIPTION:

“An ecosystem is a complex of plant, animal and micro-organism communities, while the non-living environment interacting as a functional unit. Ecosystems are characterized by strong interactions between the components within their boundaries, which become weaker if outside of them.

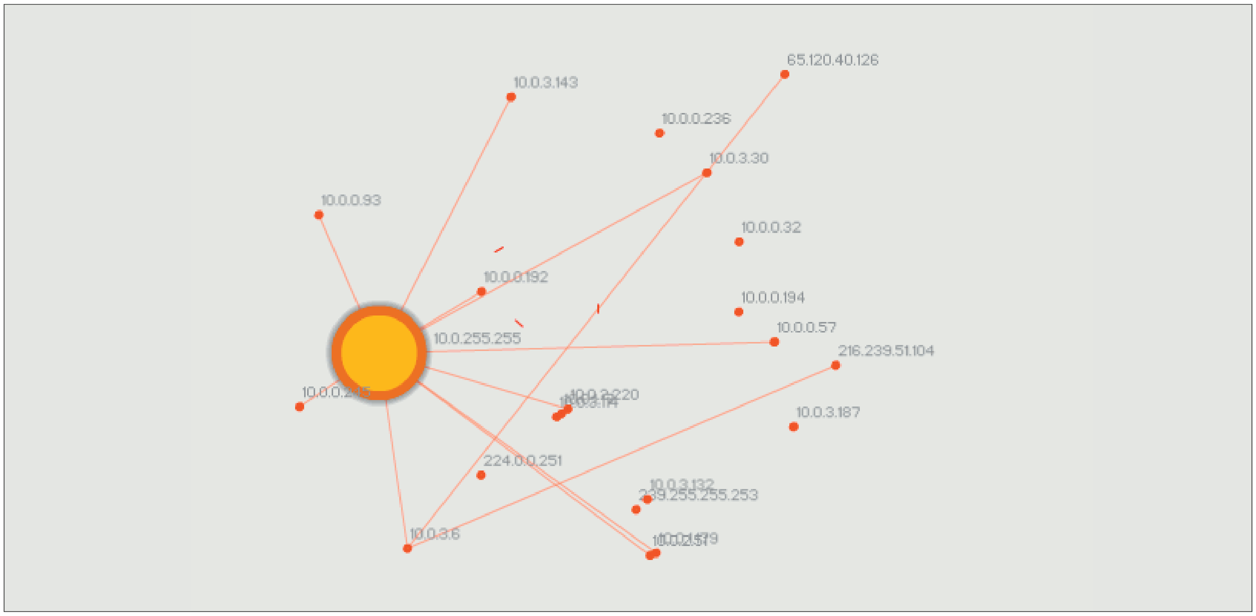
Datas reported in this visual project are obtained from the 2007 IPCC Report (Intergovernmental Panel on Climate Change) whom considerations and data are mainly based on 2 scenarios: DGVM Dinamyc Global Vegetation Model (based on A2 emission scenarios) and GCMs Global CLimate Models (based on B1 emission scenarios).”



SOURCE:

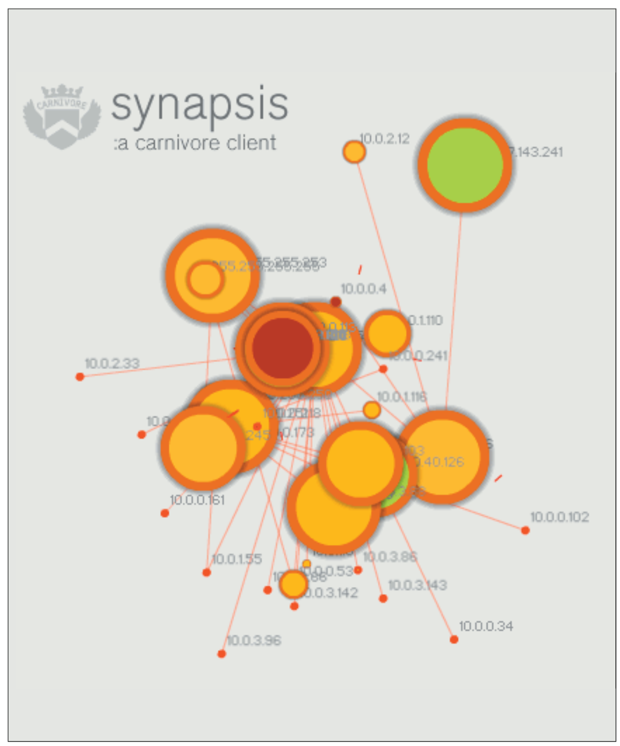
DensityDesign, “Climate Chain: Ecosystems and their goods and services.” *Visualizations*, 20 February 2012, http://www.visualizing.org/visualizations/climate-chain-ecosystems-and-their-goods-and-services (3 July 2012).

SYNAPSIS



DESCRIPTION:

“Synapsis is an application that partially visualizes network traffic. It is the uppermost layer for Carnivore, a network surveillance tool. Carnivore is an application that listens to all data traffic in a network (email, web surfing, etc.). Data travels on the Internet between two computers in packets. The Synapsis client visualizes the actual packets flowing on the network and partially reveals the network topology, at the same time that utlizies that input to generate a unique sound ambience.



SOURCE:

Weskamp, Marcos. “Synapsis.” *Visual Complexity*, 2003, http://www.visualcomplexity.com/vc/project.cfm?id=59 .

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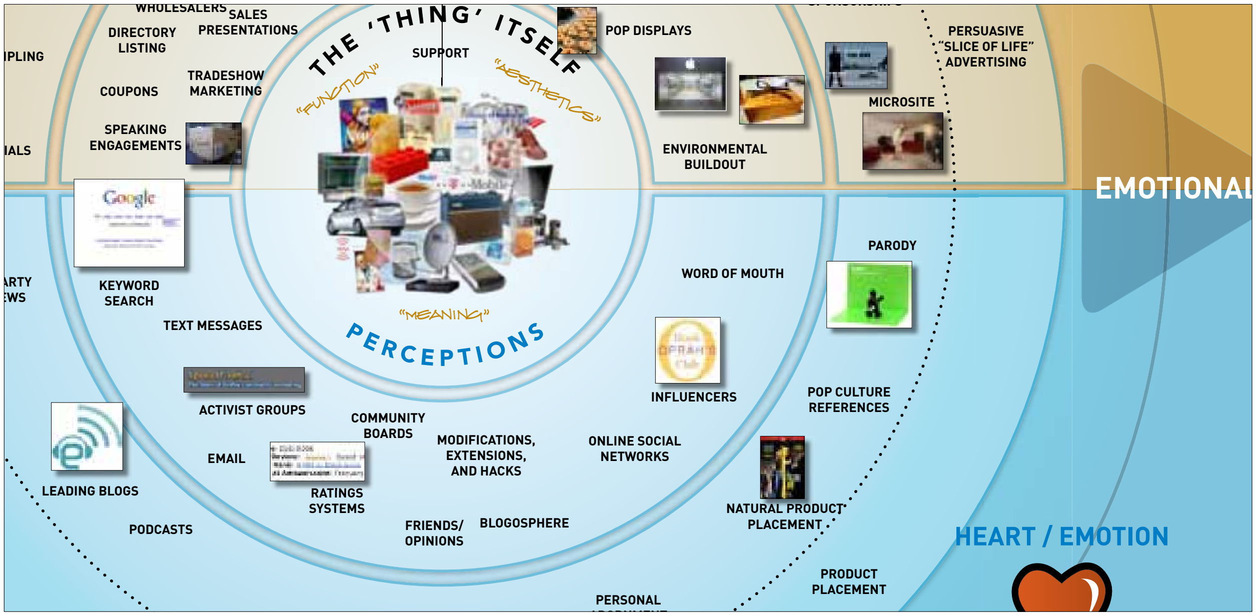
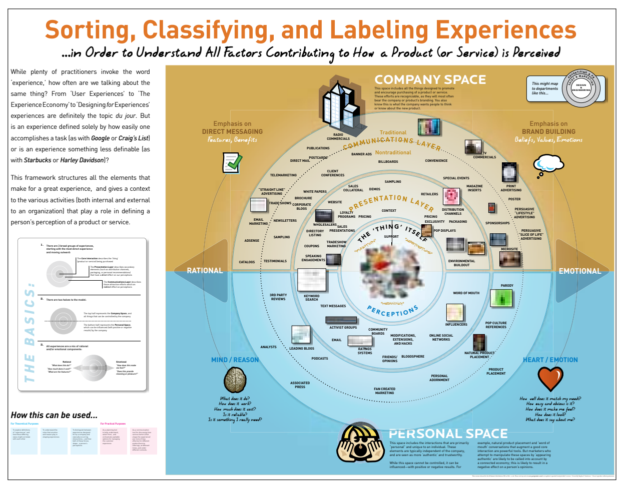
EXPERIENCE CLASSIFICATION 3456 x 2592



DESCRIPTION:

"While plenty of practitioners invoke the word 'experience,' how often are we talking about the same thing? From 'User Experiences' to 'The Experience Economy' to 'Designing for Experiences,' experiences are definitely the topic du jour. But is an experience defined solely by how easily one accomplishes a task (as with Google or Craig's List) or is an experience something less definable (as with Starbucks or Harley Davidson)?

This framework structures all the elements that make for a great experience, and gives a context to the various activities (both internal and external to an organization) that play a role in defining a person's perception of a product or service."



SOURCE:

"Microsoft HealthVault." *Infographics Depot of Information Graphics*, 2 February 2009, http://infographics.w3ec.com/transport-infographics/microsoft-healthvault (3 July 2012).

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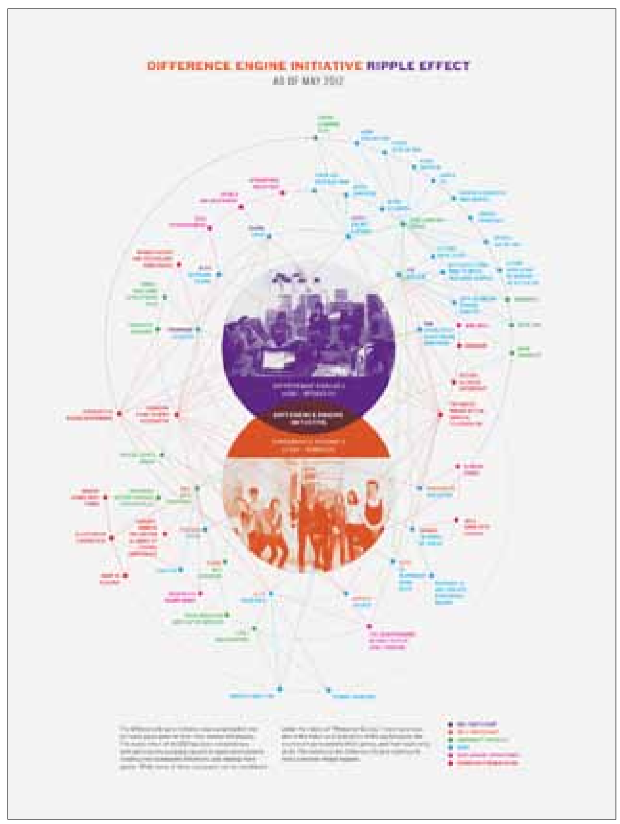
DIFFERENCE ENGINE INITIATIVE 1024 x 1366

DESCRIPTION:

This visualization was created to demonstrate the growing impact of feminist game-making initiatives such as the Difference Engine.



SOURCE:

Lee, Una. "Difference Engine Initiative Visualization." *Una Lee*, http://www.unalee.net/work/difference-engine-initiative-visualization (26 June 2012).

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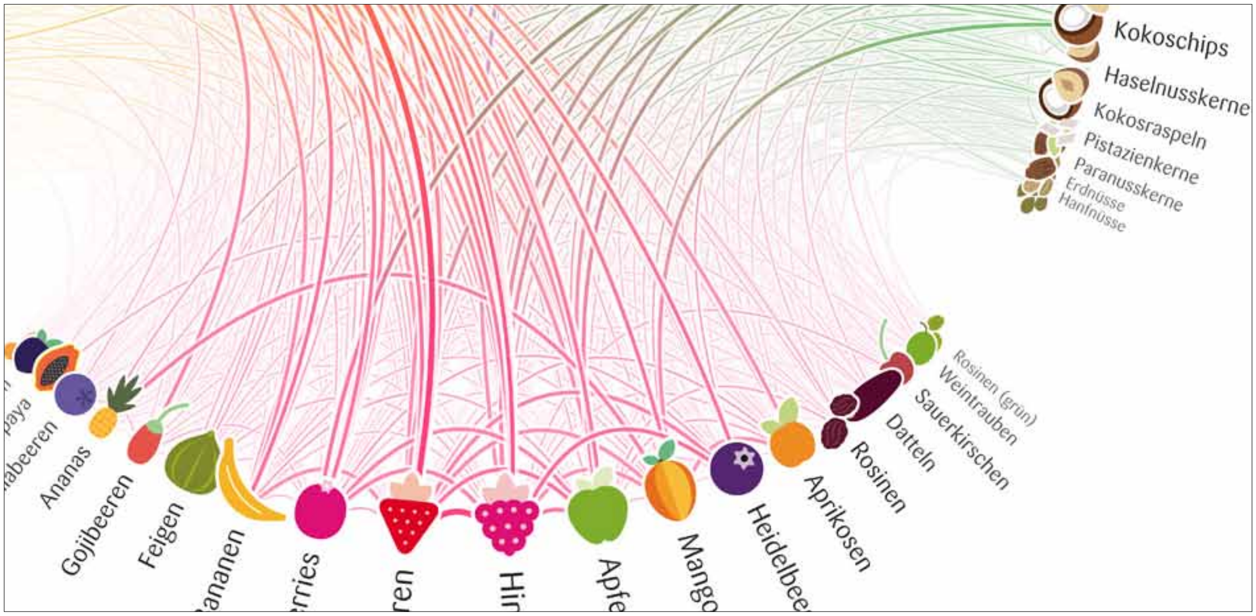
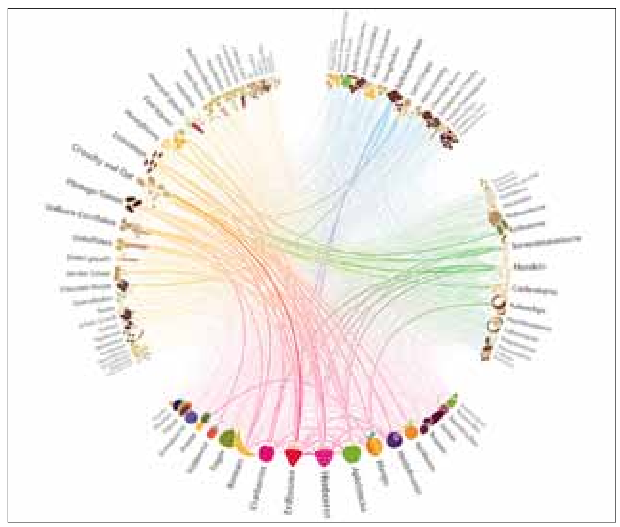
INGREDIENT COMBINATIONS 1500 x 1268



DESCRIPTION:

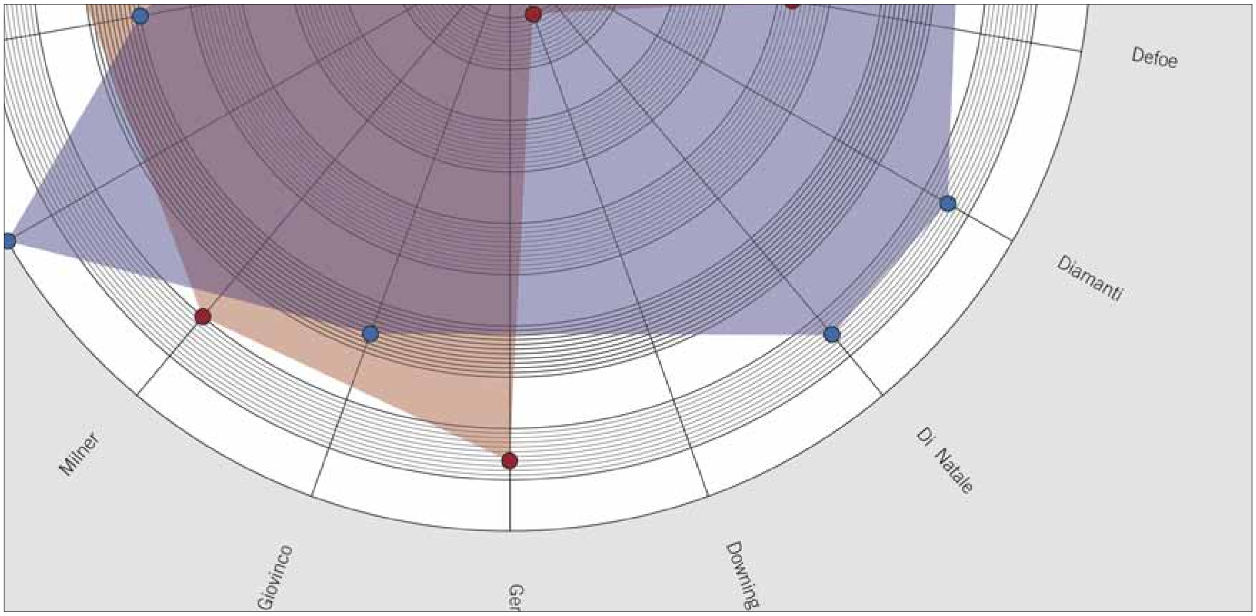
Radial network visualization for a German start-up (mymuesli.com) of how clients combined the ingredients offered.



SOURCE:

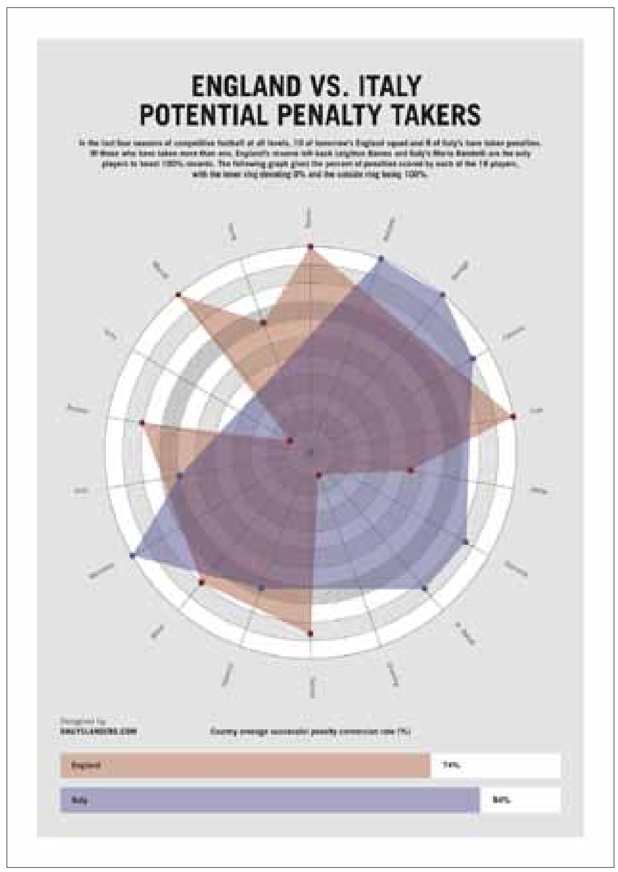
Stefaner, Moritz. "Müsili Ingredient Network." *Moritz Stefaner*, http://moritz.stefaner.eu/projects/musli-ingredient-network/ (26 June 2012).

PENALTY KICKS 1199 x 1695



DESCRIPTION:

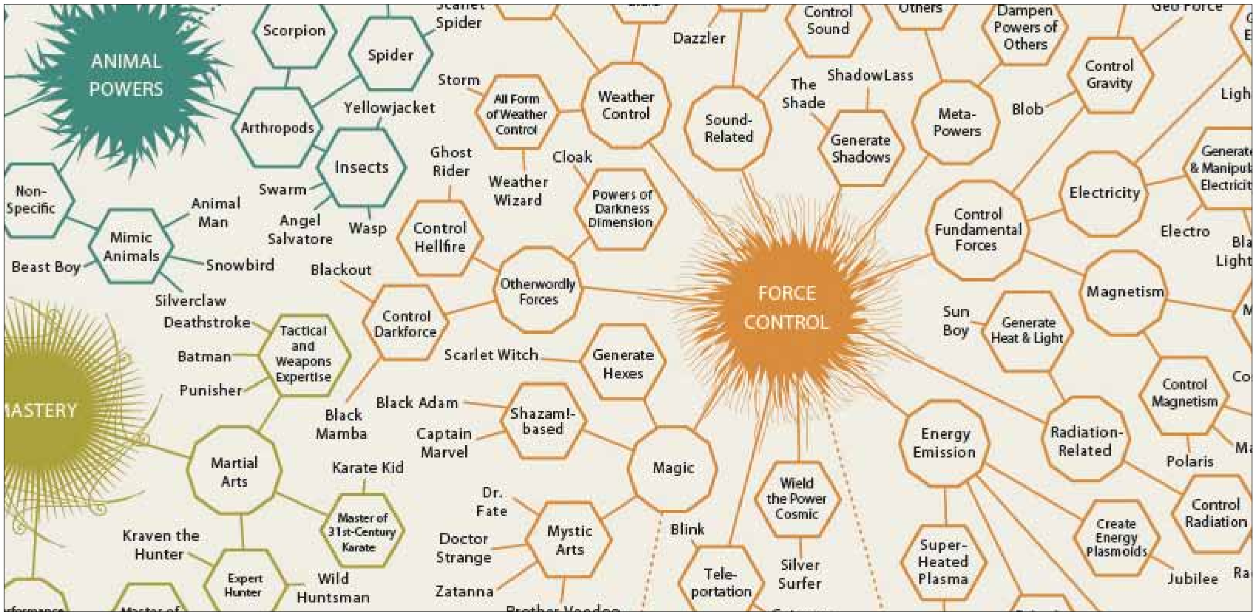
With England and Italy's Euro 2012 quarter final, I've decided to look at the successful conversion rates of penalties taken by the 2 squads.



SOURCE:

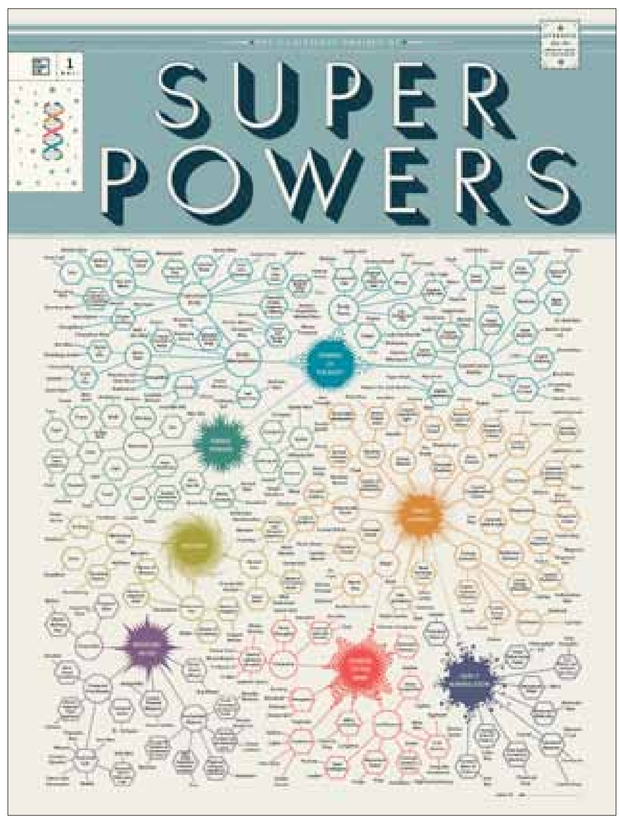
"England vs. Italy Penalty Infographic." *Daily Slandered*, 24 June, 2012, http://www.dailyslandered.com/2012/06/england-vs-italy-penalty-infographic/ (2 July 2012).

