GOING…GOING…GONE DIGITAL – A BBC NETWORK RADIO PERSPECTIVE ON 'HARD-DISK' PLAYOUT

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1 INTRODUCTION

The BBC broadcasts 12 UK wide radio channels to listeners in the UK over FM, AM, DAB, Digital Satellite/Terrestrial TV and the internet. For many years the number of channels was stable and has now increased with the introduction of digital transmission platforms in the UK.

BBC Radio commissions radio programmes from in-house production teams and from independent producers. It carries a wide mix of programmes including live concerts, pre-recorded talk shows and DJ based music programmes. All these programme-makers have differing requirements, but the BBC has been able to pull these together to use a single, hard-disk based audio system for supporting production, playing out on-air and, shortly, archiving programmes.

The hard-disk audio system is more than just a jukebox for pop music tracks. As well as simple tasks for DJ programmes, such as playing music, jingles and trails, it is responsible for playing out some radio channels for long parts of the day automatically, acting as the live store for pre-recorded programmes and ensuring that they are all played out in the correct order, reliably, and in high audio quality.

This paper sets out benefits for radio broadcasters of using a hard-disk audio system and focuses on the associated technical issues for audio. The users' requirements are considered, placing the system in the context of the business of broadcasting and its workflow.

2 SETTING THE SCENE – USING A HARD-DISK SYSTEM

2.1 Benefits For Broadcasters

Analogue technology evolved to meet the requirements of radio broadcasters. The functionality is still required, although the exact usage can change with the flexibility offered by computer based audio systems. Consider two types of radio programming: a DJ music show and a live talk/magazine show. Each has different requirements from the technical systems. Previous working practices and changes with new technology are outlined to demonstrate the advantages hard-disk audio systems can bring.

2.1.1 DJ Music Show

Take the example of a three hour long DJ music show in the 1980s. The show would mainly be music tracks played back from records or CDs, with each item on its own disc. As well as music, the DJ would talk and play jingles, trails for other programmes and other pre-recorded clips. This meant the DJ would bring circa 70 CDs or records, plus a set of NAB cartridges with jingles and open reel tapes into the studio. To produce a show that sounded slick, the DJ would need to find the next disc

to play against a running-order for the show and cue the discs up, so the music would start when he/she wanted it to. The audio levels would have to be checked for each track played. Plus the running-order timing could never be perfect, because of slight variations in playback speed on the various machines. The NAB cartridges would automatically cue-up, which helped a little!

Translate this same example into a world with a hard-disk system. The music tracks are all preloaded into the hard-disk system – all the regularly played music tracks (approximately 10,000 tracks) are always available in the system. Therefore, it offers the DJ a running-order with the music schedule ready to play.

Cueing-up has gone too. Each track on the system is already edited to be 'near perfect', with no silence at the start or end of the tracks. This means the system can accurately countdown to the end of the track to help the DJ. The DJ still has freedom to choose the schedule, as the system does not force him/her to follow the running order.

Jingles have changed too. Where in the past, the DJ might have a maximum of four or five jingle cartridges ready cued up in players, now he/she has instant access, using touchscreen technology, to many jingles and clips.

This all helps the DJ produce a show that sounds impressive to the listener.

2.1.2 Talk Show

A talk show, or 'magazine' programme, works differently. It is primarily a broadcast of live studio guests, possibly with additional pre-recorded clips from other guests or interviews. If the programme is broadcast live on-air, then the production team will use the hard-disk system to play back clips. It can also be used to record the programme This is particularly useful where programmes are recorded for later transmission, as the completed programme is already in the system ready for playout.

Some production teams prefer to use the other audio editing systems and software which have more appropriate functions and facilities for their programme making, such as drama. This can be used with the files then transferred into the main hard-disk system for later playout and archiving.

2.2 Keeping The Audio – Archiving

The benefits of a digital hard-disk system created a discrepancy with the business workflow for keeping programmes in the archive. Earlier in the BBC's life, only recordings that were considered to be valuable programmes were archived, and many live programmes were only 'sampled' for the archive. However, with the ever decreasing cost of hard-disk storage this now has the potential to be reviewed.

Archiving is not required for music tracks. The commonly played tracks are stored in an active working area for anyone to access, live.

