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<td>Frohlich, Robert.</td>
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Managing Technical Resources - Radio

Robert Frohlich
tfrohlich@ntu.edu.sg
telephone: +65 790 6453
fax: +65 792 7526

Division of Electronic and Broadcast Media, School of Communication Studies, Nanyang Technological University, Singapore

BACKGROUND

In the early days of radio, programmes could only be produced 'live'. Performers and production personnel had to 'get it right the first time' as no methods for postproduction were available. With the advent of tape recorders, post-production was born. Programmes could be edited through physically cutting the tape with a razor blade, and splicing it together in the desired sequence. Mistakes could be edited out of programmes and effects could be added. The introduction of multi-track audio recorders meant that producers could assemble their work during multiple passes. Rerecording discrete performances, whilst listening to the material previously recorded on the tape, actors, musicians and producers were able to refine the quality of performance and in turn the quality of the programmes produced. Radio production could be undertaken in a more flexible manner than previously available. Different versions and mixes (balances) of the combined tracks on the multi-track recording could be produced, and the most appropriate could later be selected. Editing, utilising source machines and a record machine, also offered similar flexibility for postproduction. Programmes could be edited repeatedly until producers were satisfied with the final product. A major problem existed, in that, if a subsequent change was desired, a complete re-edit, from the point in the programme where the change occurred, was required or a loss of audio quality would be encountered through generation loss and the addition of noise.

The integration of computers within the radio production environment, enabled various replay devices to be automated, thereby providing multiple sources which could be combined to form the final programme. In post-production, re-edits could be automated, so that the original sources could be re-used ensuring that no generation loss would ensue. This additional flexibility and control within the production process, has led to a higher complexity being expected of the technical resources. The cost of these resources has also increased in line with the desired complexity. Staying abreast with the technology available to the broadcast industry became more and more difficult for broadcasters, especially in developing and less affluent countries, as it was becoming more and more expensive to be able to possess this high level of resources.

The convergence of digital technologies, currently under way, may be creating problems for managers of technical resources for radio. Will the huge capital investments that they have made in analogue technologies need to be replicated for the new digital technologies, or will they still be able to utilise their legacy equipment within this future broadcast environment? What are the cost savings, in both capital expenditure and time, through more streamlined production processes, that may be realised through the integration digital technologies in analogue broadcasting?

DATABASES FOR TECHNICAL RESOURCE BOOKING

Relational databases are a computer technology that may be employed to help streamline the booking and costing of resources and facilities, as well as the cataloging of large collections of broadcast and archived material.
Through the use of customized relational databases, individual users are able to see the availability of all facilities and resources that may be required for their individual productions. They can then enter their required bookings and receive a confirmation as to the booking status. If approval is required, from supervisors and management, reports can easily be generated of all outstanding bookings so that they can be individually approved or approved in bulk. Users can readily generate reports of confirmed bookings and bookings pending approval.

The instantaneous nature of this type of booking system allows better utilization of facilities. If a booking is cancelled, that time-slot becomes instantly available for other bookings. If a resource requires maintenance, it is simple to block it out of the system until it is available again. If there are existing bookings for resources that need emergency maintenance, reports of these bookings can be generated so that alternative resources can be sourced and booked.

On the financial side, broadcasters who use an internal costing or billing system can readily generate reports of resources used by individual departments or programmes, so that billing procedures can be implemented. Even if internal costing is not an issue, these reports can be used to show the utilisation of individual resources and highlight resources that are heavily used and may require duplication.

DIGITAL AUDIO

Digital audio has been a part of radio broadcasting since the introduction of the Compact Disc (CD), in the early 1980’s, but it is only recently that the prevalence of digital technology has enabled some broadcasters to utilise digital signals exclusively for programme creation, distribution and on-air broadcast. CD’s employ Pulse Code Modulation (PCM) to derive a binary representation of the original analogue audio signal. The audio signal is sampled 44,100 times per second (44.1 KHz sampling frequency), and a digital 16 bit binary word is created. A 16 bit word can have 65,536 discrete values which represent the amplitude of the audio signal at a given time instant (1/44,100th of a second). The audio signal can be ‘re-created’ by a replay device generating an audio signal whose amplitude matches the numeric representation contained in each digital word. This replay process also occurs 44,100 times per second, producing modulated waveforms similar to those which made-up the original audio signal. This PCM technology produces audio reproduction with a frequency response of 20 Hz to 20 KHz and 96 dB of dynamic range, although in the higher range of frequencies it does not faithfully reproduce the wave-shape of the original material. An audio signal with a 10 KHz square wave, digitized at a sampling frequency of 44.1 KHz, will be reproduced as a 10 KHz sine wave. This frequency response and dynamic range surpasses the requirements of FM broadcasting.