SUPER POWERS 1308 x 1734



DESCRIPTION:

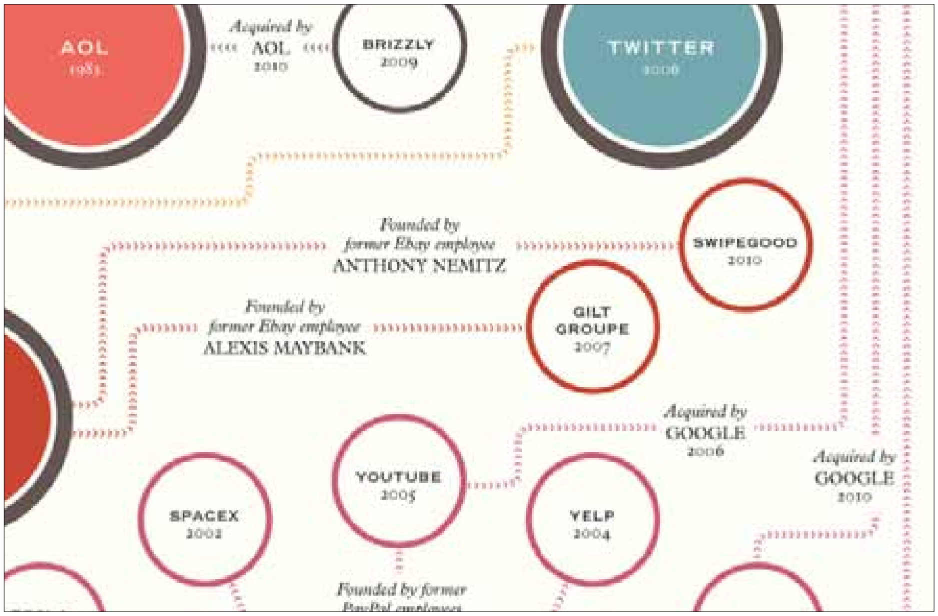
Super powers of over 300 heroes, anti-heros, villains, and beasts. Face front, True Believer.

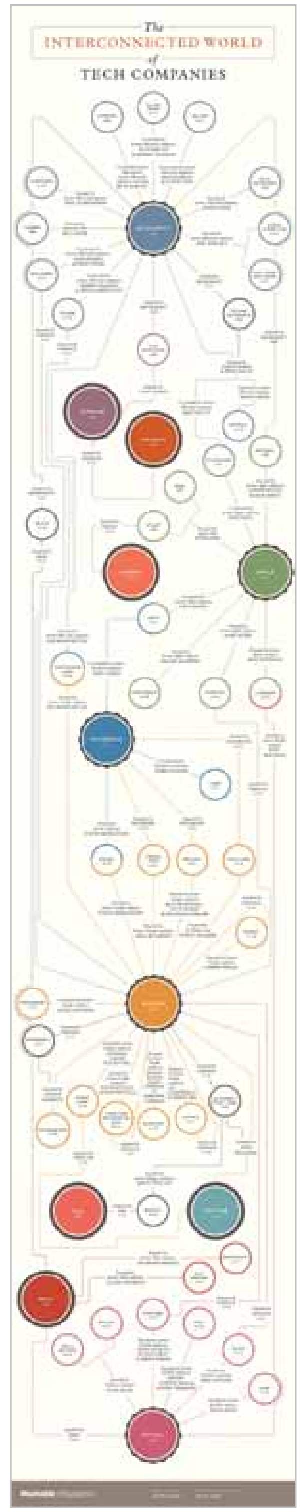


SOURCE:

Darell, Richard. "Superpowers Mega Chart: They Are ALL Here." *Bit Rebels*, August 2011, http://www.bitrebels.com/geek/superpowers-mega-chart-they-are-all-here/ (2 July 2012).

TECH COMPANIES 972 x 5125





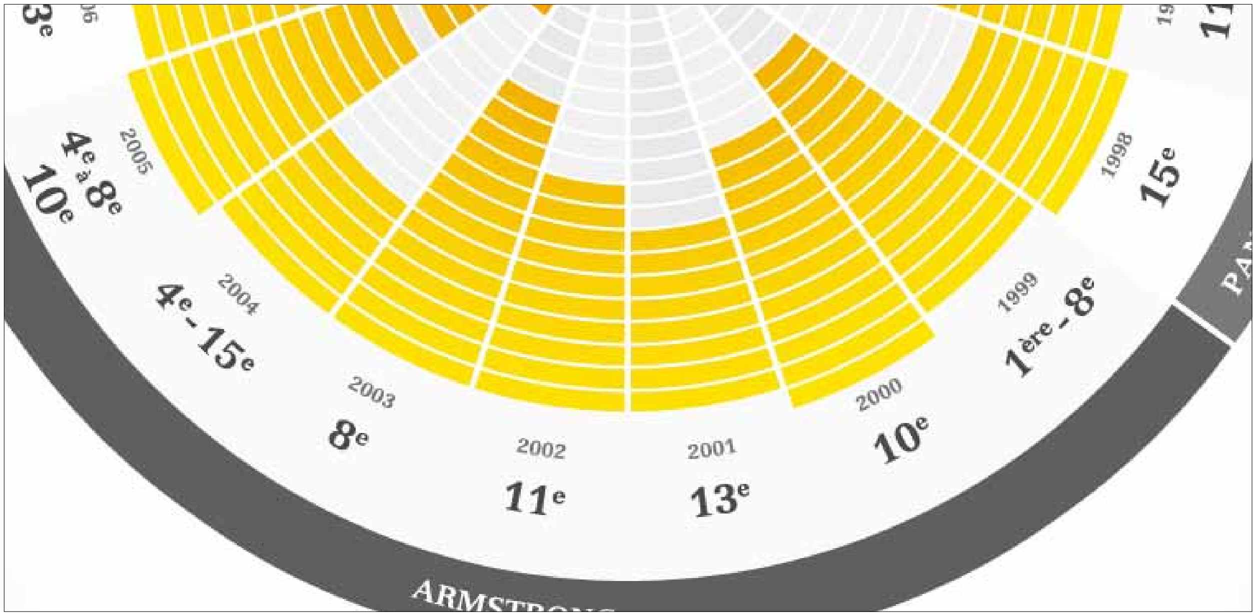
DESCRIPTION:

Between digital giants' appetites for acquisitions and the tendency of their ex-employees to start new companies, it's easy to see how nearly every blip in the ecosystem is closely related. We've mapped just a few of these family ties between "Xooglers," the "PayPal Mafia", "Softies" and the many other tech connectors who have yet to be nicknamed.

SOURCE:

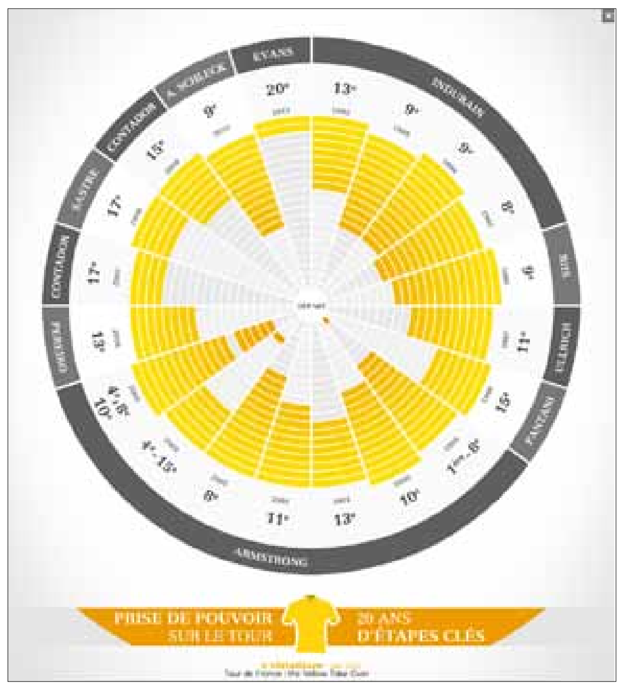
Kessler, Sarah and Sigler, Nick. "The Interconnected World of Tech Companies [Inforgraphic]." *Mashable Tech*, 19 July 2011, http://mashable.com/2011/07/19/tech-companies-infographic/ (2 July 2012).

TOUR DE FRANCE WINNERS 1024 x 1136



DESCRIPTION:

This data shows the take-over of future winner for each edition of the Tour de France. (the days where leader endorsed the famous yellow jersey)



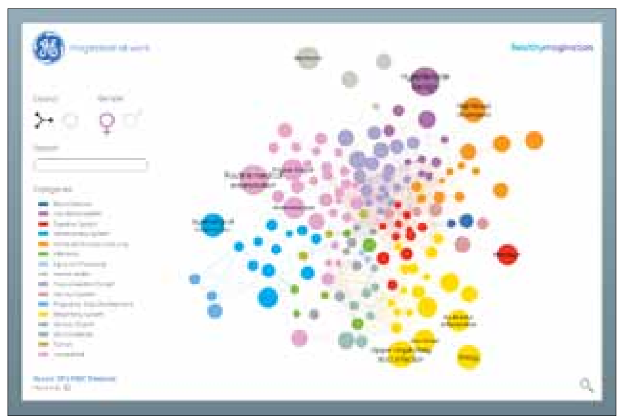
SOURCE:

Vistadium, "Tour de France: 20 ans de conquêt du maillot jaune." *Vistadium*, 29 June 2012, http://www.vistadium.com/2012/06/29/tour-de-france-20-ans-de-conquete-du-maillot-jaune/ (3 July 2012).

RELATIONSHIP BETWEEN AILMENTS 1068 x 710 (INTERACTIVE)

DESCRIPTION:

The information used for this visualization is based on 7.2 million patient records from GE's proprietary database, and represents some of the conditions that commonly affect Americans today. By investigating how different ailments are related, one may gain various insights about condition associations. The numbers and percentages are meant to represent general trends. Looking at the data in new ways like this can help us understand health and gain new insights about how to take better care of ourselves and the healthcare system.



SOURCE:

Baczuk, Eric and Chen, Xiaoji and Dahlem, Dominik. "Health InfoScape." *GE Data Visualization*, 2012, http://visualization.geblogs.com/visualization/network/ (3 July 2012).

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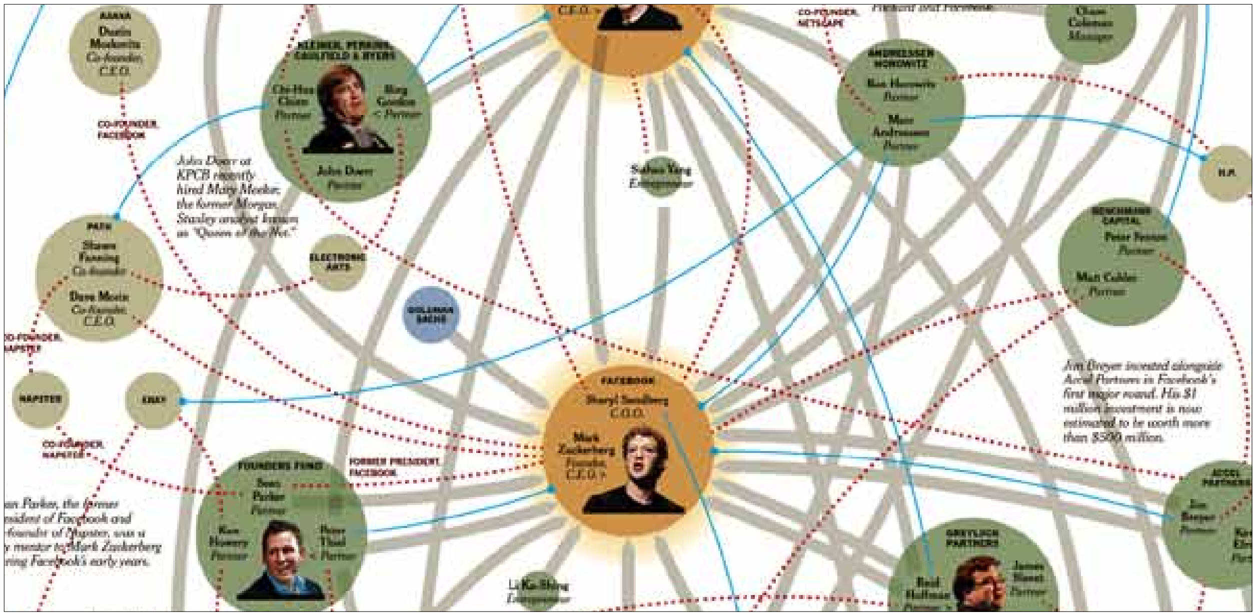
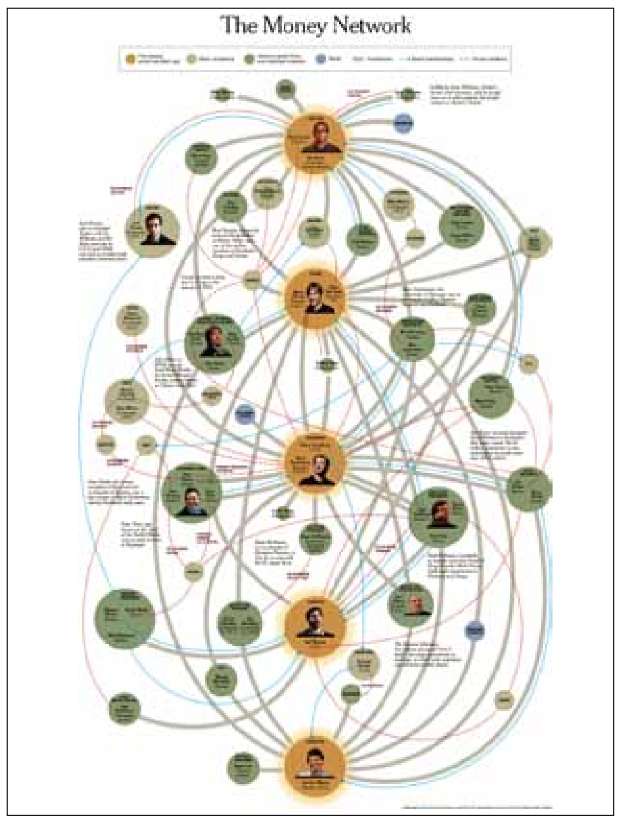
MONEY NETWORK 1405 x 2352



DESCRIPTION:

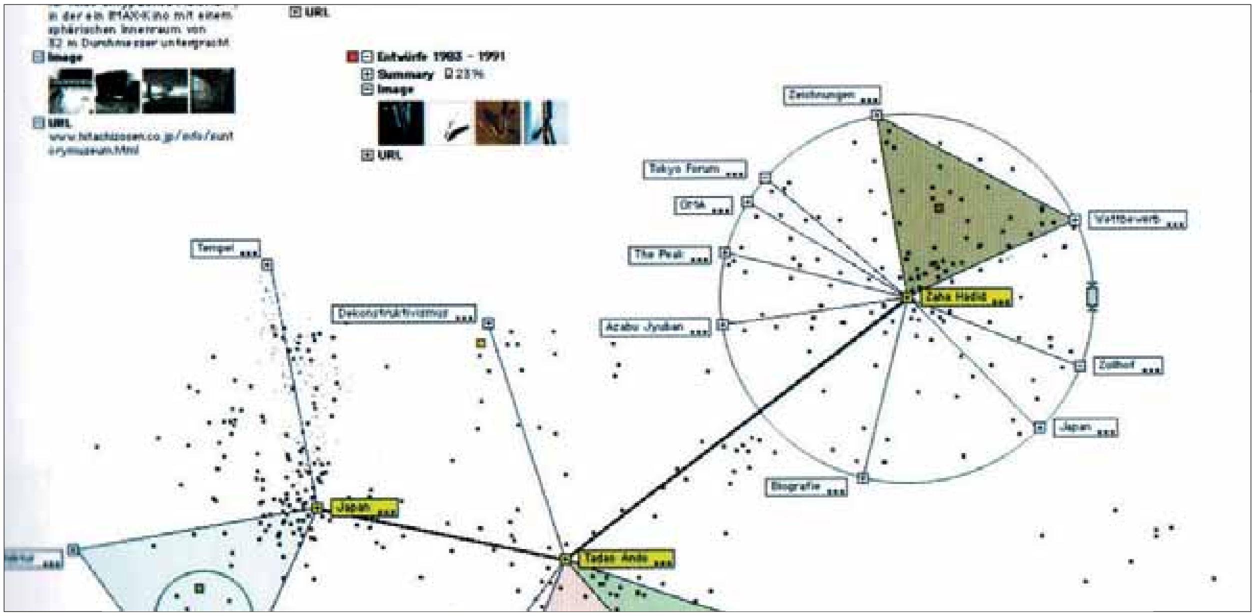
Facebook, Zynga, Groupon, Twitter and LinkedIn have come to define the social Web. The club of technology insiders is a deeply connected, interdependent network, with many players overlapping at one time or another on the same investments, boards and payrolls. This shows the relationship and position of the people involved.



SOURCE:

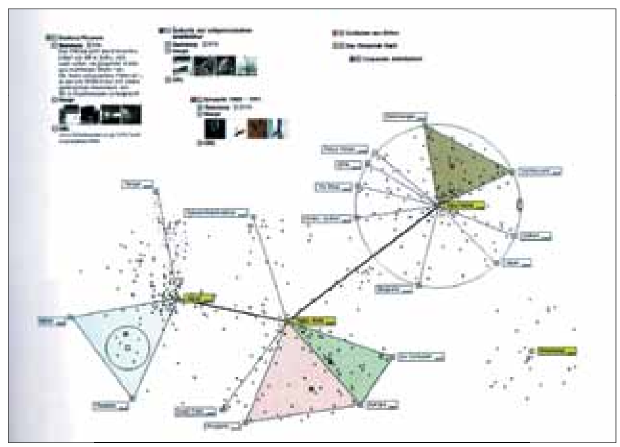
Gates, Guilbert and Rusli, Evelyn. "The Money Network." *Dealb%k, New York Times*, 7 April 2011, http://dealbook.nytimes.com/2011/04/07/the-money-network/ (3 July 2012).

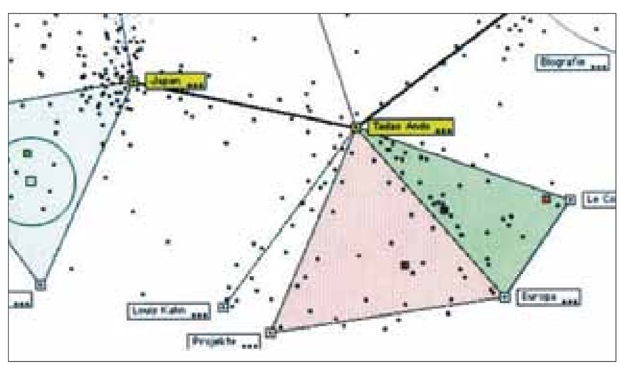
KRYPTHASTHESIE



The results appear not as a list but as as data clouds in the form of points in a circle around the central search word. If you search for information about Japan, for example, all the available information on that country appears as points distributed in a circle. A dynamic data map is created on the surface which permits a geographical orientation.

The points closest to the search word contain a lot of information about Japan and the more distant ones less. If a second word - museums - is entered at the edge of the circle the points rearrange themselves dynamically. They move towards the word to which they are most closely related. The user can now look at a point in more detail that is close to the word "museums" but relatively far from "Japan". The information revealed when one clicks on the point turns out to be a museum of ethnology with Japanese exhibits.

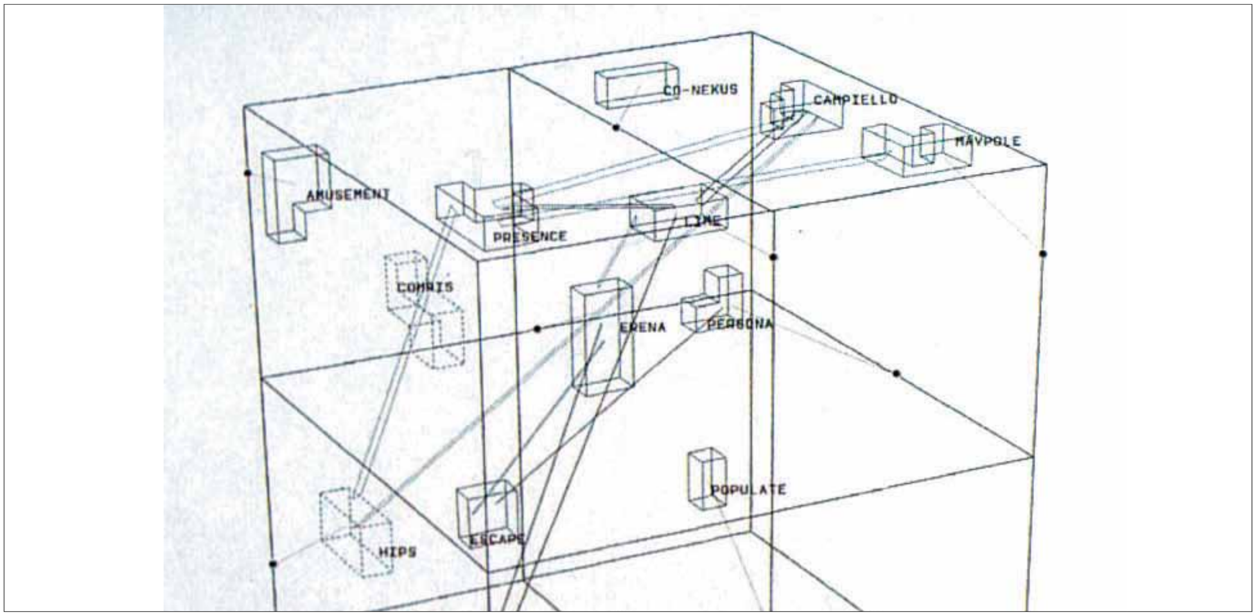




SOURCE:

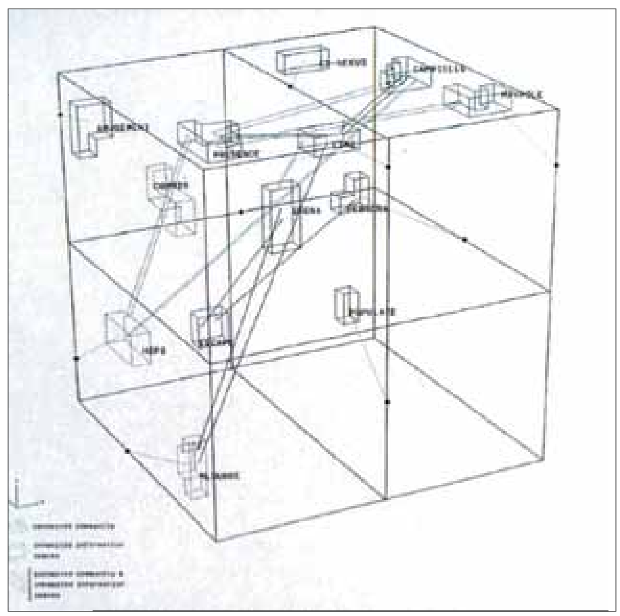
Fawcett-Tang, Roger. *Mapping Graphic Navigational Systems*, Rockport Publishers: 2008.

