NetSon: Perceptual Monitoring of Network Metadata in Realtime

David Worrall
Erlangen, June 2015.

NetSon is a prototype perceptual monitoring tool that uses sound and moving image to display features of an organization's network. Its pragmatic use is to assist people to peripherally monitor the activity the individual parts of a network–the ways in which they converge and interact–or of the network as a whole system. This can help them understand the operational characteristics of the network in real time and while engaged in other tasks.

NetSon can be used to monitor and display an organization's network in a number of configurations: as an IT operational support tool, as a multichannel installation in a building's foyer, or as a streaming audiovisual webcast (in explicit or data-protected versions) from an organization's web- or intranet-site. The techniques used are equally applicable to other Big Data monitoring and exploration challenges.

Big Data
The increased complexity and sophistication of modern computer networks, and the explosive increase in the amount of data that these networks carry, present significant challenges for network monitoring, particularly when performed by humans. For example, security industries and IT communities are beginning to understand that prevention-only approaches to network security will eventually fail. "Rather than just trying to stop intruders, mature organizations now seek to rapidly detect attackers, and respond efficiently in order to limit the damage they might cause." [1]

There are other challenges of Big Data, as recognized by the European Commission's Research and Innovation activities, including "...collaborative projects to develop novel data structures, algorithms, methodology, software architectures, optimization methodologies and language understanding technologies for carrying out data analytics, data quality assessment and improvement, prediction and visualization tasks at extremely large scale and with diverse structured and unstructured data." [2]

The monitoring and exploration of such large amounts of data requires a new generation of tools and methods, including those that rely on human perception. As a technique, *information perceptualization* (principally *visualization* and *sonification*) seeks to create 'polymodal' ways of intuitively conveying abstract information in algorithmically reproducible ways; to use sound and image representations and interactions to take advantage of the broad pathways between the brain and sensory organs to allow users to hear, see, explore, and understand large amounts of information in a short period of time. Like most mammals, humans have evolved as polymodal perceiving bodies. Sight and hearing, for example, are sensitive in different ranges of the frequency spectrum and can be used to attend to spatial and temporal information with different levels of discrimination. So, while our aural perception is clearly superior in differentiating temporal sequencing and frequency discrimination and better adapted to detecting movement in our surroundings, our visual perception is well suited to creating stable 'scenes' that assist us in understanding the spatial relationships between perceptual objects. The impetus for a polymodal approach comes from an understanding that while the separation of the senses can be useful for deconstructive analysis, and we still have a lot to learn about how to use them for detecting information in data, they do not work independently, and certainly not

in isolation [3].

Data Sonification
Somewhere in the fuzzy spectrum of categories of visual expression between realistic representation and abstract expression falls landscape. In music too, that most abstract of the arts, we have a gamut from embodied gestures to algorithmic composition. Data sonification (or simply sonification) can be simply described as the representation of abstract data relations in sound. It occupies a space in the aural gamut similar to that occupied by landscapes in visual art: Just as some landscapes are more representational than others, with sonification, some highlight structures in the data in explicit and reproducible ways, others distort or disguise these structures in the service of extra-representational ideals, such as musical form.

NetSon
NetSon began its development in 2014 for an Art and Technology project at Fraunhofer IIS entitled *Corpo Real*. The metaphor is of a corporation as a living organism as revealed through sonified aspects of its communal activity in interior (private) and exterior (public) representations. The title is a play on the idea of revealing the (corpor)ation's corporeal (bodily) existence through the connective neural 'tissue' of its digital networks.

Our initial experiments in sonification and visualization of network metadata specifically took a decidedly artistic approach, that is, unconstrained by the early need to produce predefined outcomes, at the same time as remaining designerly [4][5]. This gave us greater opportunities than a purely pragmatic approach would have, to discover unusual features in the data; to explore some novel approaches and extreme constraints; to learn, as a multilingual group who had never worked together before, how to function as an effective team to create better understandings and, hopefully, sounder insights into the information in the data. Three examples of this early work are publicly available [6].