To facilitate a more faithful reproduction of the original analogue signal requires increasing both the bit rate and the sampling frequency employed in the digitizing process. The data stream required for stereo, 16 bit, 44.1 KHz digital audio is in the vicinity of 10 MB per minute and higher bit rates and sampling frequencies translate to higher data requirements. 24 bit, 48 KHz sampling has been common in the recording industry for some years and recent developments for the Digital Versatile Disc - Audio (DVD-Audio) have employed sampling frequencies as high as 192 KHz to attempt to replicate the nuances of audio signals. This 24 bit, 192 KHz sampling provides an audio frequency response of up to 96 KHz and a dynamic range of 144 dB. Another recent development by Sony and Philips is the Super Audio Compact Disc (SACD), which employs Direct Stream Digital” (DSD”), 1 bit sampling at a frequency of 2.8224 MHz to produce a frequency response of more than 100 KHz with a dynamic range of 120 dB. The dynamic range that humans can hear, is approximately 140 dB, as sound louder than 0 dB Sound Pressure Level (SPL), is audible (depending on frequency), and the threshold of pain is 140 dB SPL. This means that current recording technology can faithfully reproduce the full spectrum of sound that is audible.
LOWER COST DIGITAL RECORDING

Digital Audio Tape (DAT) has been used for the past decade to record digital audio. It offers full 16 bit PCM at 44.1 KHz and 48 Khz, and so has equal to or better than CD quality. DAT is commonly used for recording on location and in studio production. MiniDisc (MD) is a very economical alternative to DAT if the highest standard of audio quality is not required. In order to store 74 minutes of stereo audio on a 64 mm magneto-optical disc, it samples at 44.1 KHz, and uses a data compression process called Adaptive Transform Acoustic Coding (ATRAC) to reduce either a 16 bit or 20 bit word to a much lower bit-rate. This type of data compression is known as 'lossy' compression, because the data that is removed and discarded is never returned to the audio signal. ATRAC makes use of two psychoacoustic phenomena to eliminate 'unnecessary' sound information anticipated to be unheard, and so not perceivable to the listener.

One of these phenomena is based on the equal loudness contours, charted by acoustic researchers Fletcher and Munson in 1933, where they quantified the non-linearity of perceived loudness in human hearing across the audio spectrum of 20 Hz to 20 KHz. At low SPL's, both the low and high frequencies of a sound are inaudible, but as the SPL increases, hearing becomes more linear. The plots in figure 1 join points of equal apparent loudness at the different frequencies within the audio spectrum. It can be seen that at frequencies below 90 Hz, amplitude of less than 40 dB SPL will be inaudible and that our hearing is most sensitive between 2 KHz and 5 KHz. ATRAC removes and discards the data created by audio signals that are calculated to fall below the threshold of hearing upon replay.

The other psychoacoustic phenomenon is 'masking', whereby a louder sound will mask softer sounds of a similar frequency. The louder sound will be audible to the listener, and take precedence so that the softer sound will not be perceived. ATRAC splits the audio spectrum into 32 discrete frequency bands and analyses the audio components of the digital signal and discards the data for sounds that are calculated to be masked by others.

The resultant sonic quality of audio recorded on MD is not of as high a standard to that recorded on DAT. For classical music and other content requiring subtle timbre and tonal nuances, MD may be found to be of somewhat inferior quality, but for speech and popular music it is an adequate recording medium. MD however, has a number of major benefits over DAT. MD accesses the data stored on the disc nonlinearly. Basic edit functions can be easily performed on the material and the sequential order of the data can be rearranged. With this function, combined with MD's extremely compact size, journalists can perform basic edits on their material whilst on location, or in transit. MD can store up to 74 minutes of stereo audio, or 148 minutes of mono. The magneto-optical media is a very robust storage medium. It is not susceptible to magnetic fields or mould, unlike the magnetic tape used for DAT, and high temperature (180° C), is required to erase the data from disc. Discs can be re-recorded more than 1,000,000 times and still store the data reliably. Portable recorders are available for under US$300 and the discs cost less than US$2 each. Non-portable recorders are also available for studio use and offer more precise editing functions than the portable recorders.

IMPROVED AUDIO QUALITY

Audio and radio production techniques have evolved to be highly complex and require sophisticated procedures which often require many hours of creative decision making during the actual production of a programme. It is partly through these technological developments, that production processes have been refined to the point where high quality audio has become an expected and integral part of modern broadcasting. The sophistication of receivers and listening environments has also led to the technical quality of programmes needing to be of a higher standard, in order to be recognised as being of an acceptable quality. With the introduction of Digital Radio, consumers will become even more conditioned to possibly
perceive technically inferior programs as being of low quality, when previously the same standard was perceived to be acceptable.

PRODUCTION TOOLS

Radio production has historically been a capitally intensive exercise and many broadcasters had relatively limited access to complex post-production facilities. Previously, capital budgets in the millions were required for broadcasters to be able to offer high standard post-production facilities. For many broadcasters, even if a high-end post-production facility was available, it was usually stretched to afford producers much more than the minimal time required to post-produce their programmes using fairly standard post-production techniques. There was rarely time available for producers to access these facilities and be able to experiment, as they usually had to focus on producing their programmes. They did not have the time to try out the integration of many of the production effects available for modern radio production.