I3 MAP



DESCRIPTION:

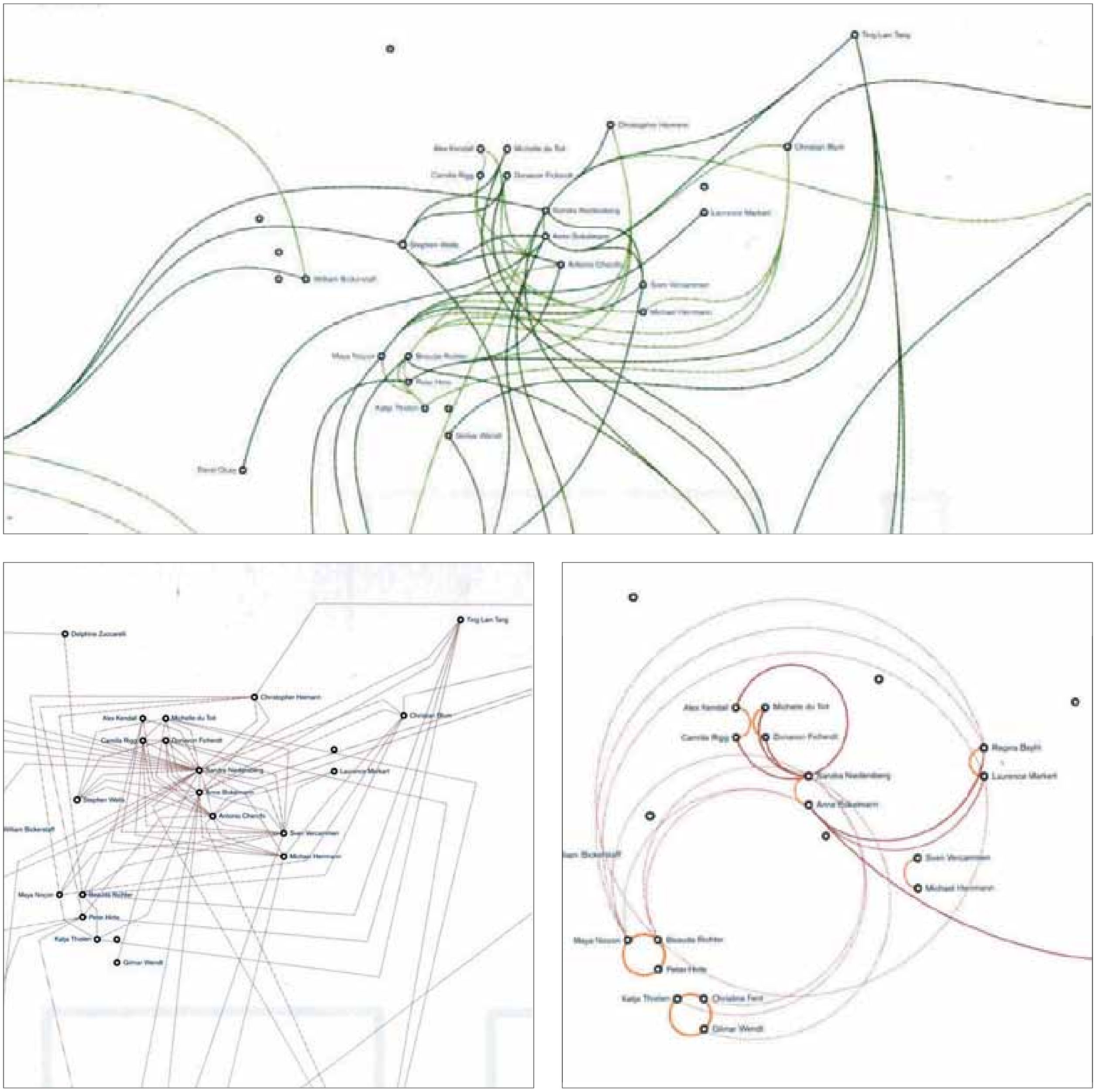
I3 is a design program of the European Union involved in research into intelligent information interfaces. As a contribution to the design publication IF/THEN, design company Lust designed a map which showed the relationships between the projects of the 71 institutions involved with I3. It was important to show which project was associated with which other project, whether geographically or conceptually. To map the spatial relationships between the institutions, a cube representing the world was used which was the deconstructed to reveal the existing and virtual connections of the corresponding projects. The map, although certainly informative in nature, also reveals the "virtual" or "experimental" aspect of each project. As well as hinting at the name of the program, the choice of the cube was also a conceptual necessity since it afforded multiple geometries in which to visualize the connections. This map was designed by Lust for the Werkplaats Typografie, Arnhem, Holland.



SOURCE:

Fawcett-Tang, Robert, and William Owen. *Mapping: An Illustrated Guide to Graphic Navigational Systems*. Rockport Publishers, 2002.

LONDON CONNECTIONS



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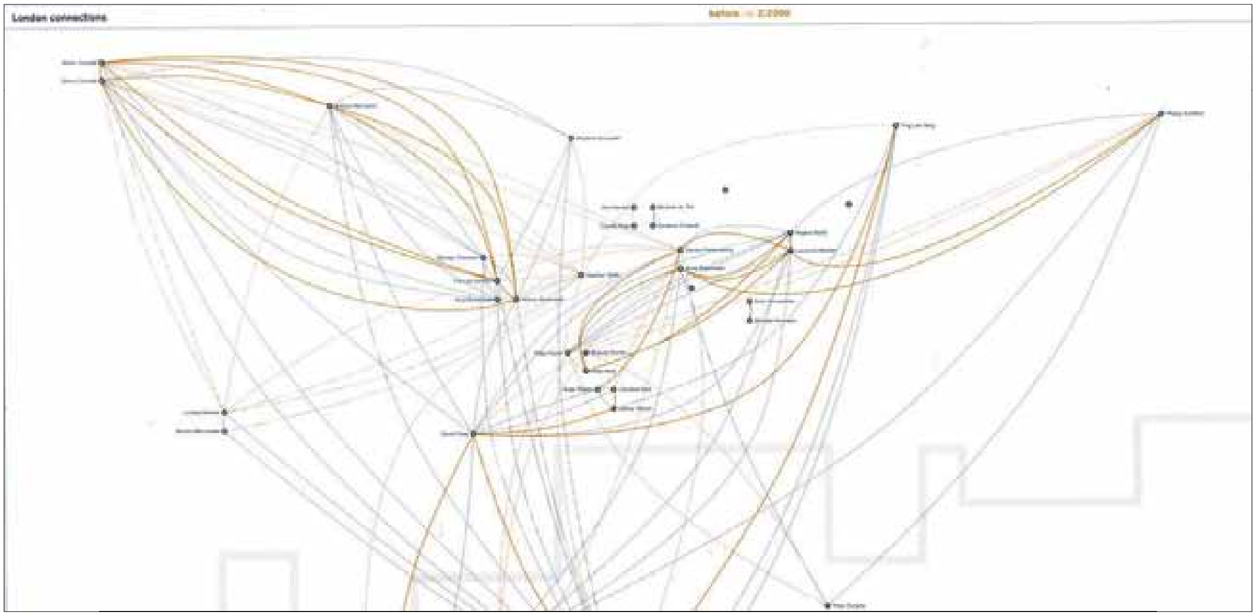
LONDON CONNECTIONS



DESCRIPTION:

The "six degrees of separation" theory claims that any two people are connected to each other through a maximum of six friends or associates - assuming that everyone knows a hundred people and those hundred people each know another hundred. In this way six connections are enough for the six billion people living on the earth.

Using this information as an inspiration, Sandra Niedersberg mapped and analyzed the way she made friends and acquaintances over a five-month period after moving from Germany to London. The research was extended to include interviews with each contact which formed a book. With the information amassed she also created a series of A2 maps printed onto translucent paper allowing the different levels to be over-laid to show further associations.

Each map uses the geography of London as its framework, reduced to a symbolic representation of the river Thames. Each person is represented by a dot and their name, the position of which corresponds to where they live. All the co-ordinate dots appear on every map, but a person's name only appears if they have a connection on that particular map. Each map shows different statistics for different situations, such as living, home, work, institutions, school, meeting points and so on, with colour coding used to reveal further levels of information.

SOURCE:

Fawcett-Tang, Robert, and William Owen. *Mapping: An Illustrated Guide to Graphic Navigational Systems*. Rockport Publishers, 2002.

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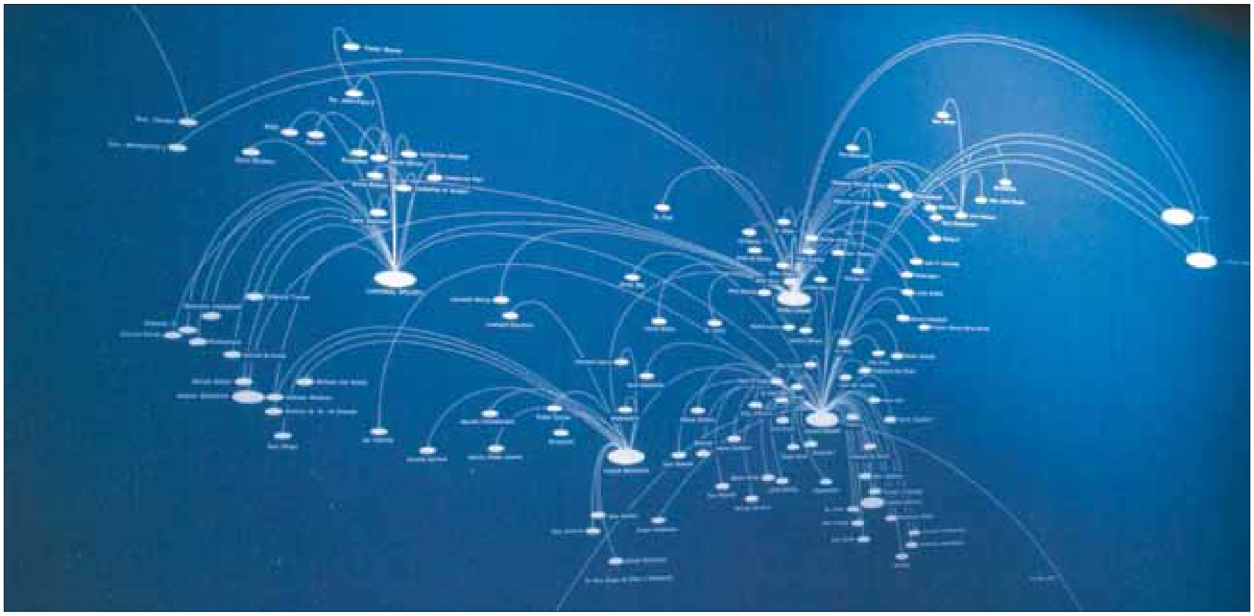
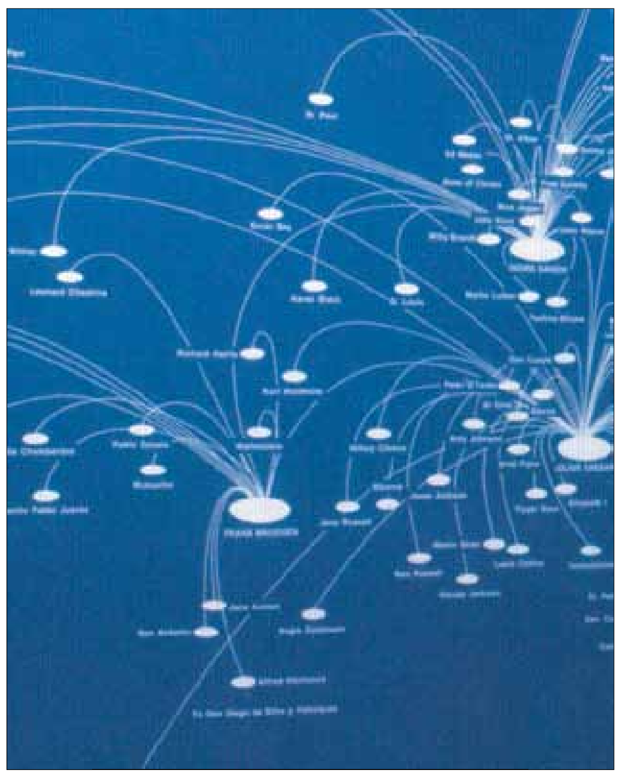
J.P. 232 IN C.S.O. BLUE



DESCRIPTION:

"The artist Simon Patterson, a finalist for the Turner Prize, the UK's leading award for modern art, has worked extensively with the process of reinterpreting existing information systems. Shown here is a work by the artist which utilizes maps and navigation/ information systems.

"J.P. 233 in C.S.O. Blue" is a large wall drawing which takes as its reference a global airline route map, using large sweeping arcs to represent the journeys between countries, which are implied by their relative positions rather than a delineation of boundaries. The destination names are replaced with seemingly unrelated famous people, from Julius Caesar, Elizabeth I, Pope John Paul II and Mussolini to actors William Shatner, Helen Mirren, Leonard Nimoy and Peter Falk."



SOURCE:

Fawcett-Tang, Robert, and William Owen. *Mapping: An Illustrated Guide to Graphic Navigational Systems*. Rockport Publishers, 2002.

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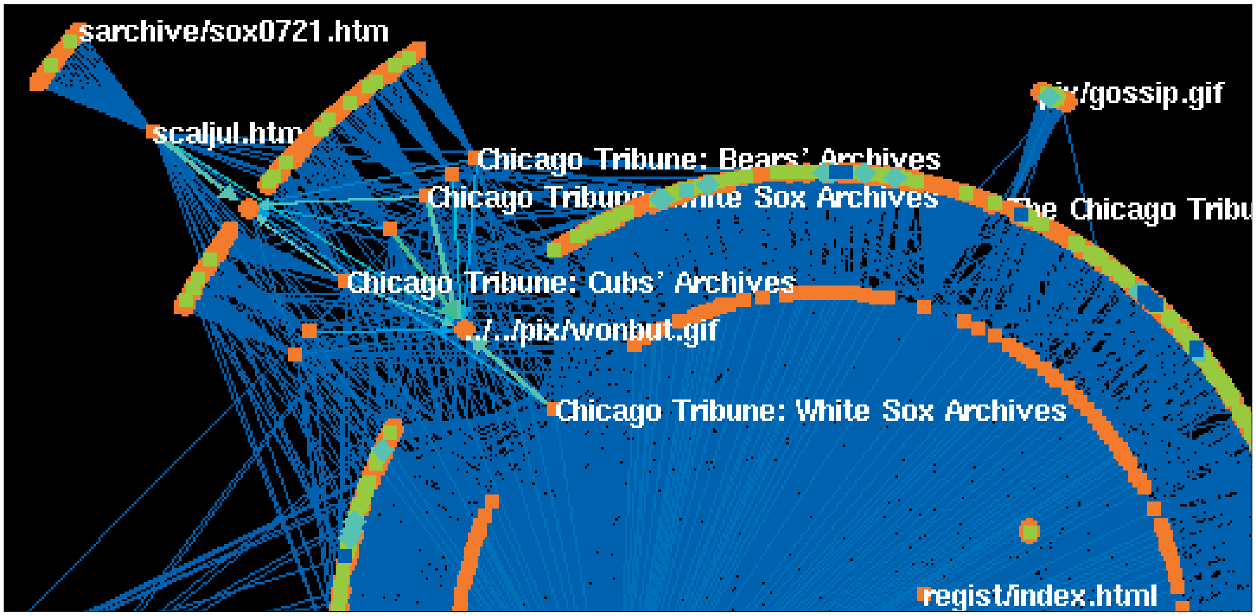
THE CHICAGO TRIBUNE WEBSITE

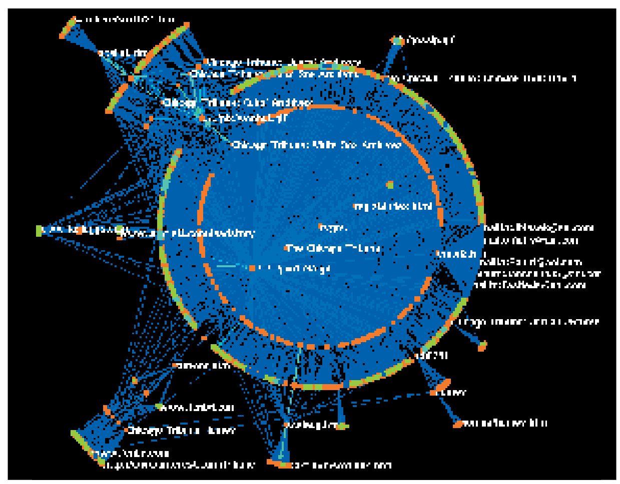


DESCRIPTION:

The Chicago Tribune is one of the two big Chicago papers, and as such is a good example of an organized, commercially- oriented website. The site made its data available for exploration, and has been downloaded and explored using NicheWorks in the EDV environment. The goal of the analysis was to understand the structure of the site and see what desing criteria had been used in its production.

"We have set both color and shape of the nodes to reflect the node type and status as returned from MOMspider. The coding is:

- Orange squares: Local pages
- Orange circles: Local images
- Blue squares: Off-site pages
- Yellow squares: CGI queries
- Light-blue: Avoided



Links are colored on with brighter hues indicating more links from one URL to another. Some key URLs have been interactively labelled."

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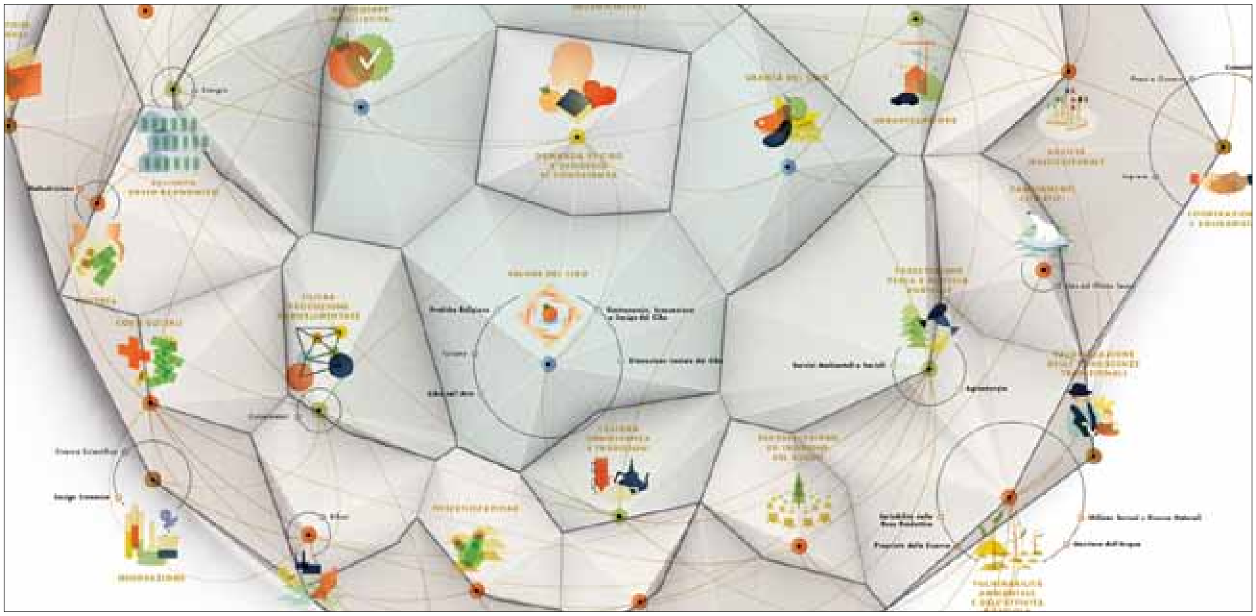
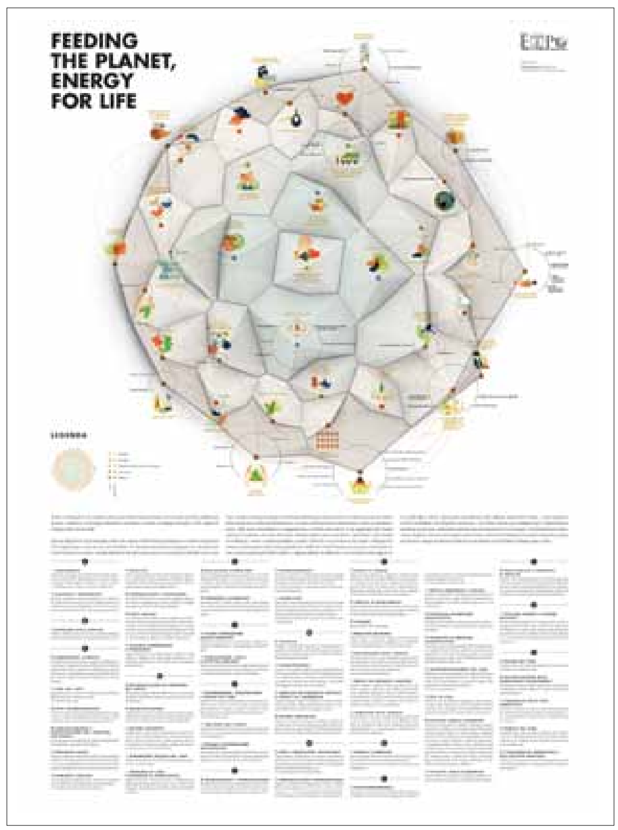
SOCIAL CIRCLES 2011 x 2736



DESCRIPTION:

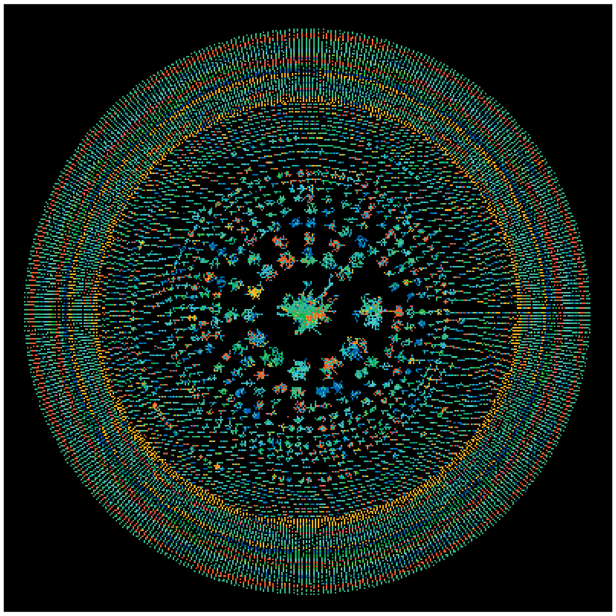
Expo 2015 S.p.A. asked DensityDesign to work on the Expo themes and generate a visualization able to communicate the complexity stemming from the relationship between food production and consumption; social and environmental concerns; technological and sustainability issues.

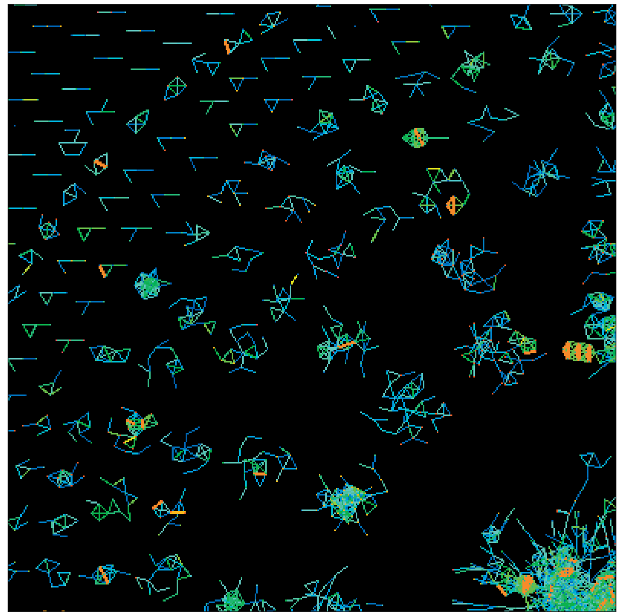


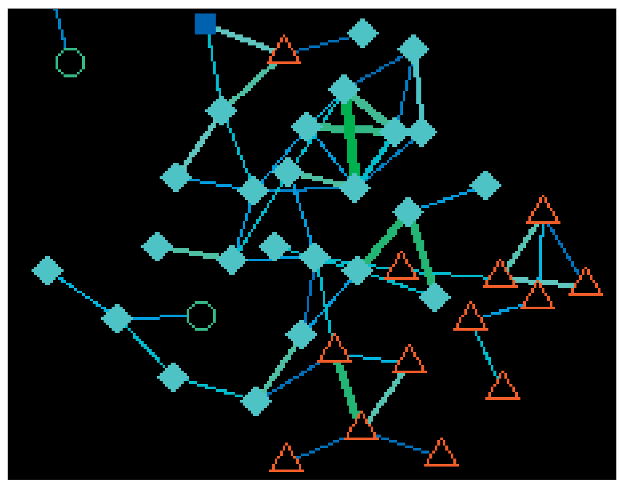
SOURCE:

DensityDesign, "EXPO 2015 themes visualization." *Visualizations*, 16 September 2011, http://www.visualizing.org/visualizations/expo-2015-themes-visualization (3 July 2012).

DYV STORE RECEIPTS







DESCRIPTION:

A set of 10 million receipts from a large DIY store were processed so as to link together items that often appear on the same receipt. The resultant network of 40K nodes and many links has several important variables associated with the nodes; price, discount, volume, department.

“In this example we’re examining over 1.8 million receipts taken from a set of hardware stores over a week. For each item sold we have information on its cost, department and class. Each receipt stated what was bought, how many and what was the price. Discount information was also present.

I took this data and constructed a Nicheworks data set by relating items together based on their probability of appearing on the same receipt. I discounted any links with probability factor of under 0.05. The placement algorithm in Nicheworks then grouped the items into component clusters and placed them in a layout that places items close to other items they are often bought with.”

SOURCE:

Wills, Graham J. “DIY Store Receipts.” *Visual Complexity*, http://www.visualcomplexity.com/vc/project.cfm?id=14 .