The situation for pre-recorded programmes is more complex. In the past, all programmes were prepared for broadcast on physical media (e.g. a reel of tape) and any important live programmes could be captured in the same way. Archive staff would simply collect the physical item and store it. The 'asset' was easy to find and, as long as the storage centre was physically large enough, the archive process worked.

The hard-disk audio system has brought a new process to be managed. For example, during an early trial of a fully integrated broadcast production and playout business process, it was quickly realised that the Archive were not capturing these trial programmes, because there was no actual physical media to be collected and saved. The Archive's business practices needed to change too.

Although some programmes do still arrive on physical media (e.g. CDs from independent production companies), many programmes have a 'virtual' existence in the hard-disk world. A process is needed to collect audio from the active workspace areas and deliver it into an appropriately sized and resilient archive structure. Otherwise 'magnetic storage history' repeats itself and valuable programmes are 'recorded over' on the hard-disk to make way for new ones…

2.3 Benefiting From The Extra Data

It is time to mention the word 'Metadata' – in the broadcasting context, this means data related to a prorgramme, for example production team credits, record labels, and other useful programme related information.

One advantage of having all the audio content in a computer based system is that information about what was broadcast, and when, is easily retrievable. This helps support the business side of broadcasting, as well as benefiting the listener.

For example, royalties are paid for most music tracks played on-air. This data was time consuming to capture when a DJ brought a collection of CDs and records into a studio. With a computer system, this information, together with playing times, can be captured automatically and processed quickly.

The listener experience can be improved. Text displays on DAB or FM RDS radios can show information that is linked to playout 'events' in the computer system's schedule, for example displaying the titles of tracks currently being played.

And in the future as more detailed programme information is stored and indexed electronically, it provides the ability for segments of programmes to be easily identified.

3 TECHNICAL ISSUES

3.1 Quality – An Introduction

The technical quality of a digital audio recording/playback system far out-performs the old analogue formats of tape, records and, especially, NAB jingle cartridges. There is a huge leap in the technical performance: frequency response, distortion, speed accuracy, dynamic range/signal to noise ratio and phase response.

However, digital hard-disk audio systems are not perfect. Other issues have to be considered to maintain this same level of quality throughout the overall broadcasting chain – from microphone to the listener; issues such as such as reliability, storage format, sample rate and dynamic range.

3.2 Staying 'On-Air'

The old analogue technology was surprisingly reliable!

Tape recorders rarely failed while playing a pre-recorded programme live on-air. And if one did fail, then the operator simply lifted the tape spools off the machine and put them on another. The listener heard only a slight gap in the programme; often, by the time the announcer had apologised for 'technical difficulties', the programme was ready to restart.

This mobility of the playback media also provided 'geographic' resilience. For example, if a complete studio failed, the team would carry the tapes and discs into another studio and carry on where they left off. This all led to a very reliable service.

Unfortunately, hard-disk audio inevitably brings with it the word 'computer' and everyone has experienced the apparent unreliability of computer systems. When a computer stops, it frequently needs rebooting, which may or may not cure the problem. This all takes time – longer than the announcer would normally be expected to apologise for!

Computer systems can appear to fail in three main ways:

- Hardware faults (disk drives etc.)
- Operating systems/software locking
- Network traffic.

Let's consider how these potential problems can be overcome to provide a similar level of reliability to that provided by the old analogue systems.

Overall, the system chosen by BBC Radio is structured to minimise these problems. Usual broadcasting practices are then also applied to increase the overall reliability experienced by the listener.

BBC Radio's hard-disk system uses four separate central cores. Each core has database servers, audio storage and Storage Area Networks (SAN), using Compaq/HP Alphaservers running OpenVMS, i.e. these are a much higher specification than standard PC configurations. Each core is distributed over a number of equipment rooms and different buildings. Also, each studio uses a professional high availability server to play back and record the main audio. A typical studio will also have one or more 'standard' PCs, normally used for playback of jingles, but which can also be used to play programmes or music on-air, thus minimising the risk of 'silence' on-air. This all helps to make the studio systems highly resilient.

Geographic resilience has been built-in. Audio can be downloaded into studios in different buildings around the UK.

