Project Terms of Reference

auditory display techniques for monitoring networks

KV6003: Individual Computing Project

Grant Allenby / w18013678

BSc Computer Science

Investigative Project

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# Background

The nature of this project is to investigate the usability of auditory display techniques to assist in the real-time monitoring of computer networks. The question this intends to answer is to what level is an auditory display of a computer network useful to a user.

I chose this project from my previous experience as a student. I found that I was inexperienced in monitoring software, both within visual and auditory displays. With visual notification programs such as swatch or min, these are inherently intrusive due to their visual nature. That is why I was excited to learn about auditory display techniques, which can be applied to this problem.

From a student perspective, I consume a lot of my information through audio, as I find this easiest to multitask with, such as a screen reader playing back information to me whilst I work. From my experience as an IT professional, having the ability to listen to information whilst also working on something visual would have been a great advantage in terms of performing multiple tasks, and something I feel other IT professionals could gain an advantage from.

On a more personal level, I use audio in my day to day life nearly constantly, as do many others. However, so much more visual information is fed to us in the modern world that it can be easy to dismiss auditory displays to the wayside as an antiquated idea. I feel that auditory displays are of paramount importance in the modern world, due mainly in part to how busy life is, it would simply be a lot less stressful if information could be moved into an audio-based paradigm, so that our other senses can focus on other tasks.

Auditory display techniques have been around for quite some time, for instance one very well-known auditory display device would be that of the Geiger counter, which echoes out a series of clicks based on the severity of the radiation present within the vicinity. Furthermore, there are many other instances of auditory information sharing that people experience in their day-to-day life, like with notifications on a computer, these share a visual and auditory alert system, but from personal experience as an avid computer user, I notice the audio queues a lot quicker than the visual.

One paradigm of auditory display techniques is that of sonification, which seeks to translate information into non-speech sound (Flowers, 2005). Sonification “seeks to translate relationships in data or information into sounds that exploit the auditory perceptual abilities of human beings such that the data relationships are comprehensible” (Hermann, et al., 2011, p. 9). Sonification translates information into non-speech audio in order to convey information to the user. One major problem of audio sonification however is the lack of a flexible software or tool that would allow the idea of auditory display systems to be further utilised by users (Flowers, 2005).

The domain I will be working in will be mainly based around IT professionals and network administrators, as with my project focusing on real-time network monitoring, this clientele would be the most likely to use and understand the project. With the particular highlight of network traffic, as well as the mention of web server workload, I plan to use a similar method in producing an auditory display technique for monitoring computer networks.

This project would be aimed at network administrators, as from prior investigations auditory display techniques and Sonification have been used in ways such as botnet detection (Vickers & Debashi, 2018), creating a ‘soundscape’ of network traffic (Gilfix & Couch, 2000), and another being the sonification of web server workload (Barra, et al., 2002). This can be seen as useful to many network administrators who have to handle these situations, such as aggressive botnet phishing attacks. This work within botnet detection and network traffic soundscapes is what initially piqued my interest within the project.

The most important idea that will define this investigative project is the term ‘Usefulness’, as since these systems exist in some capacity and have been growing for a while, it will be key in finding how effective they are, how user friendly they are, and if they could be used in a realistic manner within a network domain. This will ultimately determine the usability of an audio-based network monitor.

This idea came to mind through discussions with the project supervisor, in which different ideas were brought up, and through further reading. From reading about the soundscape of network traffic (Gilfix & Couch, 2000), I found myself drawn to the idea of a real-time auditory display of network traffic for the IT professional. I was immediately intrigued about the usefulness of an auditory display of network traffic to the IT professional, and whether this kind of display could be used more generally.

# Proposed Work

The proposed project is to investigate different audio-based network monitoring systems such as the aforementioned botnet system, gathering the required information such as whether this project will use a parametric or non-parametric model and the software that will be used. This will ultimately bring forward an investigative project that highlights the usability of audio-based network monitoring systems.

This investigative work will involve reading into different tools used to aid in translating the information into something that can be manipulated within programs like SoniPy, such as with SoNSTAR (Debashi & Vickers, 2017), which is currently being used to complement intrusion detection systems (IDSs). SoNSTAR is defined as “a monitoring tool developed to complement existing IDSs to provide another degree of flow granularity to operators, helping them to understand how a specific network operates and behaves” (Debashi & Vickers, 2017, p. 1).

Investigating whether ideas like pitch coding of numeric values would be something applicable to this project, or whether “temporal or rhythmic patterning of loudness levels, especially when integrated into pitch and timbre defined data streams” can be more efficient for this type of auditory display (Flowers, 2005, p. 2).

Investigating whether software exists that can be used to perform the investigation of usefulness in auditory displays will be a particularly important aspect of this project. If this is not possible, then further investigation and development of an application that will allow this will be needed.

Looking into programming languages that can be used, Java, Python and JavaScript have all been particularly highlighted within my investigation. There are a few web based sonification applications that exist, as well as the Python-based SoniPy and the Java-based xSonify.