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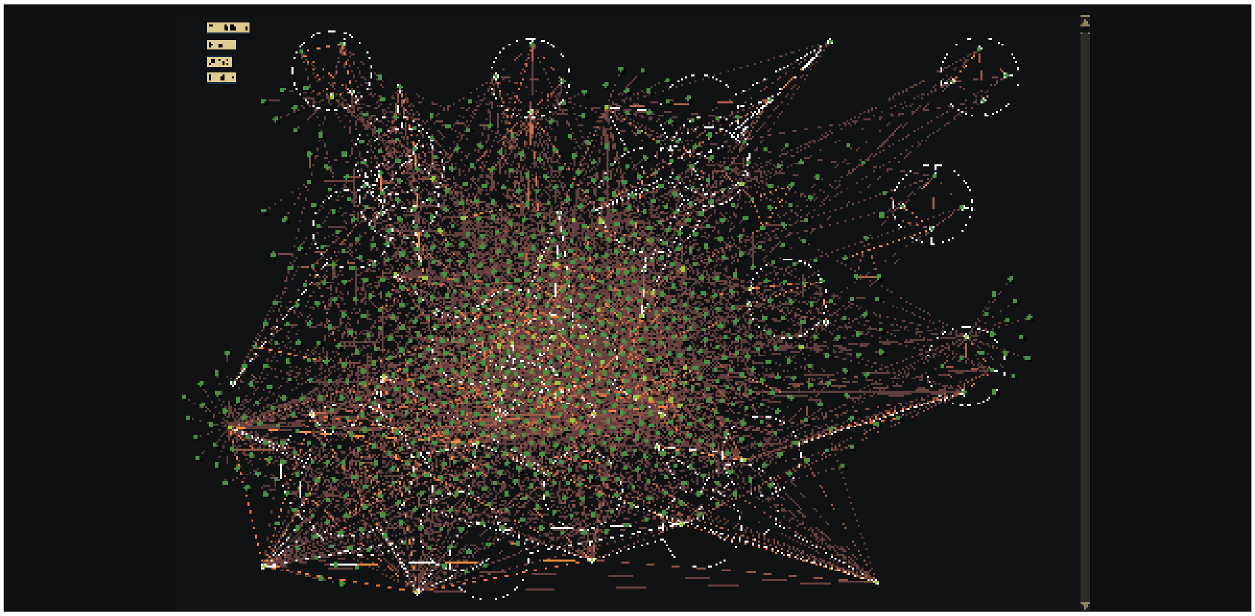
TRACE ENCOUNTERS



DESCRIPTION:

"TraceEncounters is a social network tracking and visualization project. It was debuted September 3 in Linz, Austria at the 2004 Ars Electronica festival. White circles now connect cliques of size greater than 3 when you click the "Find cliques" button. (This image is the result of a lot of tinkering: double click nodes in cliques and pull them away from the center to disambiguate overlapping cliques.)

The brighter links mean more encounters between the two people involved, and the're also the strongest springs, so it's possible to extract cliques by pulling out one or more of the people involved in the clique. (Often the greenest ones—the people having the most connections to other people regardless of the number of conversations—are the best to pull on; they're intentionally the easiest to pick when several nodes are nearby.

The project distributed aproximately 900 small stickpins, each of which uses limited-rage infrared data exchange to remember every other pin that it encounters. When pin wearers came to a central location to view the accreting network, they saw a thousand circles on a plasma display panel, each representing a pin. The plasma panel had its own special pin, connected to the computer that generated the image, so it could tell who's viewing and light up that person's circle. The pin also downloaded all of the saved encounters from the viewer's pin, (highlighting these new links in red and the old ones in yellow) and a drew a simple straight line to all the other circles representing the other pins this viewer encountered. As the database got richer, so did the visualization. We started with a mechanical-looking, trivial visualization and updated it several times during the show. Viewers could see well-interconnected subgroups (several of size two, three, and four; one large one of ten or so) and pull them away from the rest (the plasma panel was also a touchscreen), to disentangle them from the Ars community as a whole and see how connected they were to the rest of those wearing pins."

SOURCE:

Han, Jeff and Paley, W. Bradford. "Trace Encounters." *Visual Complexity*, http://www.visualcomplexity.com/vc/project.cfm?id=60 .

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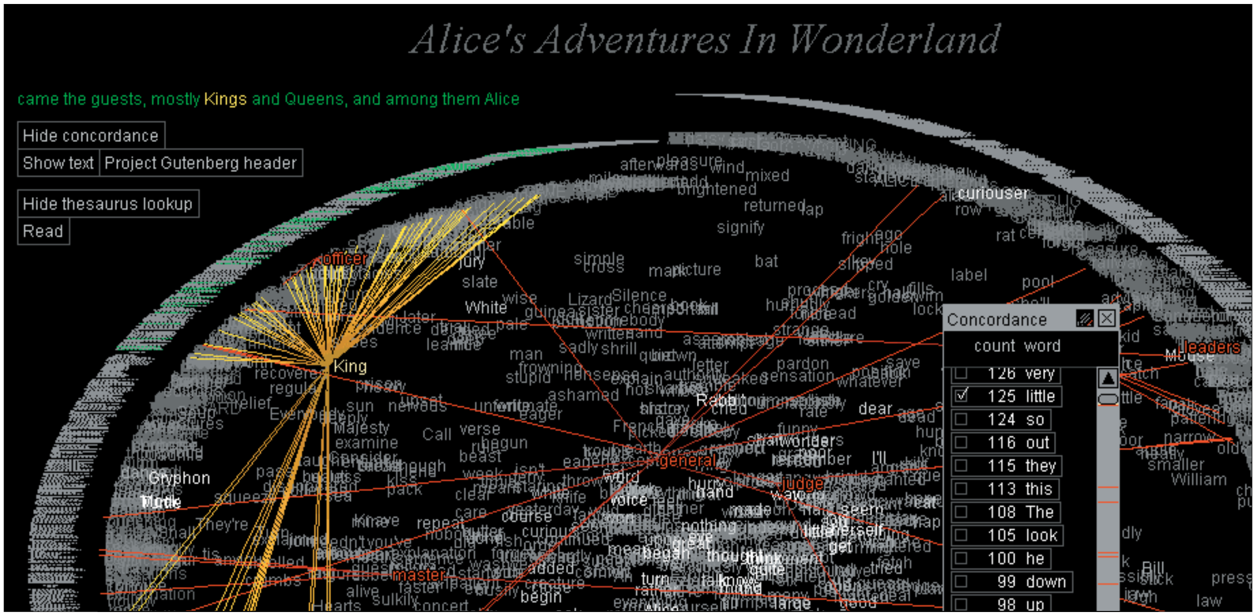
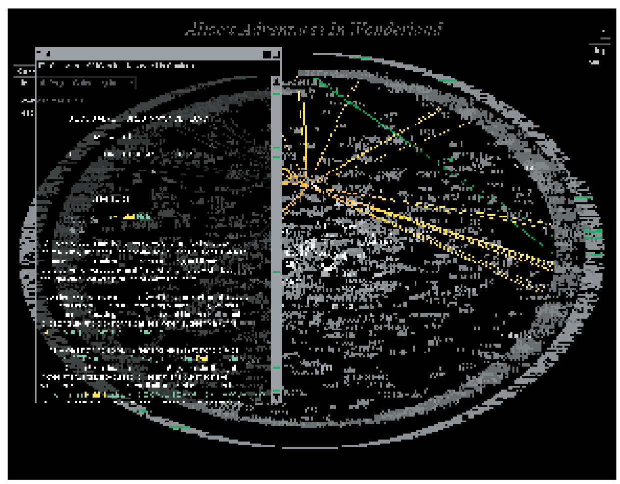
TEXTARC



DESCRIPTION:



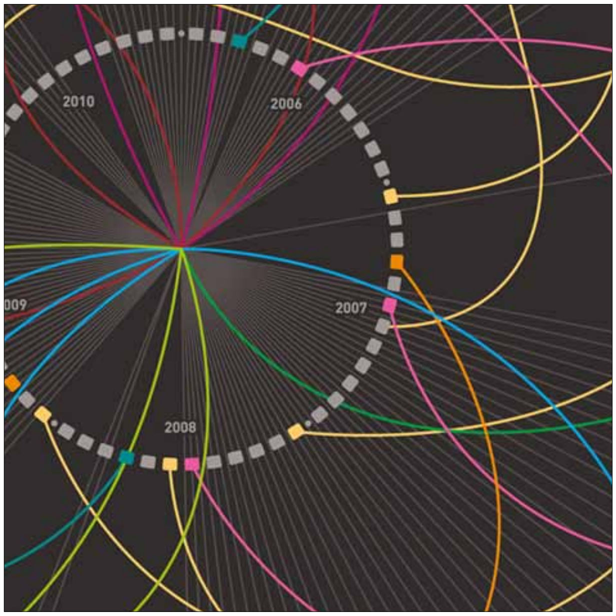
"TextArc: Revealing Word Associations, Distribution and Frequency. TextArc is a tool designed to help people discover patterns and concepts in any text by leveraging a powerful, underused resource: human visual processing. It compliments approaches such as Statistical Natural Language Processing and Computational Linguistics by providing an overview, letting intuition help extract meaning from an unread text. Here, an analysis of Lewis Carroll's Alice in Wonderland demonstrates TextArc's structure and some capabilities.

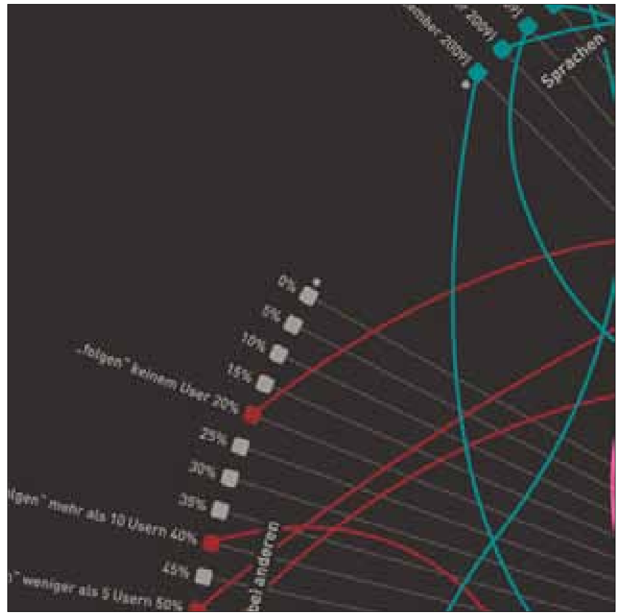
TextArc represents the entire text as two concentric spirals on the screen: each line is drawn in a tiny (one pixel tall) font around the outside, starting at the top; then each word is drawn in a more readable size. Important typographic features, like the mouse-tail shape of a poem at about two o'clock, can be seen because the tiny lines retain their formatting. Frequently used words stand out from the background more intensely."

SOURCE:

Paley, W. Bradford. "TextArc." *TextArc*, http://www.textarc.org/ .

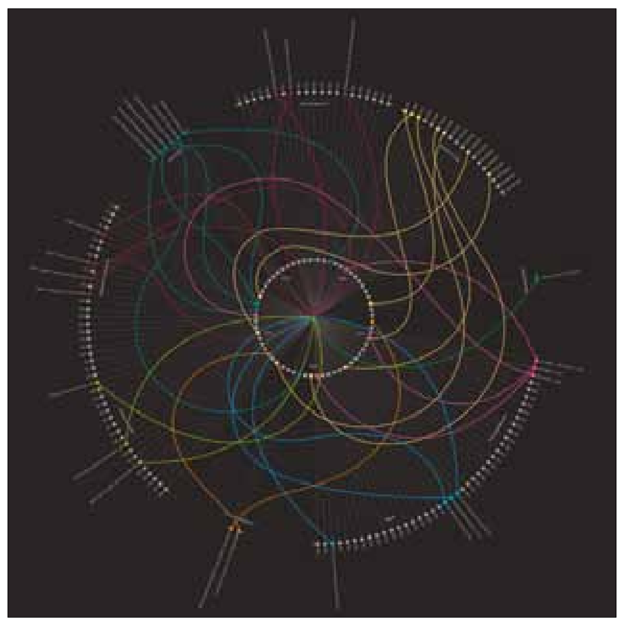
TWITTER ANALYSIS 600 x 600





DESCRIPTION:

"I visualized different facts of Twitter in (for example) relation to the time, when it "happended". There are also relations within the 9 subjects on Twitter I chose (marked in different colors). The visualization itself is pretty simple. 9 subjects (on the outside circle) with their inner theme (e.g. percents, numbers, ...) relating to the inner circle, which works as timeline, as long as the facts were available."



SOURCE:

Stirner, Melanie. "Twitter Infographic." *Melanie Stirner*, 17 October 2010, http://www.behance.net/gallery/Twitter-Infographic/758372 (26 June 2012).

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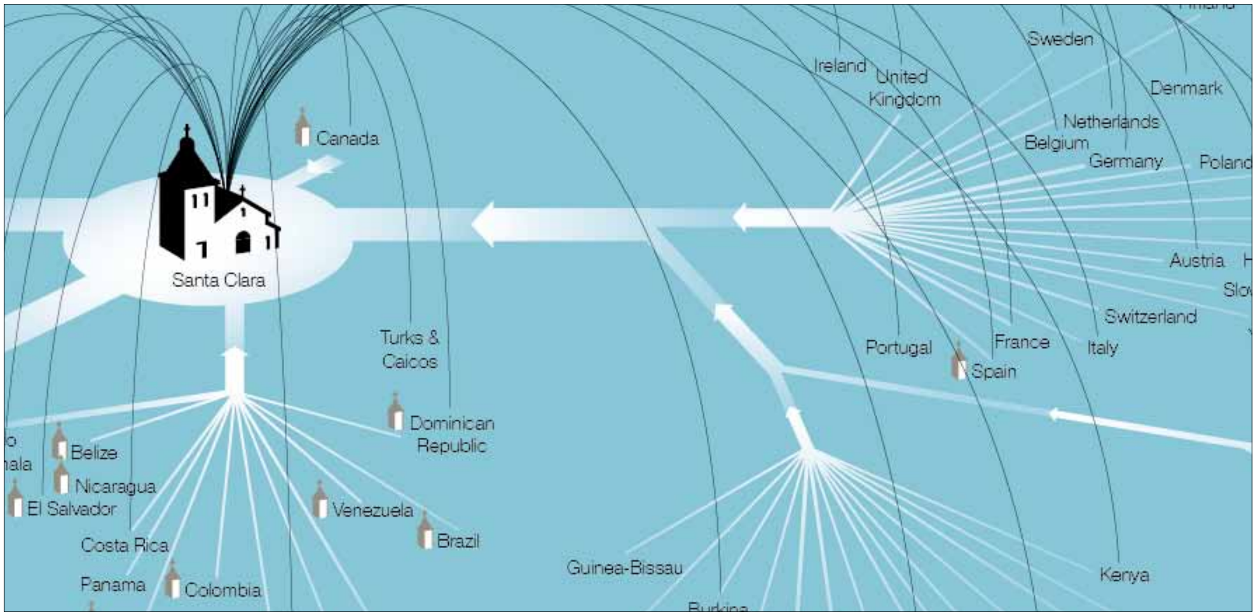
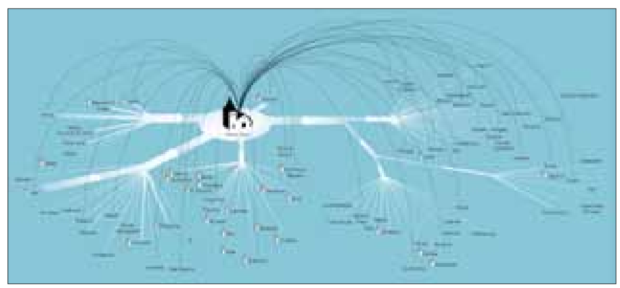
STUDENTS ABROAD 1756 x 795



DESCRIPTION:

The spread featured here highlights SCU's global reach, showing the inflow of international students who study at the university and the outward reach of students who leave to study abroad during their time at SCU. A third layer of global connectivity shows the affiliated Jesuit institutions scattered across the world.



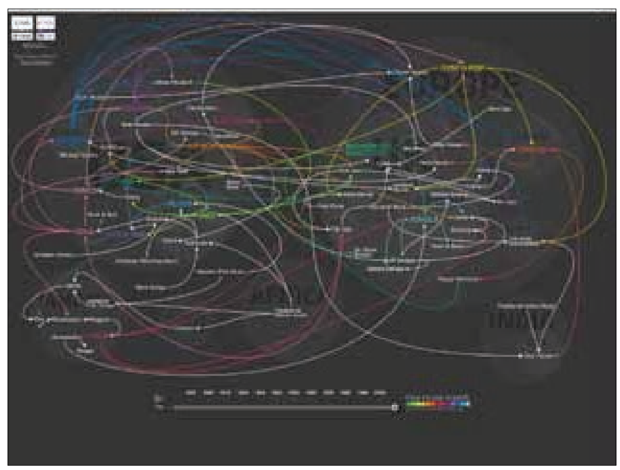
SOURCE:

Jacobsen, Erik. "Global Connections." *Three Story Studio*, 2012, http://blog.threestory.com/wordpress/2012/global-connections (28 June 2012).

WESTERN DANCE MUSIC EVOLUTION INTERACTIVE

DESCRIPTION:

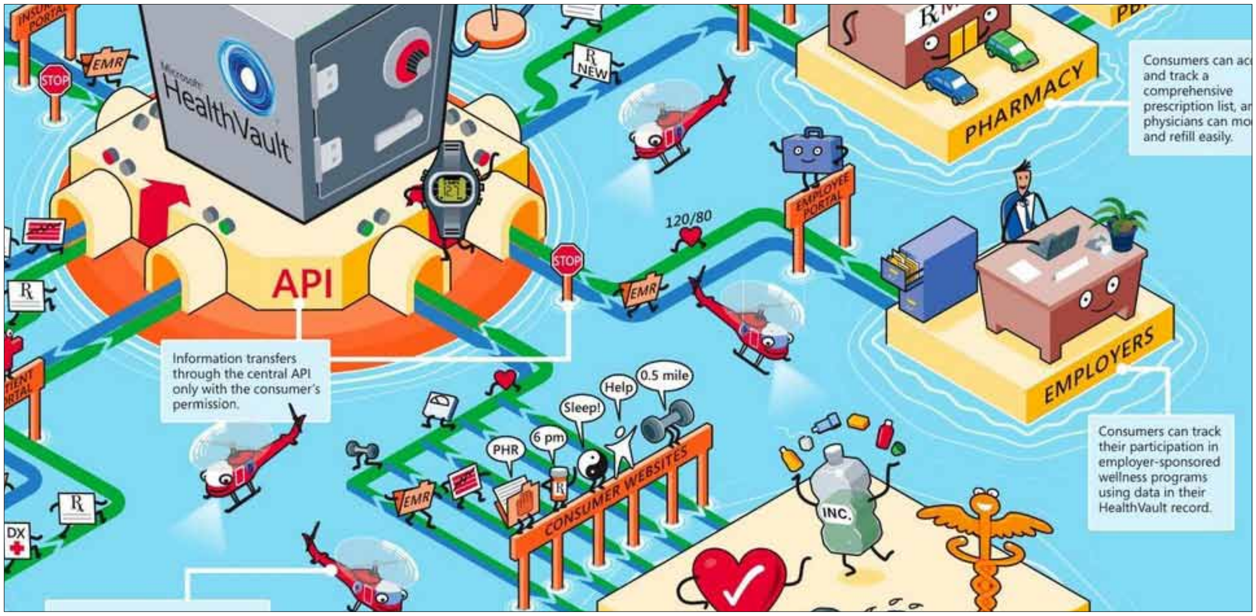
The evolution of western dance music is observed and presented through this interactive by following various paths of inspiration for each type over time.



SOURCE:

HTML5 Infographics, "The Evolution of Western Dance Music." *HTML5 Infographics: Showcase of the Latest and Greatest Interactive Infographics*, 2012, http://html5infographics.com/the-evolution-of-western-dance-music/ (28 June 2012).

HEALTH VAULT 1600 x 1035



DESCRIPTION:

Microsoft HealthVault is a platform designed to put people in control of their health data. It helps them collect, store and share health information with family members and participating healthcare providers, and it provides people with a choice of third-party applications and devices to help them manage things like fitness, diet, and health.

SOURCE:

"Microsoft HealthVault." *Infographics Depot of Information Graphics*, 2 February 2009, http://infographics.w3ec.com/transport-infographics/microsoft-healthvault (3 July 2012).

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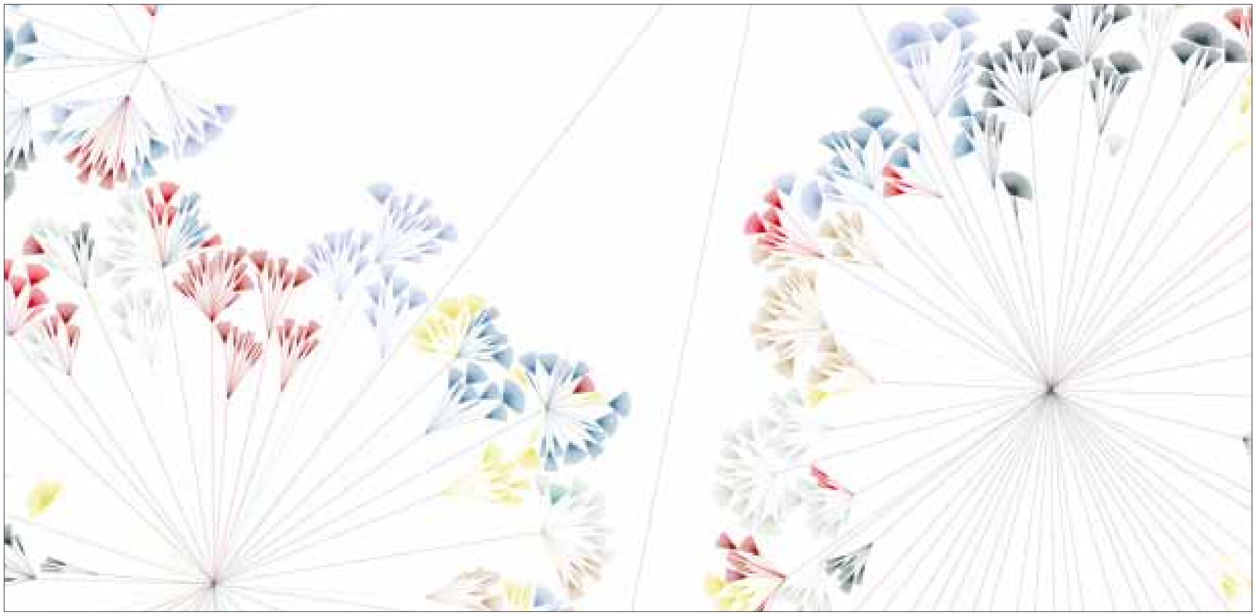
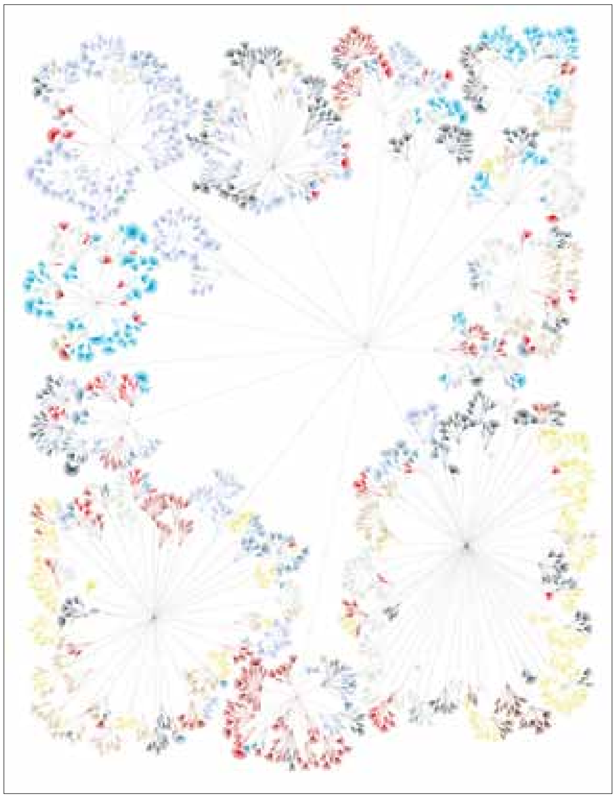
ON THE ROAD 1600 x 1035



DESCRIPTION:

A chart of the structure of part one of Jack Kerouac's On the Road (1957). Each splitting of the branch into progressively smaller sections parallels the organization of the content from chapters to paragraphs, sentences, and words. Each color relates to one of eleven thematic categories created by Posavec for the book (e.g., travel, work and survival, sketches of regional life).