<u>The sounds of *NetSon*</u>
The sounds are relatively simple, psychoacoustically speaking; carefully chosen so that they can be listened to for long periods of time with very little fatigue. They are selected so as to combine to form an auditory field or scene in which the individual sounds can be clearly differentiated by selective listening. This is analogous to what occurs at a pond where the frogs and insects produce a chorus of acoustic communication that is essential for their survival in both defense of territory and in attracting mates.

NetSon is currently designed to represent two kinds of network information: individual or group events (for example, activity in Department X, or on Server P) and overall network processes, such as network load. Network load, or the density of network traffic, is represented by fixed-pitches: the higher the pitch, the greater the rate of data flow in the network. The rising and falling of pitches thus depicts the fluctuation of the overall load on the system, much in the same way that the rising and falling of a LED display depicts the varying amplitude of a signal being monitored by a meter. For events, in addition to using identifiable specific sounds for each event type, they are also placed in specific locations in the sound field. This 'sounding objects at fixed locations' approach assists the listener to differentiate the various identities as they appear over time.

Whilst a lot of network traffic is between known entities (file-servers and departments, for example) some traffic, such as email or website data arriving from or being sent to unidentified addresses. In *NetSon*, these communications are represented with glissandi (sliding pitches): a rising glissando indicates that data is to an unidentified location and a descending glissando that it is arriving from one. Furthermore, the durations and range of

these glissandi indicate the virtual distance of those locations from the Institute.

Graphical display

NetSon includes a (realtime, dynamic, auto-adjusting) graphical display of the data being sonified. Initially this graphical feature was added to help users to easily identify the mapping of sounds to identities within the organization. A simple colour-coding that shows the source and destination of the data, enables *NetSon* to display some features of the data visually, others aurally, and still others, both. For example, because a redshift occurs when a light source moves away from an observer, red and blue is used indicate whether data is being received (blue) or sent (red). By varying the transparency of the simple shapes, it is possible to overlay several of them to create visual clusters that adds to the aural perception of flow dynamics within the event groups.

Informal user-testing indicates that these features are easily learned and remembered, and within a few minutes users are able to make observations about the activity of the network. One hears a sequence of events, identifies them through a combination of remembering previous aural events, reading their identity in the dynamic legend and then visually observing how such a sequence relates to previous sequences. Because perception involves both short term remembering and anticipation, careful observation during this monitoring process reveals subtle ways in which in some circumstances the ears lead the eyes and in others, the reverse.

General Comments

NetSon is part of a larger research project concerned with the interactive optimization of parameters for generative polymodal design. As an experimental proof–of–concept, it has yet to be formally evaluated. However, during its development over a period of months in a publicly-accessible space, people passing through have been asked for comments and informal evaluations of various aspects of the system. In this way, many helpful suggestions have been incorporated into the design. General observations by visitors to the *NetSon* installation have been very positive, with some people even describing it as 'happy'. One needs to be quietly cautious about this response, however, as there is research to suggest that the pleasantness of an auditory display is not necessarily indicative of its information-carrying potential, in fact the opposite can be the case!

While *NetSon* has been developed as a proof-of-concept, several researchers who have visited the installation have expressed interest in using it to monitor other processes, such as Internet of Things devices, and this suggests that further development to assist in extracting information from big data might take *NetSon* in as-yet-unanticipated directions, leading to sound, but as yet unseen applications.

References

[1] Bejtlich, R. 2013. *Practice Of Network Security Monitoring: Understanding incident detection and response*. San Francisco: No Starch Press.

[2]http://ec.europa.eu/research/participants/portal/desktop/en/opportunities/h2020/topics/9084-ict-16-2015.html

[3] Merleau-Ponty, M. 2005.Trans: Colin Smith. *Phenomenology of Perception*. London: Routledge, 2005. (Orig. 1945.)

[4] Cross, N. 2006. *Designerly Ways of Knowing*. London: Springer Verlag.

[5] Dewey, J. 2005. *Art as Experience.* New York: Penguin, 2005. (Orig. 1934.)

[6] https:/www.youtube.com/channel/UCDm-NuvqwRkUudUH4Azy7ng/