I will have to also cover user studies and analyse data in order to build a full picture of how auditory display systems showcase data as well as how their overall effectiveness is measured. SuperCollider is also a potential programming language that can be used as this possesses real-time synthesis capabilities.

# Aims of Project

The aim of the project is to investigate auditory display techniques to monitor real time network traffic, determining their overall usefulness in comparison to established techniques.

# Objectives

Objective for this project are as follow:

* Literature and source review
* Establishing software and report requirements
* Design of software
* Implementation of software
* Design of user study
* Implementation of user study
* Analysis of results
* Evaluation of report
* Conclusions
* Write dissertation

# Skills

There is no flexible tool to utilise sonification in an effective way, however more specific applications do exist. I will have to learn about different sonification and auditory display software programs such as SoniPy, which would require knowledge of the Python programming language, as well as xSonify, a Java-based application, would both require learning particular programming knowledge centred around auditory display techniques. There is also SuperCollider, a real-time synthesis language that has been in development for a number of years, that would be ideal for this project, however this would require understanding of the C++ programming language (McCartney, 1996).

I am familiar with multiple programming languages to a degree from my prior knowledge attained from Northumbria, as well as from my own independent learning throughout my years at Northumbria.

Since I am going through BSc Computer Science (i.e. general Computer Science without a specified pathway), I am broad in my understanding of other programming languages and paradigms. This makes this task relevant with the requirements of this project, and I will be able to sufficiently build on this.

I must learn different ideas about auditory displays, such as pitch coding of numeric values, which means to translate numeric data into a pitch or frequency, in order to define that this sound is a reflection of this data, which has been shown to work, however calibration based on the specific scenario will be needed (Flowers, 2005).

I will also have to acquire knowledge of user studies, such as how they are performed, what I will need to perform these, whilst also considering restrictions on things such as the current COVID-19 situation making face-to-face studies unlikely, and therefore a remote study will have to be performed.

I will also have to expand my knowledge on data analysis, looking into ideas such as qualitative and quantitative paradigms, as well as how to effectively use these paradigms to efficiently collect and understand the data to be collected.

# Bibliography

Barra, M. et al., 2002. Multimodal Monitoring of Web Servers. *IEEE Multimedia,* 9(3), pp. 32 - 41.

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Flowers, J. H., 2005. *THIRTEEN YEARS OF REFLECTION ON AUDITORY GRAPHING: PROMISES, PITFALLS, AND POTENTIAL NEW DIRECTIONS.* Limerick, Ireland, International Conference on Auditory Display,.

Gilfix, M. & Couch, A., 2000. *Peep (The Network Auralizer): Monitoring Your Network With Sound..* New Orleans, LA, USA, Usenix, p. 109117.

Hermann, T., Hunt, A. & Neuhoff, J. G., 2011. *The Sonification Handbook.* Berlin, Germany: Logos Publishing House.

McCartney, J., 1996. *SuperCollider: A new realtime synthesis language.* Autin, TX, USA, International Computer Music Conference.

Vickers, P. & Debashi, M., 2018. Sonification of Network Traffic for Detecting and Learning About Botnet Behavior. *IEEE Access,* pp. 33826 - 33839.

# Resources

The resources of which this project will need to be completed is access mainly to software such as the ones mentioned within the skills section. This software is free and open source, and I have access to hardware capable of running these from home. This means potential access to SoniPy, xSonify and SuperCollider, however these are all open source and easily accessed.

# Structure and contents of project report

## Report Structure

The project report structure and contents consist of an Abstract, introduction, analysis, synthesis, evaluation and finally conclusion. The Abstract section will comprise of a general but concise description of the context of the report in regard to auditory display systems, discuss the usefulness of these systems to a user, the different ideas used to test these systems, highlight of results and a conclusion.

The Introduction section will compromise of what the idea of sonification is, followed by technologies relating to audio sonification, as well as state the reasons for producing this project, continuing on to talk about how this projects purpose is to verify how useful are auditory display systems for network monitoring are. Following on from this,

The Analysis section will contain a section for literature review, critically analysing the information to aid in discussing to what level these projects in auditory display were ultimately useful to the end user. Following on is the justification for the choice of an investigative approach to the project will be included. This section will also discuss how the choices for user testing were to ultimately compare toward projects such as with the soundscape for network traffic. This would then verify the initial question as to if this software would be useful. This is when the ethical issue for use of user testing will be discussed, particularly with current COVID-19 guidelines and how to assure the project is risk free.

The Synthesis section will compromise of two sub sections, firstly discussing the design of the system, how this will aid in terms of achieving the goal of this papers question. The second section will contain the design of the experimental study, including the structure of the experiment, it’s process and how the results are evaluated.

## List of appendices

Project type

This project is an Investigative report,

# Project Plan - Schedule of activities

Gantt chart of scheduled activities

# Appendix

## Ethics Form –

## Risk Assessment Form