SOURCE:

Popova, Maria. "Writing Without Words: Visualizing Jack Kerouac's On The Road." *Brain Pickings*, 7 May 2009, http://www.brainpickings.org/index.php/2009/05/07/writing-without-words/ (3 July 2012).

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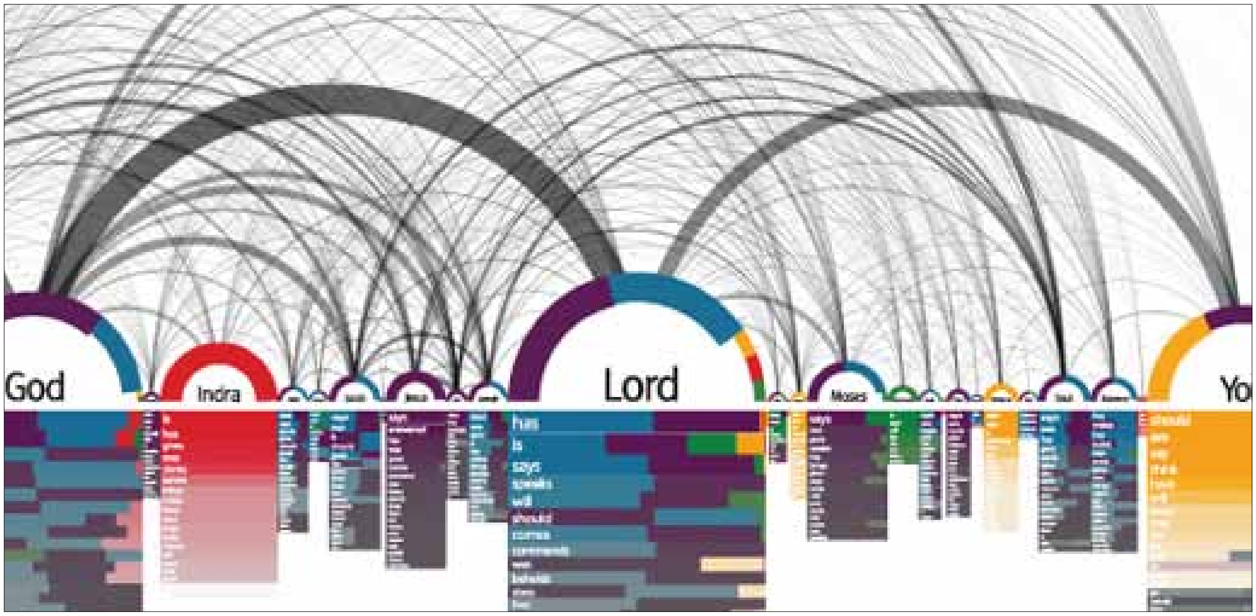
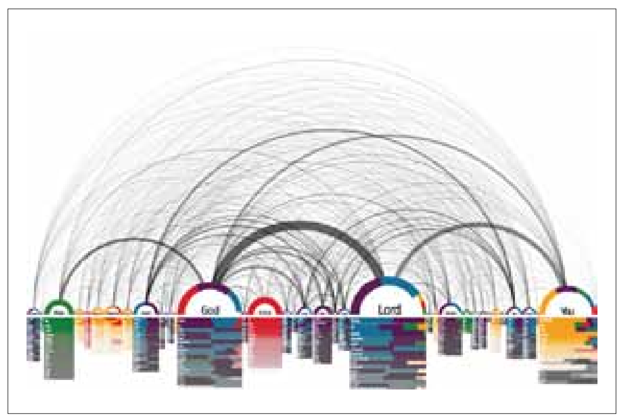
SIMILARITIES OF HOLY BOOKS 800 x 502



DESCRIPTION:

A visualization of the similarities and difference between the holy books of five world religions: Christianity, Islam, Hinduism, Buddhism, and Judaism.

From the sacred meaning of trees and their age-old use as classification systems to the science behind network thinking to the stunning and visually expressive products of cutting-edge digital visualization, Lima – author, designer, and deep thinker – not only explores the multiplicitous allure of networks, but also crafts an important analog artifact to contain these rapidly vanishing digital ephemera. (You know, in case you were wondering why computational creativity should belong in a book.)



SOURCE:

1. Madelyne, Stephia. "The 11 Best Art and Design Books of 2011." *DIY Cultures Collective*, 5 December 2011. http://diycultures.org/tag/art-design-books/ (3 July 2012).
2. Lima, Manuel. *Visual Complexity: Mapping Patterns of Information.* (Princeton Architectural Press, 2011).

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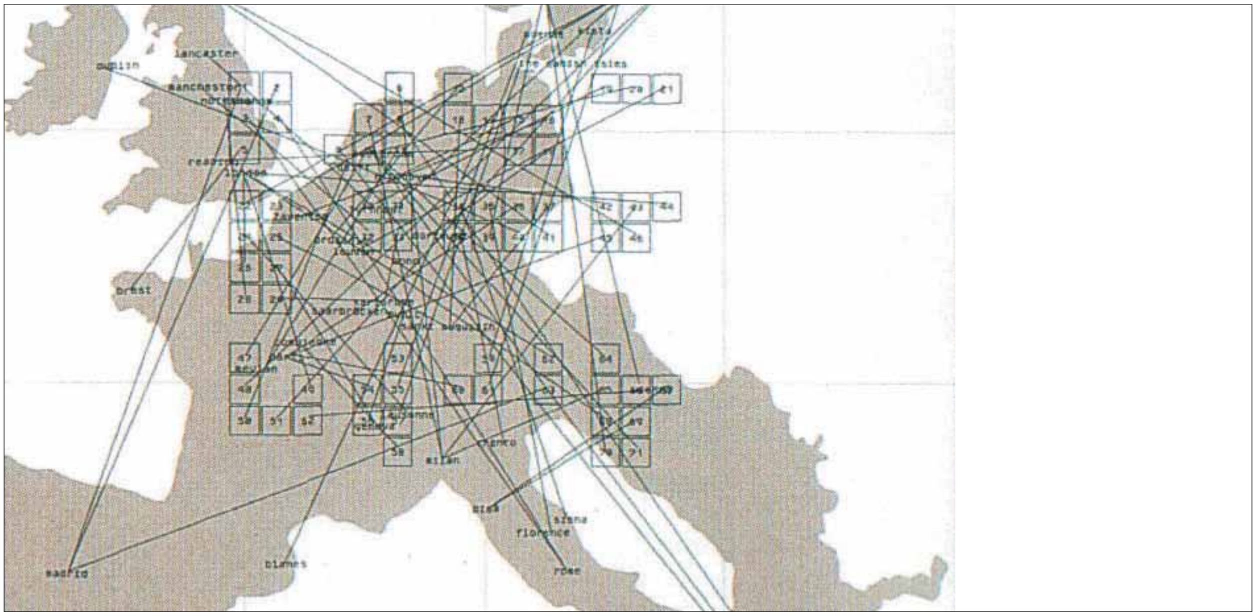
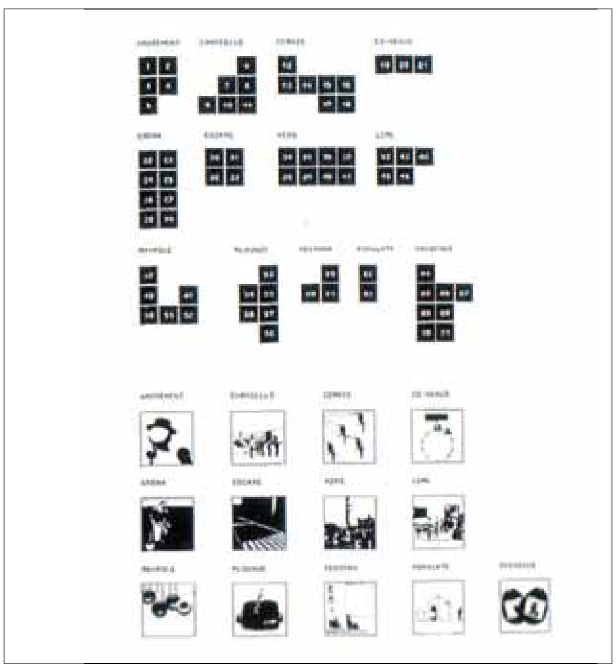
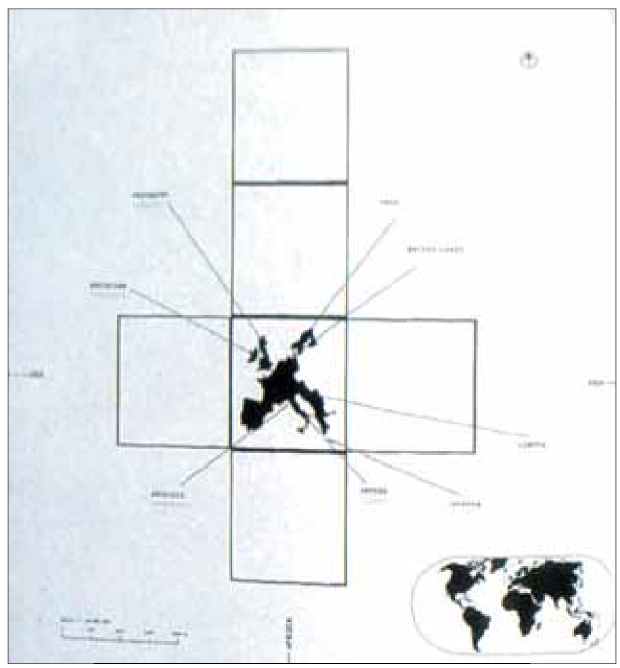
13 MAP

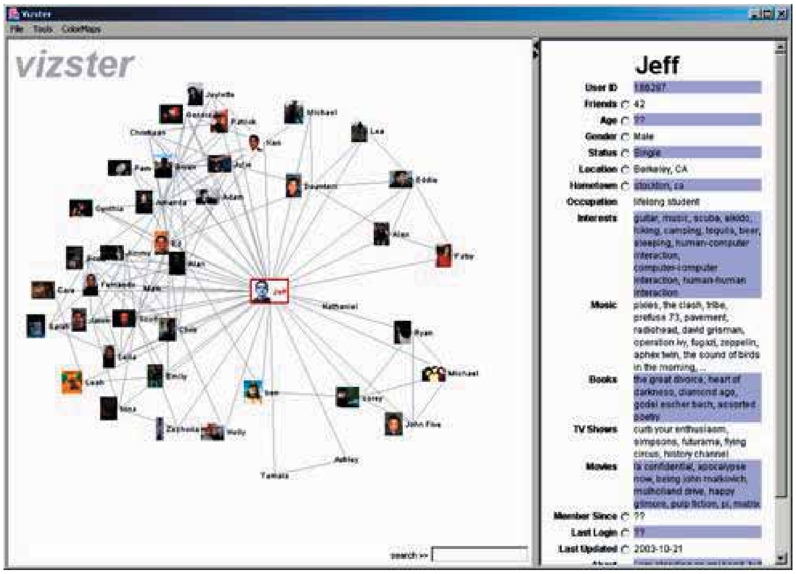






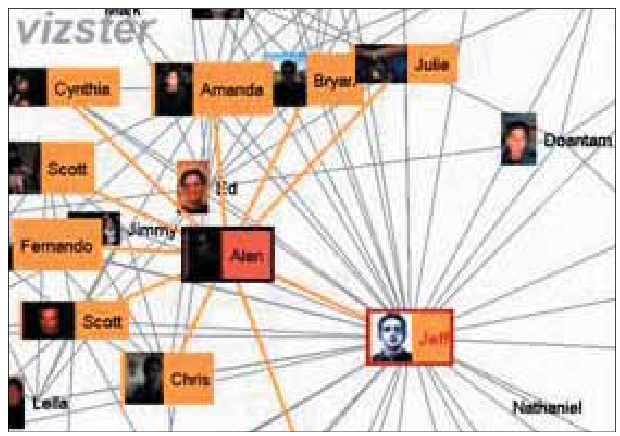
SOURCE:
Fawcett-Tang, Robert, and William Owen. *Mapping: An Illustrated Guide to Graphic Nativational Systems.* Rockport Publishers, 2002.

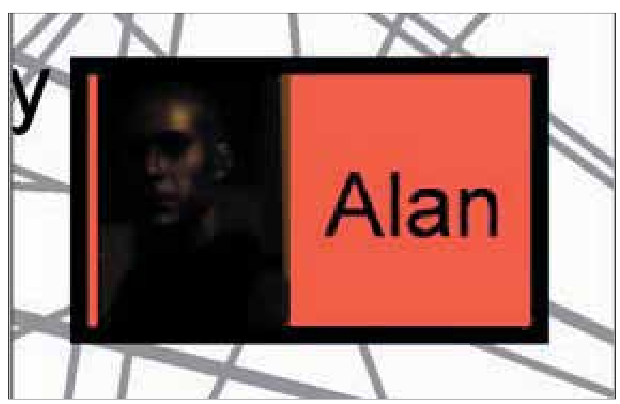
VIZSTER



DESCRIPTION:

Vizster is an interactive visualization tool for online social networks, allowing exploration of the community structure of social networking services such as friendster.com [4], tribe.net [12], and orkut [10]. Such services provide means by which users can publicly articulate their mutual “friendship” in the form of friendship links, forming an undirected graph in which users are the nodes and friendship links are the edges. These services also allow users to describe themselves in a profile, including attributes such as age, marital status, sexual orientation, and various interests. These services profess any number of goals, ranging from supporting dating and creating communities of shared interest to facilitating new business connections.

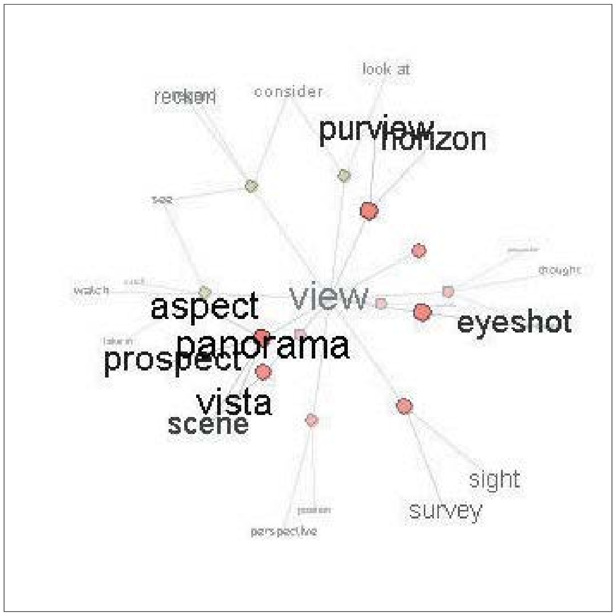


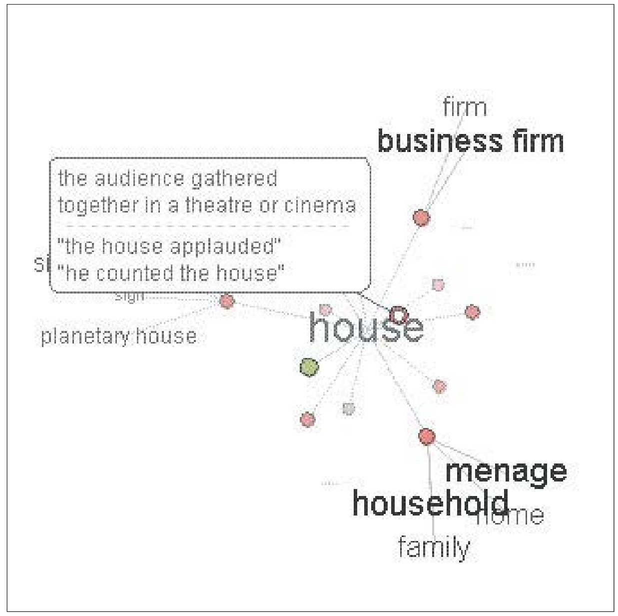


SOURCE:

Heer, Jeffrey. *Vizster: Visualizing Online Social Networks.* Vizster, Spring 2004, http://hci.stanford.edu/jheer/projects/vizster/early_design/ .

VISUAL THESAURUS

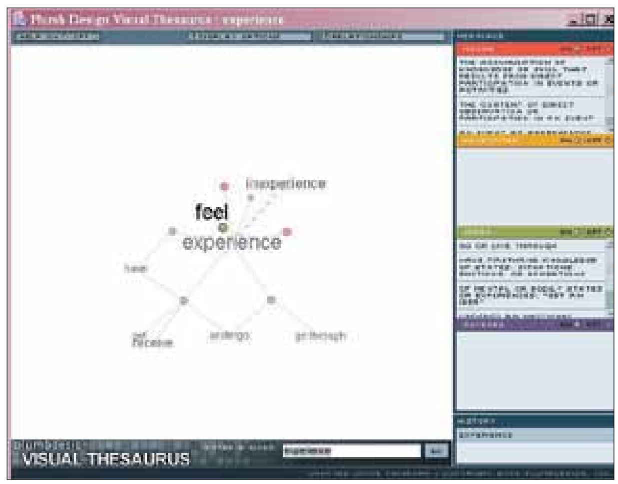




DESCRIPTION:

The Visual Thesaurus takes a unique, and remarkably beautiful, approach to presenting the results of a word lookup. Discover and learn from nearly 140,000 words, meanings and relationships. Through its emphasis on exploration and vocabulary building, the Visual Thesaurus can improve reading, writing and communication skills.

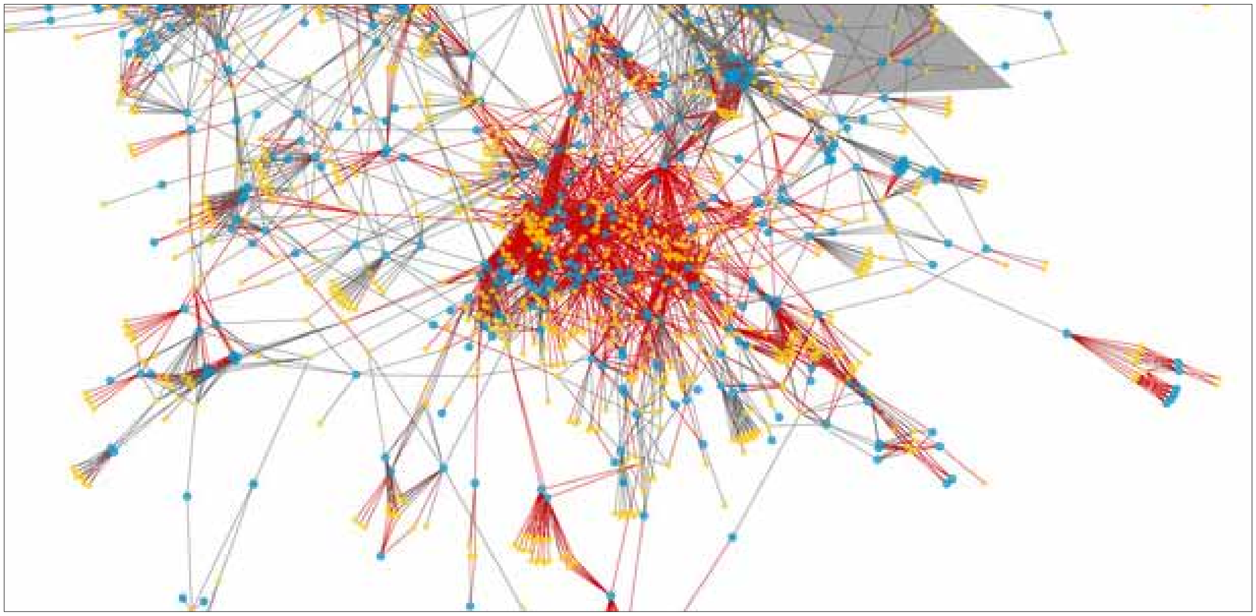
The New York Times:
"Search for the word "plain" in a conventional book-bound thesaurus, and you will find an unadorned and featureless list of synonyms on the printed page. Search for the same word with Visual Thesaurus 2.0, and the program generates an animated three-dimensional constellation in which "plain" is at the center, surrounded by synonyms and other related words. Click on the antonym "fancy" and that word drifts to middle of the screen, where synonyms rush to encircle it in an elaborate, showy and -- the people who came up with it hope -- thought-provoking display."



SOURCE:

Mirapaul, Matthew. *NEWS WATCH: REFERENCE; Swing Your Partner: A Square Dance of Synonyms and Antonyms.* Technology: The New York Times, 14 August 2003, http://www.nytimes.com/2003/08/14/technology/news-watch-reference-swing-your-partner-a-square-dance-of-synonyms-and-antonyms.html .

DRUG SIDE-EFFECT PREDICTIONS INTERACTIVE

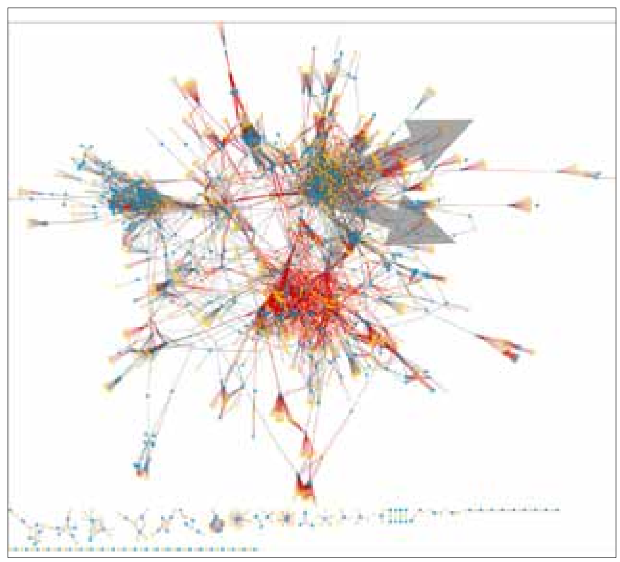


DESCRIPTION:

Since most drugs are more like shotguns than sniper rifles, hitting the intended target but possibly several others in the process, they developed a model to track and predict the side effects of drugs.

It's based upon UCSF's "similarity ensemble approach" (SEA), which compares drug shapes to assess similarities. We know that some drugs definitely interact with some proteins, but that knowledge is limited, so SEA piles all the drugs and their known side effects into one big pool, along with all their known side effects. The result is this incredible infographic. It's a map of 1,241 possible side-effect targets (the innocent bystanders) for 656 drugs on the market today.

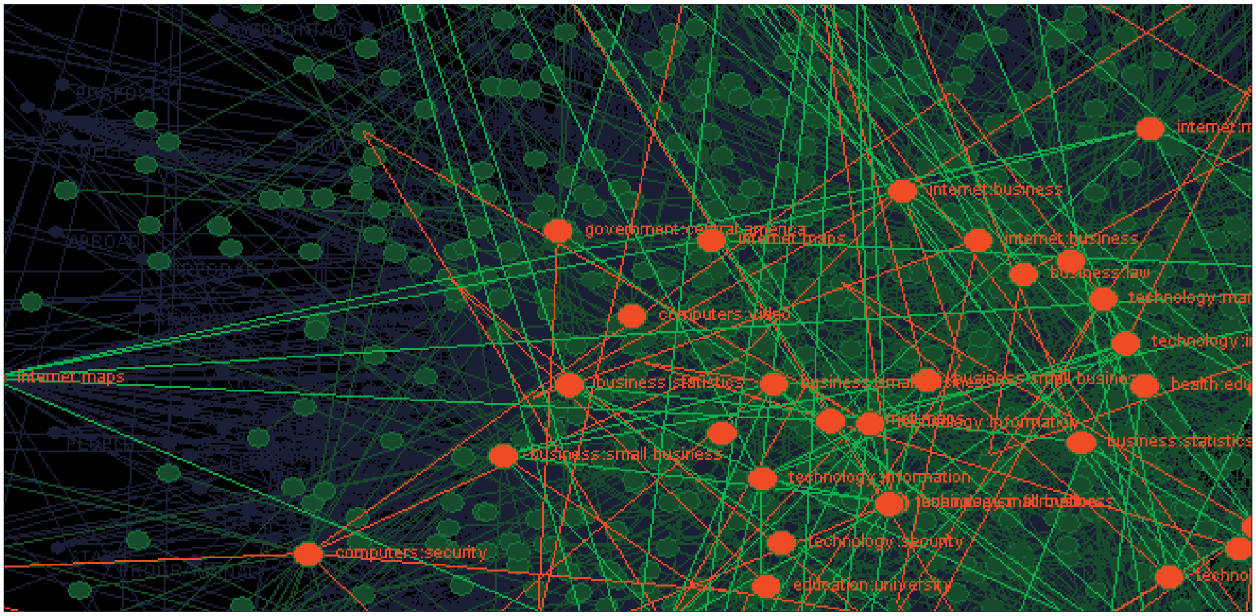
The gold circles are the drugs. The molecular targets are blue. The gray lines signify that we know a drug hits that target. The red line is the fun part--that's the prediction of where drugs may hit, based upon their similarity.