The digitisation of audio has led to a quantum leap in production processes. Audio can now be digitised and stored on a hard-disk for later editing and mixing. Digital audio workstations (DAW's), incorporate relatively inexpensive proprietary hardware and software (for digitising the audio signal) in a standard high-end Macintosh™, Windows NT TM or proprietary computer system. Instead of having to spend time changing reels of tape, and spooling from one end of a piece to the other, in these non-linear production environments any desired point on a digitised source can be accessed instantly. Screen based, 'Virtual' mixers can repeatedly recreate the precise adjustments desired, without any loss in quality. Mixes and edits can be revised without any loss of quality through repeated changes being able to be made to the edited material.

The advent of these non-linear audio production environments has led to a revolution in the way that production is undertaken and the ensuing technical resources and facilities required. Where previously, huge investments were required by broadcasters, in order to provide high-end facilities, now non-linear audio workstations can be provided relatively inexpensively. Various manufacturers produce DAW's. These include ProTools® from Digidesign ™ (a division of Avid Technologies Inc.), SADIETM from Studio Audio & Video Ltd., and MFX3™ from Fairlight ESP Pty. Ltd. There are versions of ProTools® available for both Macintosh TM and Windows NT TM operating systems, whilst SADIETM is only available for Windows NT TM and MFX3™ utilises a proprietary computer system. These systems range in price from as little as US$895 for the ProTools ™ budget ToolBox™ (excluding computer, monitors and disk-drives).

This affordability has enabled the economic construction of networked systems to link various studios or suites, where producers are able to perform recording, editing and mixing sessions for their programmes in any suite and even edit identical material for different programmes simultaneously in different locations.

Through the use of the screen-based 'virtual' mixers, provided in these DAW's systems or the current range of relatively inexpensive digital audio mixers, such as the Yamaha™ 02R (costing approximately US$6,000), many of the functions previously available only on expensive high-end consoles and through the use of auxiliary devices are provided within the DAW's. The digital signals can be amplified, attenuated, equalised, compressed, gated or expanded, and effects such as echo, reverb, pitch-shifting and time-expansion and compression can be easily incorporated into production processes, and because all functions can be automated, any mixer setting can be recreated at a later date. The relatively compact size of both screenbased mixers, and mixers such as the 02R, is achieved through the use of assignable controls, where the numerous control knobs, buttons and display functions are not repeated for each channel, but are assigned to individual channels. This allows DAW's to be comfortably housed in areas that previously could not accommodate larger analogue consoles.

Integration of a relatively inexpensive CD writer, with the DAW's, allows finished programmes to be stored on CD, so that they can be aired directly from a conventional CD player. If re-writable CD-ROM (CD-RW)
burners are used, they provide the reliability of magneto-optical discs whilst providing storage for the whole uncompressed digital audio signal, as opposed to the compressed data stored on MD.

However, care must be taken in the selection of storage media, as most CD-RW's are not readable by conventional CD players.

Digital signal routing should also be utilised between all pieces of digital equipment in order to facilitate loss free transfer of audio data.

RADIO PRODUCTION TOOLS

Digital Audio Broadcasting (DAB) offers a number of advantages over analogue broadcasting through FM and AM. Eureka - 147 is the standard for DAB that has been adopted for DAB in Singapore and other regional countries establishing DAB, including Hong Kong and Australia. For this reason Eureka - 147 is the format of DAB that I shall discuss now.

DAB's digital audio is transmitted in a compressed form (MPEG), which is said to be of CD-like quality. Analogue radio signals have been subject to many kinds of interference between the transmitter to the listener's radio. Mountains, tall buildings and atmospheric conditions usually cause this interference. DAB utilizes a number of regional transmitters and the receiver always selects the strongest signal automatically, without needing to be manually retuned. The DAB signal is not affected by interference as it is made up of binary data in the form of squarewaves and the superimposition of interference noise does not affect the rise and fall on the modulated data. A major cost benefit for broadcasters is that the electrical power requirements for DAB transmission are less than 1 % of that required for FM transmission.

A single DAB transmission (ensemble) contains multiple discrete programme sources combined through a multiplex process. The content of the ensemble can be varied dynamically and may include up to 6 high quality stereo programme streams or up to 20 lower quality mono streams, depending on the level of digital compression used and thereby the bit-rate of the resultant signal. DAB can also carry text, pictures, data and even videos, in the form of Programme Associated Data (PAD) and NonProgramme Associated Data (NPAD), and so lends itself to new and innovative business models. A major obstacle in the widespread implementation of DAB within developing countries is the relatively high cost of the current generation of receivers, with little available under US$500. In the future, as DAB becomes more prevalent, this financial barrier should be reduced, as the technology becomes more common and the manufacturers are able to recoup their research and development costs through increased unit sales.
CONCLUSION

With the aid of low cost digital audio recorders and DAW's it is now possible to offer broadcasters more creative control of their programmes. Both through the time saving afforded (by non-linearity), the portability of the re-treatable production environment and the cost savings for recording media, broadcasters appear to have a richer and more flexible production environment. These factors coupled with the use of databases for technical resources as well as on-air control, will see the economic production of relatively complex radio programmes in the future.

REFERENCE

Studio Audio & Video Ltd. http://www.sadie.com