SOURCE:

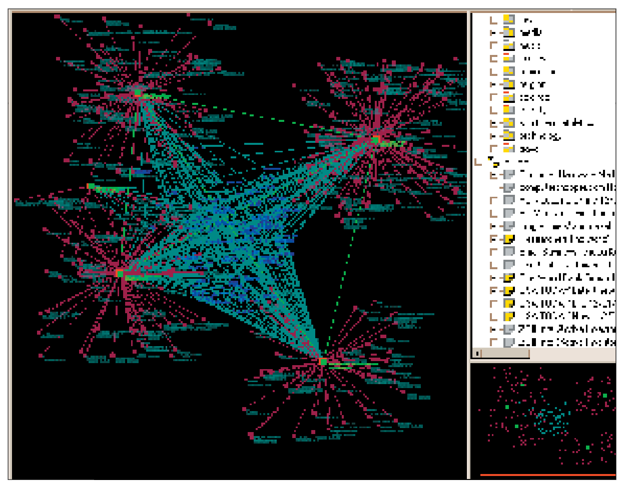
Wilson, Mark. "Infographic: A Chart That Helps Predict Drug Side Effects." *Fast Company*, 21 June 2012, http://www.fastcodesign.com/1670089/infographic-a-chart-that-helps-predict-drug-side-effects (28 June 2012).

INTERNET CARTOGRAPHER



DESCRIPTION:

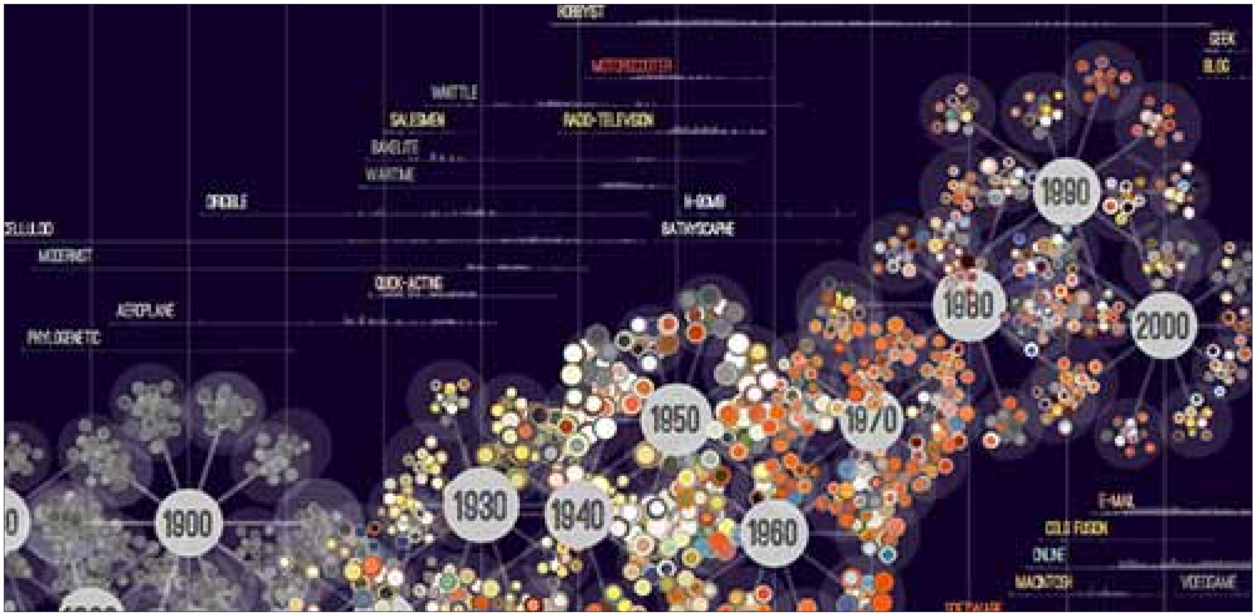
Internet Cartographer is Inventix Software flagship product, an advanced browser assistant that helps you to understand and manage the World Wide Web. Internet Cartographer works alongside your Web browser to classify and map all pages you visit. The map can be interrogated to find Web sites.



SOURCE:

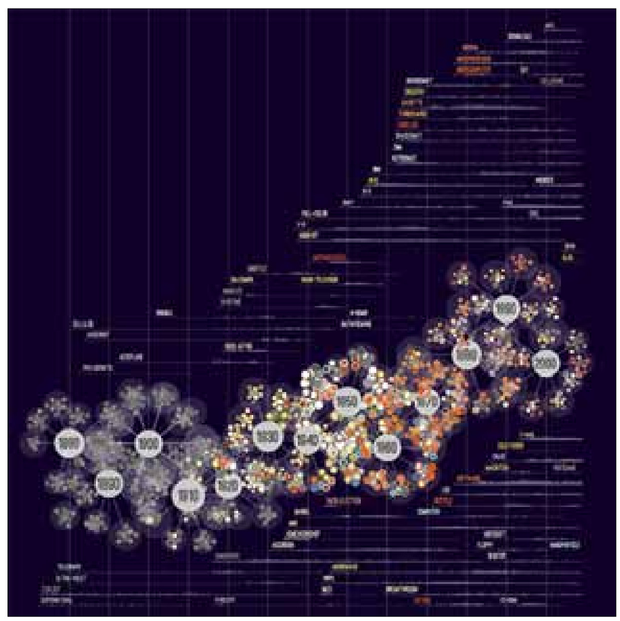
Inventix Software. "Internet Cartographer." *Visual Complexity*, 1999, http://www.visualcomplexity.com/vc/project_details.cfm?id=16&index=3&domain=World%20Wide%20Web .

POPULAR SCIENCE: 138 YEARS 600 x 600



DESCRIPTION:

The resulting graphic follows the metaphor of a molecular chain, with decades forming clusters which in turn contain clusters that represent years. Accordingly, each 'atom' stands for a unique PopSci issue, which is colored according to the average color values of the appropriate historical issue cover. In addition, the size of each 'issue-atom' is determined by the number of words in each issue. Lastly, about 70 different word-frequency histograms surrounding the main graph reveal the usage of different terms per issue.



SOURCE:

Hansen, Mark and Thorp, Jer. "138 Years of Popular Science." *blprnt.blg*, 25 October 2011, http://infosthetics.com/archives/2011/11/138_years_of_popular_science_in_an_infographic.html (2 July 2012).

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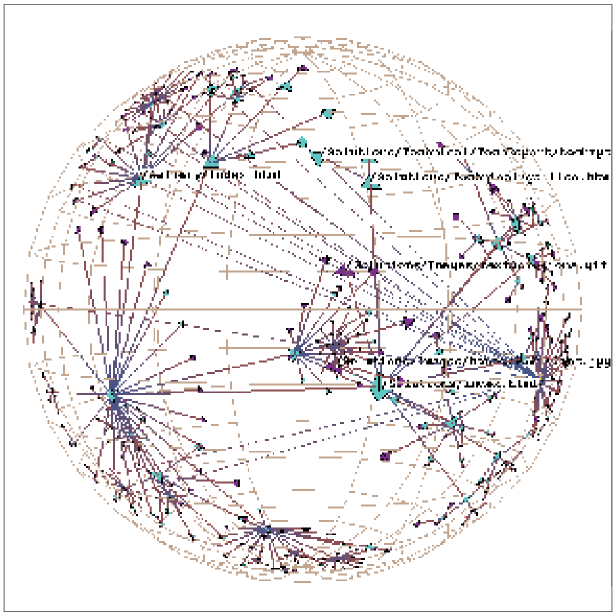
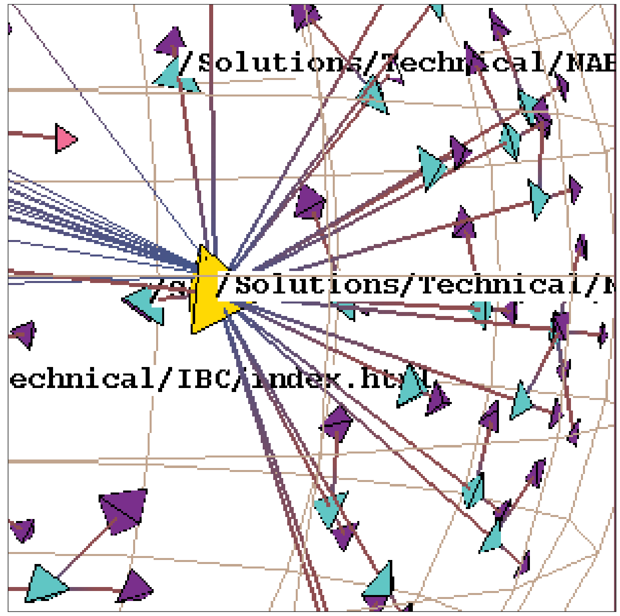
EXPLORING LARGE GRAPHS IN 3D HYPERBOLIC SPACE

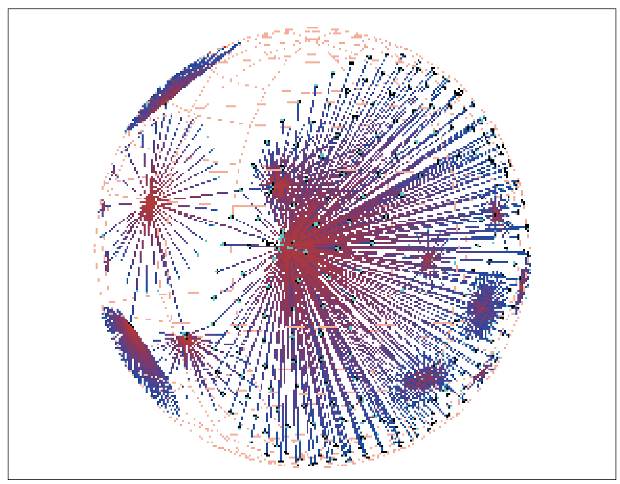




DESCRIPTION:

Drawing graphs as nodes connected by links is visually compelling but computationally difficult. Hyperbolic space and spanning trees can reduce visual clutter, speed up layout, and provide fluid interaction.

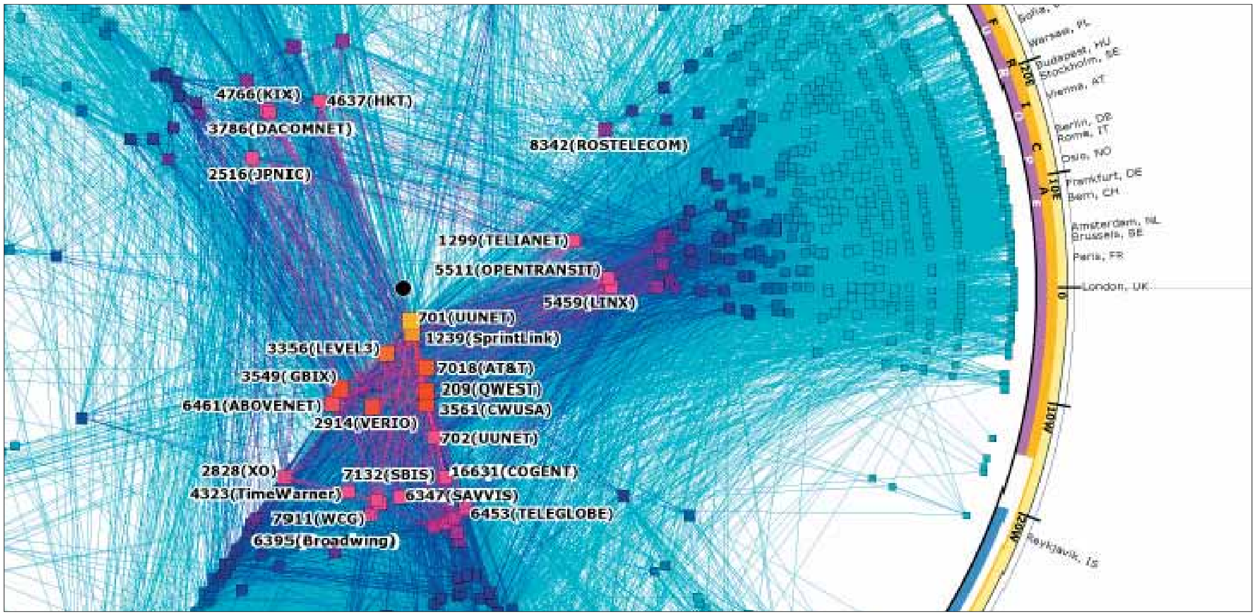
The H3 layout algorithm finds a spanning tree from an input graph and then computes its layout. A spanning tree touches every node in a graph, but only a subset of the links. In a graph a node can have many incoming links, but in a tree a canonical parent is chosen for each child. We call links which appear in the graph but not in the spanning tree non-tree links. These links do not affect the layout computation and are drawn for a selected node or nodes only on demand.



SOURCE:

Munzner, Tamara. “Exploring Large Graphs in 3D Hyperbolic Space”, *IEEE Computer Graphics and Applications, Vol.* 18, *No.* 4, pp. 18-23, July/August 1998.

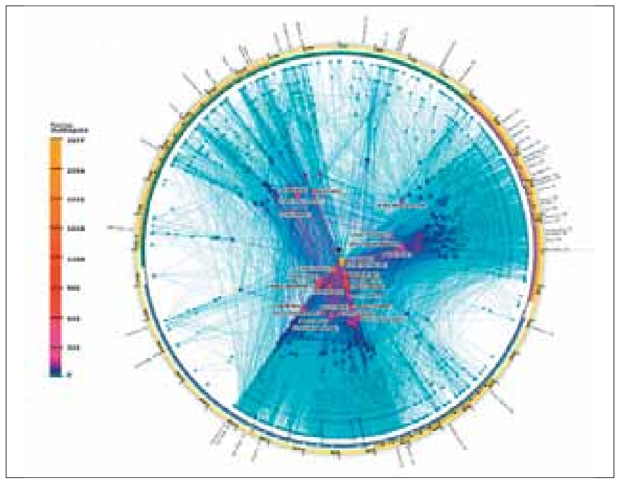
AS INTERNET GRAPH



DESCRIPTION:

This graph reflects 1,134,634 IP addresses and 2,434,073 IP links (immediately adjacent addresses in a traceroute-like path) of topology data gathered from 25 monitors probing approximately 865,000 destinations spread across 76,000 (62% of the total) globally routable network prefixes.

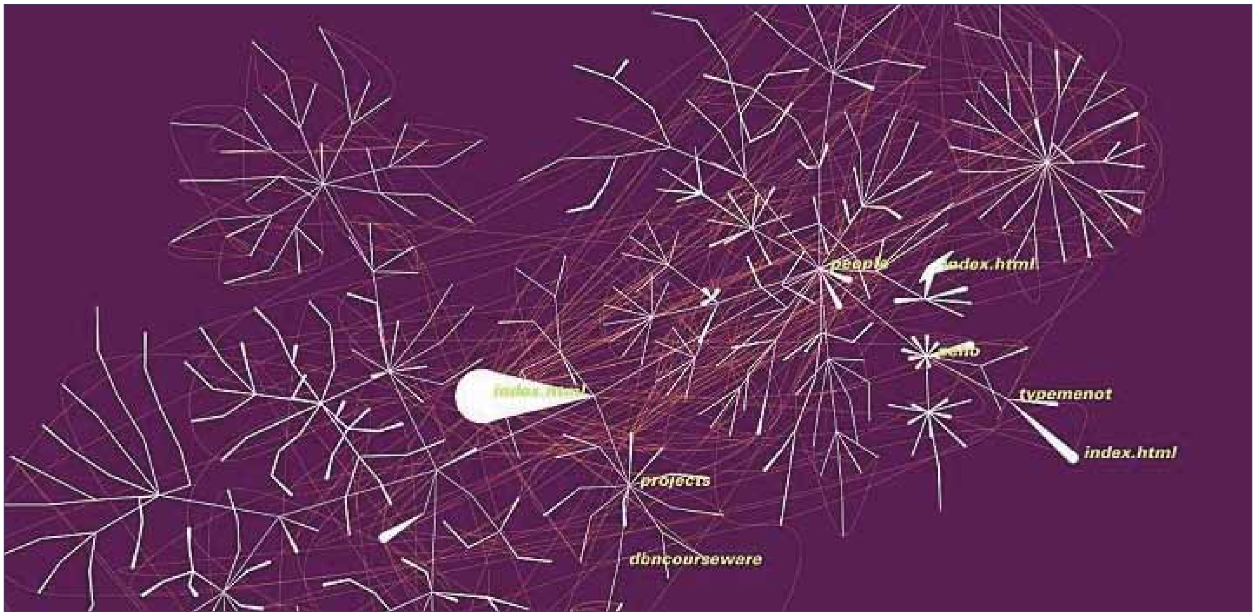
"We then aggregate this view of the network into a topology of Autonomous Systems (ASes), each of which approximately maps to an Internet Service Provider (ISP) (Some ISPs administer more than one AS but it is not typical). We map each IP address to the AS responsible for routing it, i.e., the origin (end-of-path) AS for the best match IP prefix of this address in Border Gateway Protocol (BGP) routing tables collected by the University of Oregon's RouteViews project. The abstracted graph consists of 12,517 Autonomous System (AS) nodes and 35,334 peering sessions. The resulting graph contains 11,411 AS (73% of all ASes present in RouteViews BGP tables on 8 May 2003) and 32,209 peering sessions."



SOURCE:

Claffy,KC and Huffaker, Brad and Hyun, Young and Luckie, Matthew and Lyu, Connie and Michaelsen, Will. "AS Internet Graph", *Mapping Controversies,* 4 October 2011, http://www.demoscience.org/resources/resource/498 .

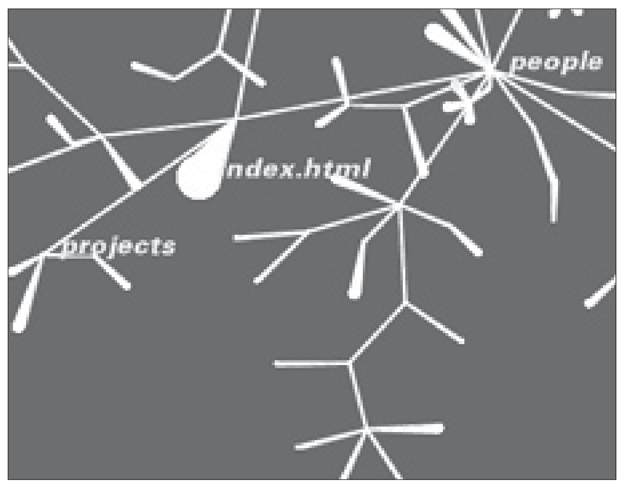
ANEMONE



DESCRIPTION:

Anemone is a project that uses the “process of organic information design to visualize the changing structure of a web site, juxtaposed with usage information”.

“Rules for growth can govern the creation of new branches of structure within the site. Atrophy rules decay unused areas, eventually removing them. Individual web pages can call attention to themselves as they are visited more rapidly than others. Individual branches grow based on input from the data. As the Preprocessor Engine reads the usage log, a reproduction rule causes branches to grow whenever parts of the site are visited for the first time. This avoids the problem of having to keep track of what pages are added to or removed from the site. Using the usage data to create an implicit model of structure is a common theme in Organic Information Design. To balance growth is the notion of ‘atrophy’. Branches associated with areas of the site that have not been visited will slowly wither away, causing them to visually thin out. Eventually the branches die, and are removed from the system.



SOURCE:

Fry, Ben. *Visualizing Data: Exploring and Explaining Data with the Processing Environment* (O’Reilly Media, 2008).

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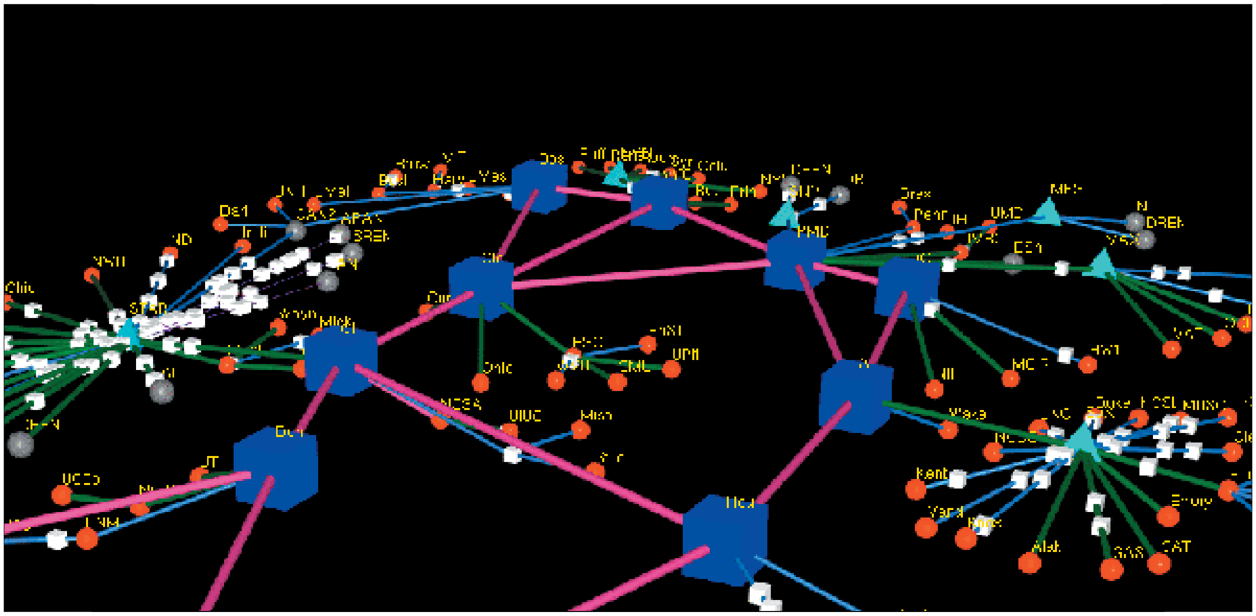
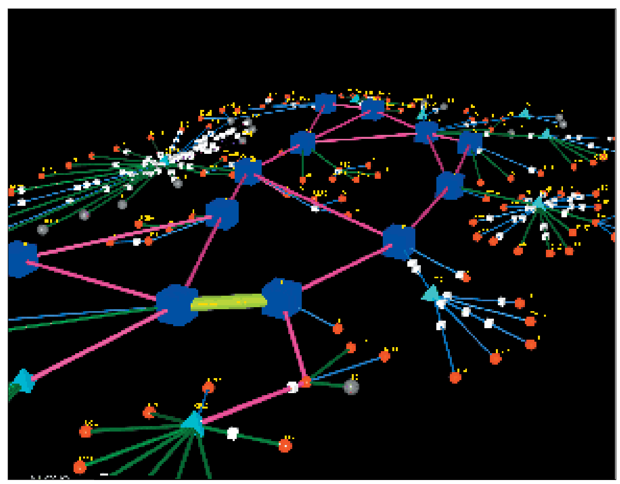
VERTEX-EDGE GRAPHS



DESCRIPTION:

This map represents a 3D model of the vBNS network which connects universities and laboratories in the USA.

"A vertex-edge graph consists of two arrays: one of vertex structures, and one of edge structures. This corresponds closely to the abstract mathematical representation of a graph as G(V;E), except that the vertices and edges in Cichlid contain not only connectivity information, but also graphical attributes. Each vertex is defined by a VtxInfo structure, which contains a 3-D location vector, a relative size parameter, color information, and a drawing style hint. Each edge is defined by an EdgeInfo structure, which indicates the vertices where the edge terminates, the directionality of the edge, size, color, and style. The vertices are defined to exist in a 3-D coordinate space, which is declared ahead of time; this space is mapped to the final graphical representation. The edges are defined to connect pairs of vertices."



SOURCE:

Brown, Jeff. "Vertex-Edge Graphs." *Visual Complexity,* 2000, http://www.visualcomplexity.com/vc/project_details.cfm?index=14&id=95&domain=Internet .

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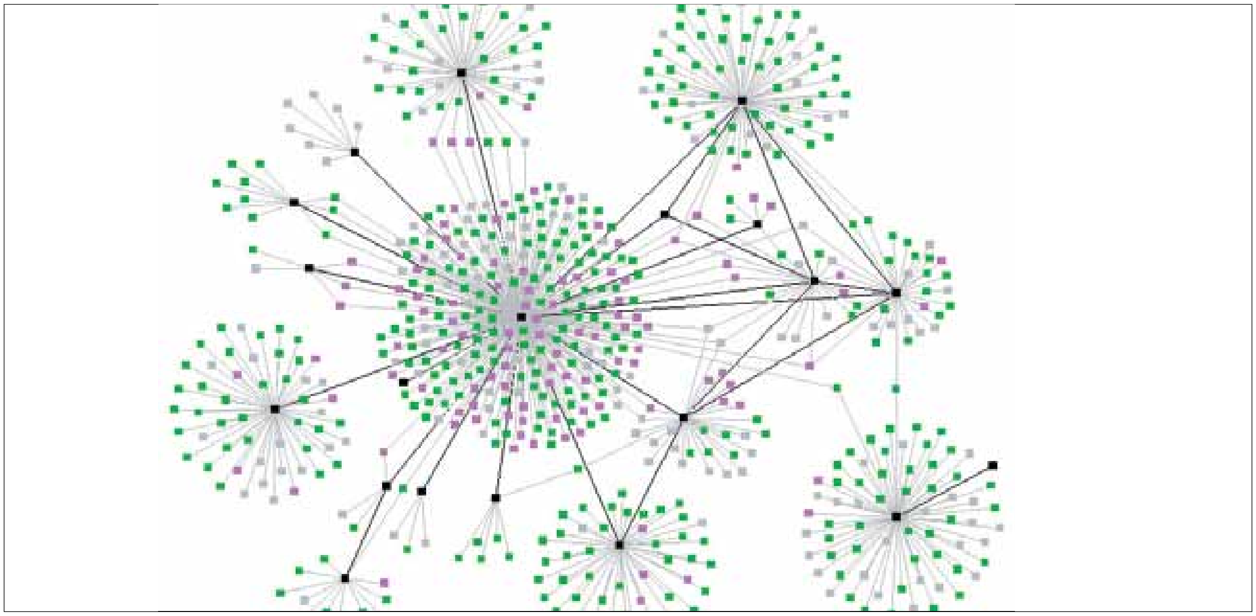
CONTAGIONS VIA CONTACT TRACING

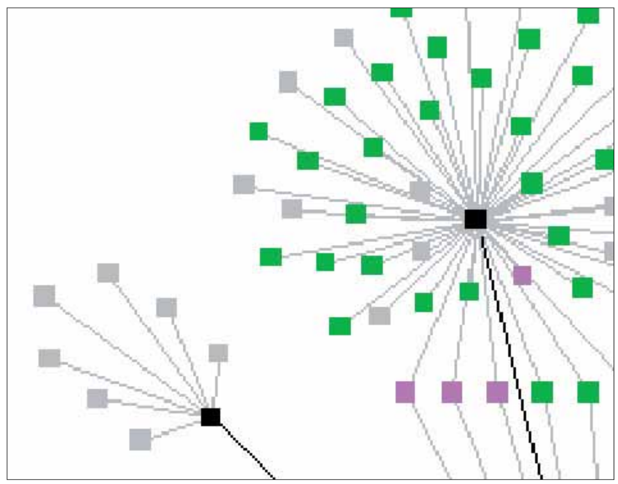


DESCRIPTION:

An airborne contagion, such as SARS or TB, spreads through human networks based on who comes in contact with whom, and how infectious and susceptible each party is. Multiple contacts play a role in the probability of infection.

Public health officials perform contact tracing to map the spread of the infection and manage its diffusion. The network above shows the spread of an airborne infectious disease. The map was created using actual contact data from the community in which the outbreak was happening. Black nodes are persons with clinical disease (and are potentially infectious), pink nodes represent exposed persons with incubating (or dormant) infection and are not infectious, green represent exposed persons with no infection and are not infectious. The infection status is unknown for the grey nodes.

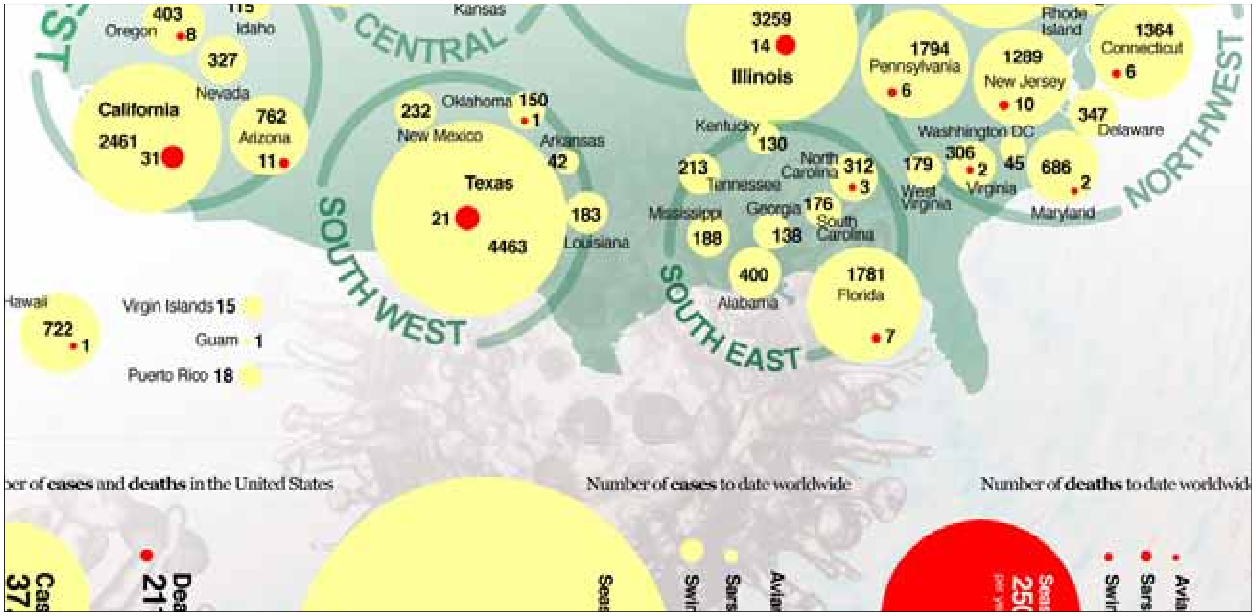
Unfortunately the 'social butterfly' in this community, the black node in the center of the graph, is also the most infectious -- a super spreader.



SOURCE:

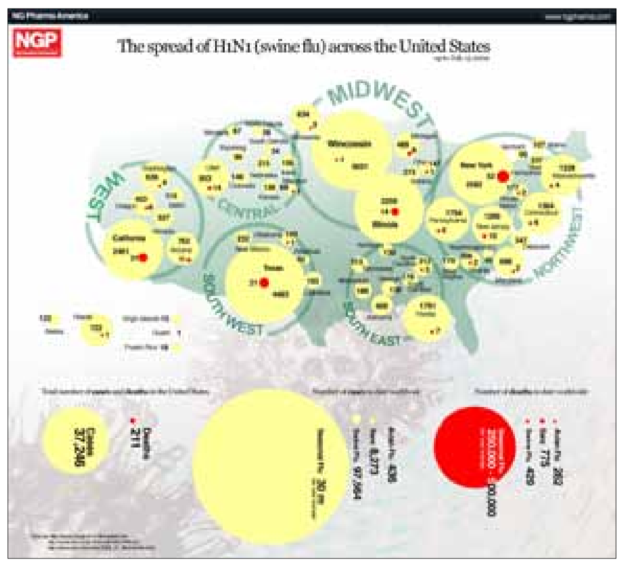
Krebs, Valdis. "Mapping the Spread of Contagions via Contact Tracing." *orgnet,* 2003–2009, http://orgnet.com/contagion.html .

SWINE FLU 1282 x 1159



DESCRIPTION:

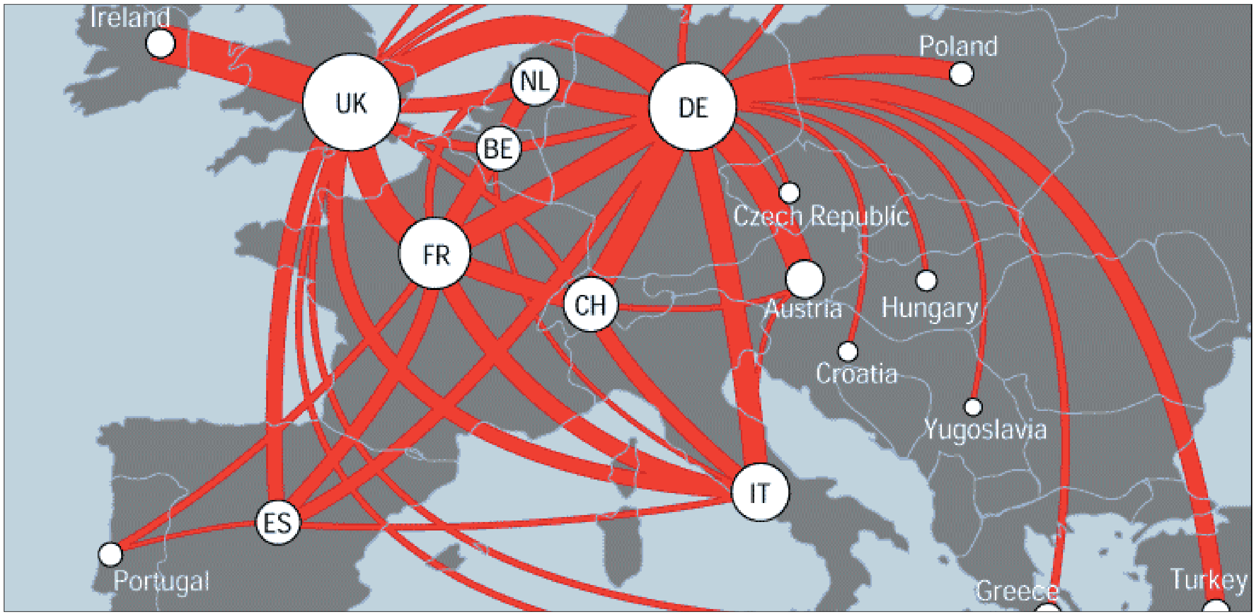
Recent deaths from the H1N1 swine flu have led many to believe the virus is getting more and more deadly. However, there are currently no indications the virus is mutating or becoming more virulent. The spread of H1N1 (swine flu) across the United States is visualized here.



SOURCE:

"The Spread of H1N1 (swine flu) Across the United States Up to July 15 2009." *Next Generation Pharmaceutical*, http://www.ngpharma.com/swine-flu-us-infographic.html (26 June 2012).

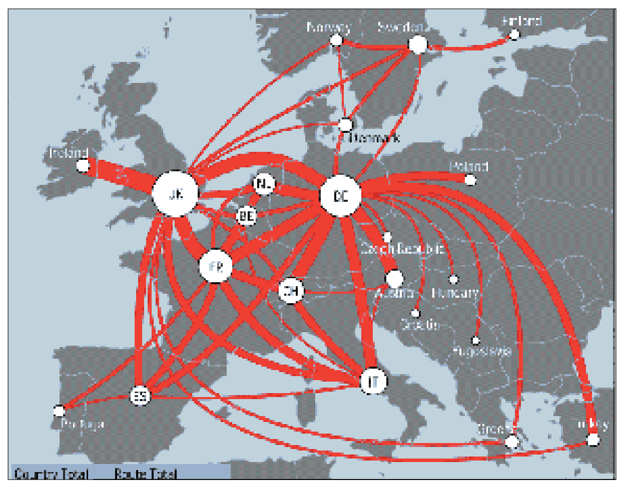
TRAFFIC FLOW MAP



DESCRIPTION:

TeleGeography has produced arguably the best flows maps of the Net thus far, based on the volume of international telephone traffic between nations. Below is an example of one of their handcrafted telecommunications traffic flow maps for the European region.

The map shows countries with traffic flows between them represented as smoothly curving red lines. The thickness of the lines is proportional to the annual volume of traffic between those two countries, measured in millions of minutes of voice telecommunication. (Note: only the principal route pairs, above a set threshold, are shown, to avoid cluttering the map.) Circular symbols, located on the capital city, encode the country's total annual outgoing traffic to all other countries. It is clear from the map that the UK, Germany, and France dominate traffic intra-European flows, forming a powerful triangle at the heart of the continent.



SOURCE:

Stronge, Timothy J. "Traffic Flow Map." *Visual Complexity,* 2000, http://www.visualcomplexity.com/vc/project_details.cfm?id=15&index=2&domain=Internet .

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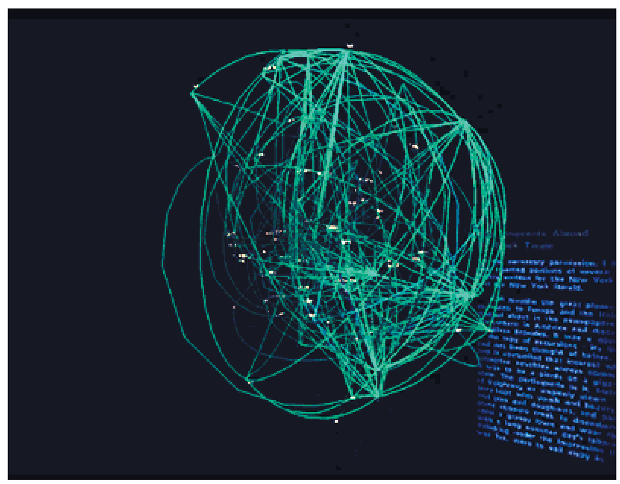
VALENCE

DESCRIPTION:

"Valence is a set of software sketches about building representations that explore the structures and relationships inside very large sets of information.

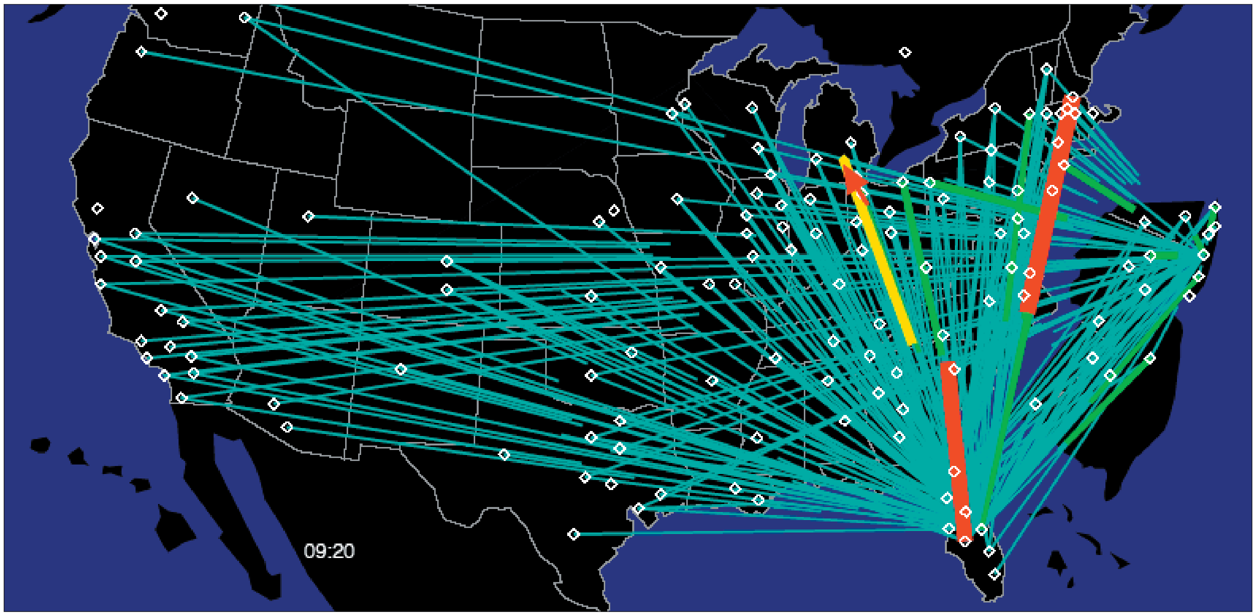
The premise is that the best way to understand a large body of information, whether it's a 200,000 word book, usage data from a web site, or financial transaction information between two multinational corporations, is to provide a feel for general trends and anomalies in the data, by providing a qualitative slice into how the information is structured. The most important imformation comes from providing context and setting up the interrelationships between elements of the data. If needed, one can later dig deeper to find out specifics, or further tweak the system to look at other types of parameters."



SOURCE:

Fry, Ben. "Valence." *Ben Fry,* 2002, http://benfry.com/valence/ .

VISUALIZING NETWORK DATA

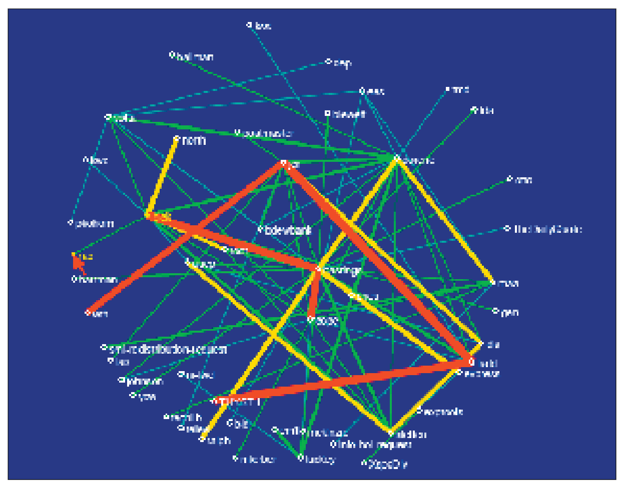


DESCRIPTION:

The overload into and out of the Oakland node. The half-lines between the nodes code the overload by direction.

The idea embodied in a nodemap is to display node-oriented data by showing a glyph or symbol such as a circle or square at each node on the map, with the visual characteristics such as size, shape, and color of the glyph coding the value of the statistic. More complex symbols can be used to represent more than one statistic simultaneously.

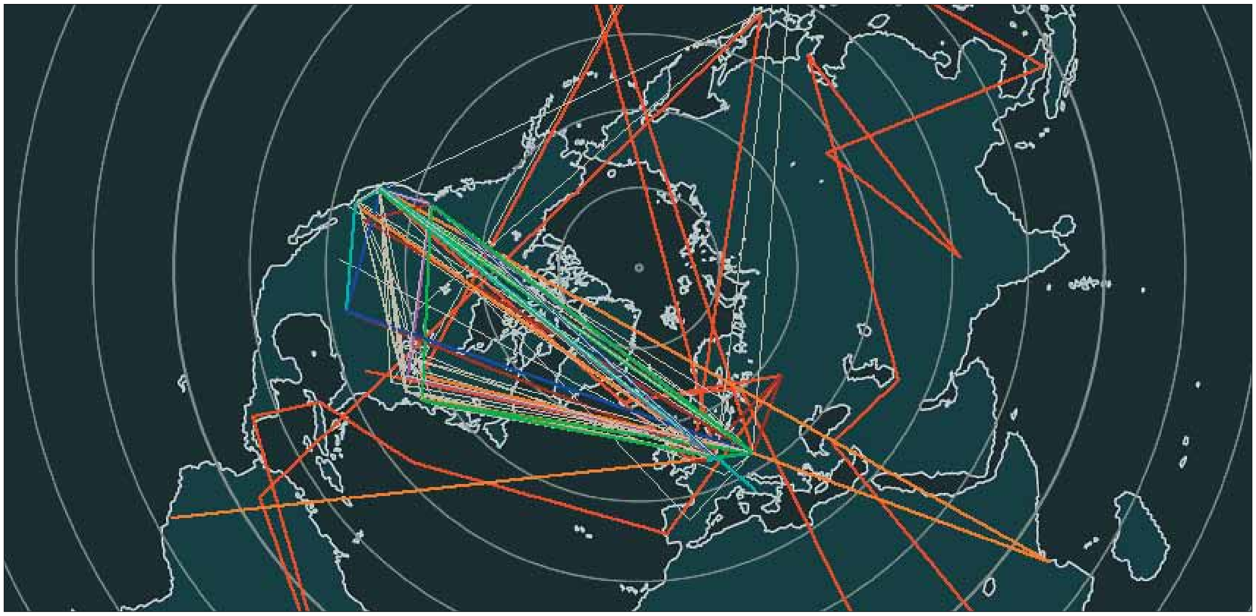
"Networks are critical to modern society, and a thorough understanding of how they behave is crucial to their efficient operation. Our focus is on visualizing the data associated with a network and not on simply visualizing the structure of the network itself. We begin with three static network displays; two of these use geographical relationships, while the third is a matrix arrangement that gives equal emphasis to all network links."



SOURCE:

Card, Stuart K. and Mackinlay, Jock and Shneiderman, Ben. *Readings in information Visualization: Using Vision to Think* (Morgan Kaufman, 1999).

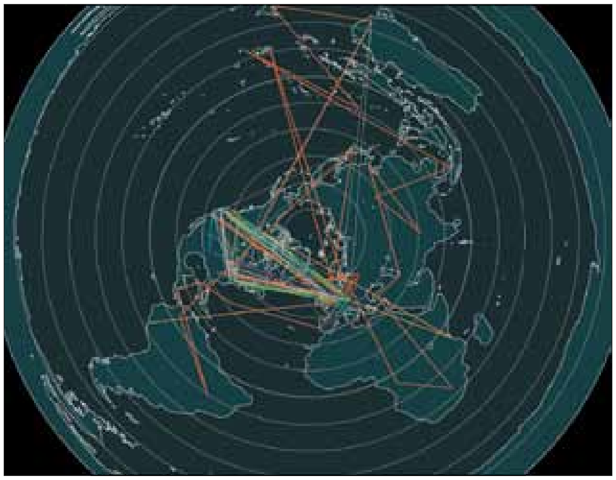
WEBHOPPER (1996)



DESCRIPTION:

“The seeds for the Web Hopper were planted in e-mail discussions with one of its founders, Koichiro Eto. Early discussions included such questions as the following: ‘Don’t you think it’s a miracle we are connected and that we can jump from one site to another?’ ‘Yes, but why doesn’t the excitement last?’ ‘Are we interested in the Web site or in the World Wide Web?’

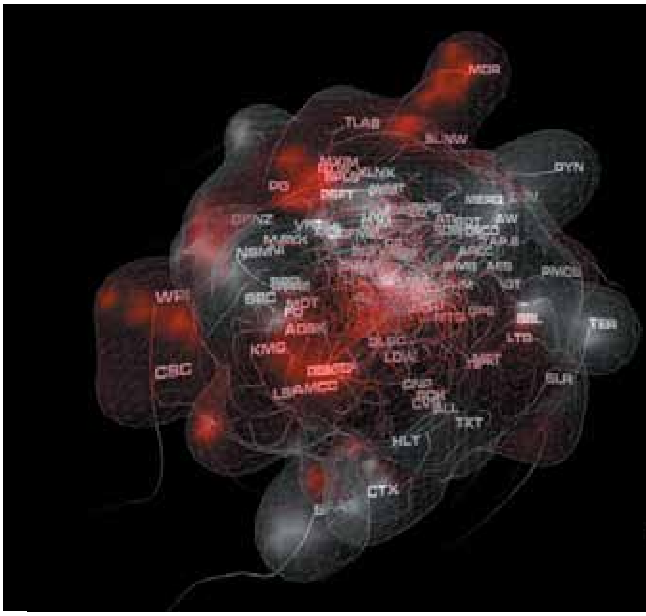
Web Hopper translates the IP address from http packet information passing through the backbone of WIDE Project into latitude and longitude which is visualized via JAVA applets. To translate from the host name to the location information, a database on the Host name to Latitude/Longitude page at Illinois University was used. We thank Matt Gardner at the Pablo VR Group.”

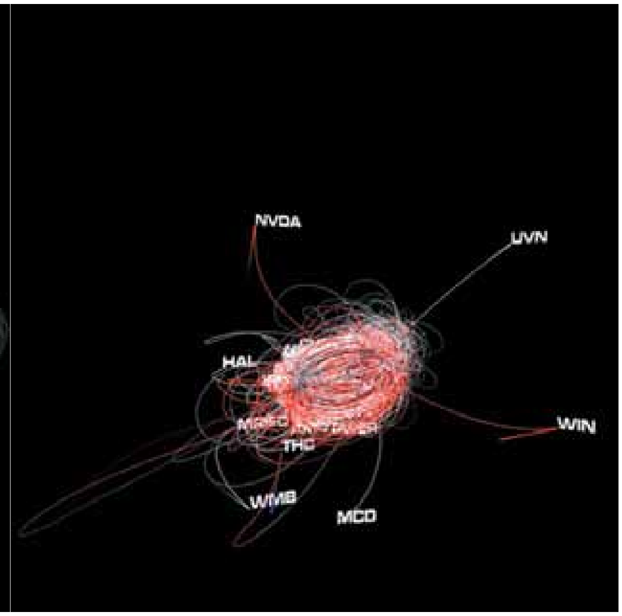


SOURCE:

Sensorium. “Web Hopper.” *Sensorium,* 1996–1997, http://www.sensorium.org/webhopper/index.html .

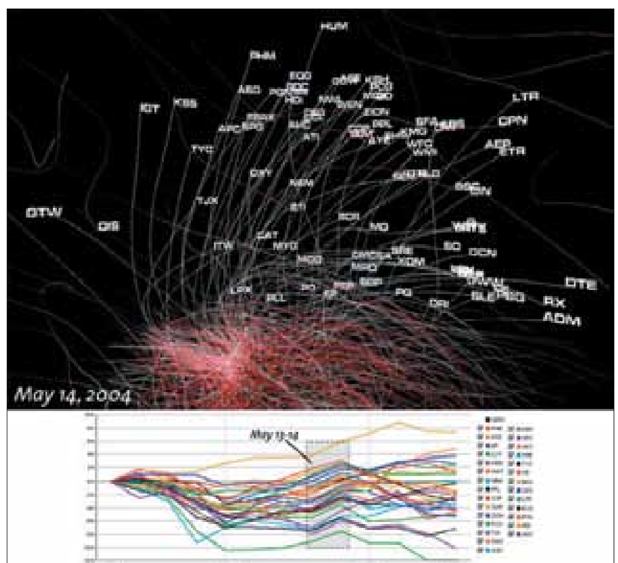
TIME-VARYING DATA VISUALIZATION USING INFORMATION FLOCKING BOIDS





DESCRIPTION:

This research demonstrates how principles of self-organization and behavior simulation can be used to represent dynamic data evolutions by extending the concept of information flocking, originally introduced by Proctor & Winter, to time-varying datasets. A rule-based behavior system continuously controls and updates the dynamic actions of individual, three-dimensional elements that represent the changing data values of reoccurring data objects. As a result, different distinguishable motion types emerge that are driven by local interactions between the spatial elements as well as the evolution of time-varying data values. Notably, this representation technique focuses on the representation of dynamic data alteration characteristics, or how reoccurring data objects change over time, instead of depicting the exact data values themselves. In addition, it demonstrates the potential of motion as a useful information visualization cue.



SOURCE:

Moere, Andrew Vande. "Information Flocking Boids." *Visual Complexity,* 2004, http://www.visualcomplexity.com/vc/project.cfm?id=44 .

Displaying Healthcare Informatics Through Node-and-Link Visualizations: Can Social Network Modeling Improve Healthcare Provision and Advance Preventive Healthcare Practice More So Than Other GUI Models?

Part Three (Next Step Planning): *Planning Toward the Development of a Node-and-Link Healthcare Tool: a GUI That Supports Preventive Healthcare*

CONSIDERATIONS FOR PROPOSED NODE-AND-LINK GUI

To proceed with the process of creating a model for a node-and-link healthcare based GUI, certain assumptions, serving as take-off-points to the endeavor, are briefed in this section. In addition to the assumptions, specific medical condition issues will serve as a "storyline" for the purpose of developing the story board. These are the major considerations and selected conditions that will guide the development for the next stage of the process (the order of the listing does not imply hierarchy):

a) A GUI-based healthcare informatics tool designed to be displayed across multiple publishing devices

b) Node-and-link based visualization/presentation

c) Touchscreen gesture-based interactivity

d) Capability to shift primary data emphasis to either the node or the link elements

e) Asymmetric data input/output capacity

f) Emphasis on preventive care model

g) Emphasis on Medical Home paradigm

h) Storyboard derived from chronic and widespread health concerns in contemporary populace:

1) Obesity, and/or
2) Diabetes, and/or
3) Chronic Obstructive Pulmonary Disease

CONSIDERATIONS

The eight considerations listed in the left column will guide the development of the GUI prototype for the next stage of research within this program. The first two items: a) A GUI healthcare tool, and b) Node-and-link based visualization/presentation are the thrust of this paper and have been covered in the former sections. Items c) through h) are briefed in this section.

TOUCHSCREEN GESTURE-BASED INTERACTIVITY

The jump from keystroke operation to mouse click processing was a first step to move from a linear command control to more spatially responsive interfaces. A combination of these two control methods (keystroke + mouse), provides a most useful third way for interface control. Touch screen interfaces can serve as a way to merely integrate these control methods or they can offer gesture-based control. Control integration with on-screen keyboards and roving cursor features permit compactness of devices, greater portability, and navigational improvements. Actual keyboards do not have to be rendered, as distances alone can begin to establish cognitive feedback loops for data entry. “A user with the ability to touch-type may type anywhere on the sensing surface without the need for a visual keyboard” (Relative Keyboard Input Systems, Daniel R. Rashid and Noah A Smith, Language Technologies Institute, Carnegie Mellon University.) These kinds of inputs may allow for greater speed and efficiency (Non-keyboard QWERTY touch typing: a portable input interface for the mobile user, M. Goldstein, G Alsiö, and S. Tessa, Human Factors in Computing Systems, 1999.)

Our model, however, with the exception of SOAP notes, should increasingly gather information from ubiquitous sensing devices. Ideally, there should very little need for individuals in the healthcare provider areas to stop there workflow and involve themselves with data entry. Our concern, therefore, is data retrieval. In this area we want to look to gesture-based touch screen models such as the Apple iPad or the Microsoft Tablet PC. When specifically textual information is to be added voice recognition software may be utilized.

Touch-screen gesture based operation will allow for the kinds of deep drill-down that providers use while also being user-friendly for recipients. The notion of device and method is not fully agnostic to the kind of presentation it supports. When one considers the pure keyboard model with a traditional application the interface is most often a presentation of text and tables. Moving into applications that contain more advanced renderings such a widgets we see the need for mouse navigation.

As we move toward gesture-based navigation the ability to rapidly enlarge, reduce, slide images, drill-down, etc. not only add great utility but may be more intuitive in their usage. The advantages of direct manipulation — compared to control manipulation is greatly advanced, if actually made possible, with gesture based modeling. (A Procedure for Developing Intuitive and Ergonomic Gesture Interfaces for HCI, Michael Nielsen, Moritz Störring, Thomas B. Moeslund, and Erik Grnum; Aslborg University, Laboratory of Computer Vision and Media Technology.) The advantages from these advances in navigational types and methods is best leveraged by the kind of visualization advocated here: nod-and-link visualization. So as devices and methods advance so too do ideal informative representations that align with their advantages. These aspects are to be investigated and integrated into the logic for the node-and-link healthcare model suggested.

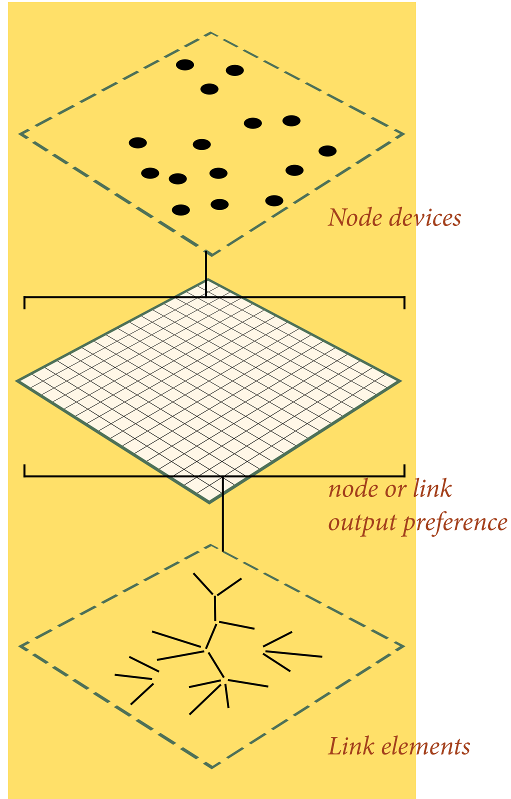
CAPABILITY TO SHIFT PRIMARY DATA EMPHASIS

The display capacity for node-and-link diagrams is extensive. The elements within node-and-link visualizations are generally orientated to the kinds of data that support them: nodes representing the entities within the healthcare enterprise; links suggesting the connectedness and activities that occur between the nodes, and the ground being reserved for fields of x-y relational types of data (visible datasets or geographic representations, for example). In practice these are defaults and general approaches, both from a historically-oriented and from a use-factor perspective.

In practice, however, the devices can be designed to receive any kind of information. The best approach is to analyze how effectively an information type renders under one device type as opposed to another *relative to the type of task it conveying*. This might lead to the atypical visualization where nodes, links, and even grounds display data, through forms and arrangement, that reveal fresh insight or emphasize some heretofore unseen relationship.

Within a more advanced model the data would not necessarily be fixed in its assignment to discrete data sets. Instead, users (mostly at the provider level) could simply move any data type into any device type and compare these as they see fit.

Another advantage of the node-and-link model is the ability to deploy extracted elements. A single node lifted from a complete informative representation can stand alone. When this nodal device has such a freestanding capacity it easily functions as an avatar or icon, say, on a smartphone. In this manner the recipient can focus on one aspect of their health through a device that stands in for them. Better, the data that is continuously collected from a recipient may modify such an icon on a hand held device while being constantly re-rendered on a central larger-scale application. The use of two-way reporting to a cloud provides all these visualization models that possess comparative, interchangeable, collective, and singular approaches to healthcare informatics.

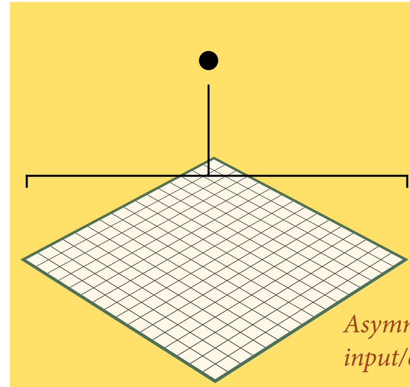


Although the default assignment of data within network diagrams would generally have entities/nodes as concrete things, and links as the conduits that interconnect them, such an arrangement can be reversed. This would have particular value if users desired to create atypical views where aspects of interconnectedness suggested by the links, e.g., treatment, visits occurrences, diagnosis, etc. were to be seen as the nodes instead. Or where patients of one kind could be seen as collective links within different kinds of practitioners.

ASYMMETRIC DATA INPUT/OUTPUT CAPACITY

The gathering of health data developed parallel with record keeping methods to store, retrieve, and present that data. These written records are now being replaced by ubiquitous data collectors, such as body monitors and other forms of wearable technology, or sensors within certain recipients environments that provide pulsed or continual data regarding medical condition. Originally, It can be said that the recording and documenting methods are quite symmetric. The document possesses signifying elements that clearly tie back to that which is being signified. For example a photograph of a cow is readily reflective of an actual living cow. However, a DNA graph of the genic coding of that cow would be asymmetric — it looks nothing like the cow, even though it is a signifier of the animal. In the early stages of recording information there is a general, and proportionate relationship between the signified and the signifiers; this is true even if the methods are not illustrative yet require a learned form of encryption. Many conditions lead to a need to increase the asymmetry of the source and recording. Volume of data, society's contemporary data-problem is such an example.

The volume of healthcare records requires the methods of reporting to be increasingly asymmetric. This is as much a requirement as an opportunity. PIIM has begun multiple investigations into Big Data as well. For our purpose we'll look at Big Data as an immensely wide net of not otherwise interconnected datasets that may provide heretofore unimaginable contextual reference. The ability to reach across the privacy of EHR for the benefit of all the participants within a system may be one area where asymmetric visualization is beneficial. Node-and-link representations are inherently asymmetric in contemporary constructs with nodes filling in for entities and links representing conceptual connections. (As opposed to, say, road map networks which are symmetric pictures of the earth's surface in small-scale). The ability to represent large sets of data with symbols in a network, and then to move those symbols into other networks addresses only one area where node-and-link diagrams can leverage asymmetry toward insight for both healthcare provider and healthcare recipient.



Asymmetric data input/output capacity

The diagram above is a conceptual drawing that portrays the meaning of asymmetric input/output capacity. The concept is simple but the execution, from a technical perspective, is often extremely involved. The classical idea of data input/output is symmetrical — imagine a typewriter: striking the "a" key produces an "a" letterform on a sheet of paper. The input cannot be manipulated, nor stored. The input generates symmetric output. Conversely input from myriad sources, stored, and manipulated, could yield something as simple as a text message to patient that says, "drink two more glasses of water today." The input could come from weather sources, patient sensors, or scheduling databases — all this potential source data does not "look" like the output sent to the healthcare recipient. This is an example of asymmetric input/output data visualization.

EMPHASIS ON PREVENTIVE CARE MODEL

At the core of contemporary, Western healthcare practice is the relationship between the healthcare provider (the "doctor") and the healthcare recipient (the "patient"). If we were to convert this into a simple node and link diagram the nodes would be these two entities and the link would be the connection between them. The link, in the traditional sense, is the mere connection — the stated, or consensual relationship of need to service. From the traditional viewpoint, it may be argued, that the "a" node (patient) is not "intrinsically" responsible for his or her health, as stated by Gertler and Simcoe, "Disease management exists because not everyone takes care of their health. This observation applies to a wide range of behaviors, from failing to exercise or maintain a healthy diet to actively engaging in harmful activities like smoking, drug use, or excessive alcohol consumption." (Paul Gertler and Time Simcoe, "Disease Management: Helping Patients [Who Don't] Help Themselves," (April 2009), 3, http://people.bu.edu/tsimcoe/documents/published/DiseaseMgmtHE.pdf) instead, this is [nearly always] the job of the "b" node. The "b" node is responsible for having the interpretive skills and the resources to cure the "a" node, or move that node back into proper health. This can be accomplished through any type of "task" that "travels" across the link between (or toward) the healthcare recipient from the healthcare provider. The link, in this traditional sense, represents the intelligence, the interaction, the analysis, etc., of the patient's medical condition.

This though, is the simplest interpretation and visually renderable model of the node-and-link scenario: nodes as entities, links as connectivity. As was discussed earlier almost any kind of information can be assigned to either the node or link. This atypical assignment of data usually provides value from an analysis perspective.

Importantly, we want to look deeply into preventive care models because node-and-link modeling can be well leveraged in this respect. The collection of data from patients, and the composite feedback of data to patients, is the desirable cycle that may yield a pattern for proceeding toward better health. Aspects of preventive care also figure into critical issues of healthcare provision servicing (availability, appropriateness of treatment, timeliness, etc.) When a patient begins to take on the role of self-care through preventive care the aspect of patient-centeredness is immensely enhanced (Leonard L. Berry, PhD, Kathleen Seiders, PhD, and Susan S. Wilder, MD, "Innovations in Access to Care: A Patient-Centered Approach"). Making preventive care a central consideration when developing the toolset also emphasis the patient will have access to the data in some representational form. This contributes to the need for asymmetric display in a very meaningful way from the design point of view. The jargon and complexity will need to be pushed aside in favor of easily assessable presentations. It is likely that these may be just phrases of text, or simple symbols and icons that build habits toward improved health.

EMPHASIS ON MEDICAL HOME PARADIGM

The initial interface designs are to be considered on three levels. The first is the human interface in the sense of doctor interfacing with a patient. The next is an interface between a user (such as the healthcare provider to a device) and receiver (such as a healthcare recipient to a device). A third way to consider the interface is through the notion of data to its representation. So our concept of interface may refer to human-to-human; human-to-device; and machine-to-machine [device to device]). In order to bring a focused and rationalized approach to the extensive potential reach of these three areas the design latitude will be controlled by considerations toward/within the Medical Home model.

The Medical Home model, or more specifically, the Patient-Centered Medical Home (PCMH) model provides ideal guidance under which to develop suggestions for a node-and-link GUI. The Medical Home scenario offers two very important aspects: medical provider oversight with patient responsibilities, and preventive care attitudes for better health. The specific definition of a Medical Home does vary however, "While the PCMH is gaining attention and popularity, transforming practices have also been observed to encounter challenges. The transformation toward a PCMH should not be viewed as a simple prescheduled set of steps in practice redesign or a fulfillment of certification requirements in stages. Instead, it represents a long lasting commitment to transformation and adaptability to patient needs." (Trajko Bojadzievski, MD and Robert A. Gabbay, MD, PhD, "Patient-centered Medical Home and Diabetes," *Diabetes Care* 34 [April 2011: 1031].)

Robert A. Berenson, et al., assert the following concerning the definition of a Patient-Centered Medical Home composition, "There is hope that primary care physician (PCP) practices, serving as medical homes, can bring some order to this chaos, providing a source of confidence, advocacy, and coordination for patients as they encounter the disconnected parts and often daunting complexity of the health care system. However, various PCMH advocates have different, although not inconsistent, expectations and emphases. For some, the concept relates mostly to the "patient-centered" component; for others, the most salient characteristics are found in improving the "system-ness" of care, aided by new health information technology (IT) and organizational structures; while still others emphasize chronic care management." (Robert A. Berenson et al., "A House Is Not A Home: Keeping Patients at the Center of Practice Redesign," *Health Affairs* 27, no. 5 [April 2011].)

For our purposes we are well-targeted for our definition of Medical Home based on an interview with conducted with Cdr. Kevin Durrance at the National Naval Medical Center, Bethesda, Maryland, on December 9, 2010. The conversation touched upon a wide number of patient-centered medical home related ideas, including: aspects of existing medical practice; reactive protocols; and comparisons between "traditional" practice and the patient-centered medical home related practice. Notes from that discussion are presented in the right column,

Of particular interest was an interview In traditional practice doctors aim for minimizing, or reversing illness—after its discovery, while medical home practice focuses on preventive health—integrated healthcare services and mind + body + prevention through good health practices. Again, existing medical practice has RNs and LPNs taking the vitals, while medical home patients take their own vitals (for such as: blood pressure, blood sugar, peak flow, heart rate; as well as more subjective areas, such as full diet diary monitoring [this can be instrumental in tracking general health]). Of particular interest are those areas of high incidence that the patient can be invested in to assist in prevention and illness mitigation on a continual basis: Diabetes, Hypertension, Obesity , and COPD (Chronic Obstructive Pulmonary Disease). With existing medical practice disease management attempts to service the patients in available time frame, versus medical home practice which focuses on outcomes. In order to make these types of comparisons there is an interest in systems that support outcome quality measurement, such as HEDIS (The Healthcare Effectiveness Data and Information, or HEDI, is a tool used by more than 90% of America's health plans to measure performance on important dimensions of care and service); (Durrance also referenced Daniel H. Pinks' "Drive" The Surprising Truth About What Motivates Us, as an example of what may be preventing improvements beyond the status quo.) Furthering the comparisons between existing medical practice: Doctors work in their own "space" such as a clinic, surrounding by other practitioners in their respective spaces; medical home practice: with exception of examining rooms, healthcare practitioners function as teams and are assembled as teams in shared spaces; patients are ideally "pre-treated" through could health and preventative practice; Dr. Commander Durrance pointed out that there are associative risks with every heath care provider/patient contact, so medical home practice permits these risks to be minimized through prevention, team analysis, and patient involvement. Existing medical practice has minimal off-site, on-line, or distance communication (the clinic is where patients show up and be serviced). Medical home practice is ideally suited for distance communication and on-line or non-contact communications. Currently the NNMC site lists these areas where patients can communicate, schedule, and manage their heath care protocol.

MEDICAL CONDITION SELECTED FOR "BACK-STORY"

In order to create a sequence of GUI presentations a storyboard derived from chronic and widespread health concerns in contemporary populace will be considered. The medical conditions considered may include any of these:

1) Obesity, and/or
2) Diabetes, and/or
3) Chronic Obstructive Pulmonary Disease

During stages of former research these areas were determined to be of great value as representative modeling guides because patients/recipients can greatly contribute to successful outcomes. (Cathy A. Nonas, MS, RD, "A Model for Chronic Care of Obesity Through Dietary Treatment," *Journal of the American Dietetic Association* 98, no. 10 [October 1998]: S16–22.) The ability of patients to alter and track their diets is a valuable tool in the advancement of general care as well as the Medical Home approach. (John D. Piette, "Satisfaction with Care among Patients with Diabetes in Two Public Health Care Systems," *Medical Care* 37, no. 6 [Lippincott Williams & Wilkins Stable, June 1999]: 538–546.) New findings offer new hope for patients with these type of conditions, concurrently, new healthcare models (such as Medical Home) involve heathcare recipients in the quest for healthfulness. (Judy Friesen et al., "Diets for diabetes: more choices than ever," *Patient Care* 28, no. 15 [September 30, 1994] and Marcia M. Ward et al., "Physician Process and Patient Outcome Measures for Diabetes Care: Relationships to Organizational Characteristics," *Medical Care* 42, no. 9 [Lippincott Williams & Wilkins Stable, September 2004]: 840–850, http://www.jstor.org/stable/4640826.)

These medical conditions are growing at an alarming rate in the United States, yet diet and exercise can mitigate and reverse these conditions; appropriate tools and information can support patients/recipients in their desire to be well. (Paul Gertler and Time Simcoe, "Disease Management: Helping Patients [Who Don't] Help Themselves," [April 2009], 3, http://people.bu.edu/tsimcoe/documents/published/Disease-MgmtHE.pdf.)

Therefore, a storyline that deals with widespread medical conditions within the populace, can be well addressed through a partnership of action on the part of both healthcare provider/recipient, and is a good example of the benefits of a Medical Home model is a most appropriate one to use when modeling the suggested GUI. The medical conditions of obesity, and/or diabetes (type II), and/or Chronic Obstructive Pulmonary Disease will be the guiding medical conditions to develop such a storyline.

CONCLUSION

A node-and-link, gesture-based, graphic user interface model supporting preventive healthcare practice may provide the most effective and flexible kind of healthcare provider/healthcare recipient toolset for the near future. Such an interface model can permit targeted delivery of information on one hand, and big data type analytics for analysis on the other: node-and-link presentations may can be approached from simple icon generation to immense presentation and contextual depth. Further opportunities to switch data through node or link orientations can provide insight into healthdata from global to single patient. Such a tool might be the ideal way to support Medical Home type practice respecting chronic, widespread illness for many of today's healthcare recipients: diabetes, obesity, and COPD included.

NEXT STEPS

The next step is to develop a series of suggested graphic user interface prototype models that are based upon factors contained in this paper. These prototypes will be presented as illustrated and text supported "screen-capture" sequences based upon a contrived storyline. Utilizing the taxonomy presented, in combination with the multiple approach-factors as outlined in this section of the document, our goal will be to create a node-and-link representation that best addresses the full combination of considerations herein. The storyline will be based on the medical condition of obesity, diabetes (type II), or COPD and will have a focus on preventive health. The appropriate kind of publishing technologies (lap top, tablet, smartphone, etc.) will be considered and researched. Based upon this multiple configurations of the GUI may be presented.

BIOGRAPHY / CONTRIBUTOR

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. His first significant project was the *Blackout Procedures Manual* for Con Edison in 1983, and the last was a major *Geospatial Media Mash-up Tool* under U.S. government contract entitled the Geospace and MediaTool (GMT). Mr. Bevington has developed toolsets for transit systems applications, stock trading applications, and health management tools as a principle designer at Spire Integrated Design, New York.

Ann Yi is currently serving as an Information Designer within PIIM. Ann provided research on the node-and-link examples presented in Part 02 of this paper, assembling this part of the document from the collection of findings provided by the author along with her findings, and the efforts of a former PIIM intern, *Manuel Lima.*