Great care has been taken with network design. Reliance on the 'free for all' nature of Ethernet networks is reduced by automatically downloading music and programmes, in advance, into the local playout servers in the studios where the material will be broadcast. Typically a rolling 12 hours of programming is stored locally in the studio servers prior to transmission. Even if a last minute change is made to a programme, or another studio needs to play new audio, the system starts to download the required audio file to the local server as quickly as network traffic will allow. This is, on average, faster than the data rate for live audio streaming. The local server will then start to playback as soon as the first audio data has arrived and so this 'buffers' the audio file onto the local server's storage. The system architecture, in this way, offers more resilience than simply streaming live audio from a central server.

Even though the software and operating systems on the main hard-disk audio system servers are highly reliable, problems could arise due to other PCs on the same network. To reduce the risk of a denial of service attack, for example, created by a virus on an office PC from affecting the audio system's network – the core business of broadcasting – all the key servers and other client PCs are connected on a separate network, known as 'The Medianet'. The Medianet does not carry office traffic such as email although, inevitably, links are needed back to the office business network, allowing producers to plan programmes and edit audio from their offices. The Medianet and office networks are linked by routers and ultimately 'Rip-cords', fibre connections which can be unplugged to separate the networks completely in the event of a major virus causing traffic problems on the office network.

This overall structure and design gives excellent reliability to the listener.

3.3 Compressed Or Linear?

'Lossy' compression systems are extremely popular. Formats such as MP3 and Windows Media are successful because they reduce the data capacity required for storing or broadcasting digital audio. Whilst there is a loss of quality, it is not noticeable to the average listener using their digital radio in the kitchen or listening to an Apple iPod in the car.

The quality of sound is determined by the degree of 'lossy' compression used. In the UK, these digital systems range from listening over the internet, to listening to a DAB digital radio in the car or the kitchen, or to listening in your living room, through a TV Set Top Box.

Broadcasting uses bandwidth, which is a scarce resource. Digital broadcasting allows broadcasters the choice of deciding how to allocate their given data capacity to the listener. For example, broadcasters in the UK have chosen to maximise the number of radio stations by using a higher degree of 'lossy' compression, which still provides acceptable sound quality.

Many of the hard-disk systems have used 'lossy' compression. If a 'lossy' hard-disk system plays audio over a 'lossy' transmission system to the listener, there would be another reduction in audio quality. To maximise the quality heard by the listener, without having to increase transmission bitrates to compensate, the BBC decided to insist on using linear audio in the hard-disk system with no compression.

However, this causes costs to increase for the hard-disk audio system. For example, larger hard-disk storage capacity is needed to store all the audio linearly. Also, the data network linking the servers has to be sized appropriately. But all these costs are substantially less than the cost of increasing bitrate to the listener.

3.4 Signal Level – Does It Matter?

The audio level is important. Audio on CDs typically peaks to the maximum possible digital signal (0dBfs). This is acceptable for 'final playout' audio stored in the hard-disk system, such as jingles and music tracks. But imagine trying to balance a live magazine show with many guests talking at the same time. The levels will vary wildly and a sound engineer could only aim to peak to 0dBfs without distortion by using audio limiters, which would be 'over-used' and so would sound harsh to the listener.

A compromise is needed. Theoretically, the hard-disk system could carry audio recorded at different peak levels. In real life, inevitably mistakes will be made about choosing the correct playback level. This approach would also not meet the need for automation, where the system will play back a range of audio tracks without a sound engineer present.

So what is the solution? When digital recording first started, BBC Radio used a nominal peak level of 10dB below digital full-scale for recording live programmes. This was chosen because it had been found to guarantee that no peaks were clipped during normal productions, whilst only marginally reducing the technical quality due to the limitations of the 16bit depth of CDs. A compromise of 4dB below full-scale has been used for the hard-disk system.

3.5 Sample Rate – 48kS/s Is Correct Surely?

Analogue audio is surprisingly easy – there is no choice of sample rate. Today the most common 'standard' sample rates are 44.1kS/s for CDs and 48kS/s for digital radio/TV. There are higher rates such as 96kS/s and 192kS/s used for some high resolution 'master' recording.

One could choose to run the entire production and playout system at the highest common denominator…currently 352.8kS/s for DXD – "Digital eXtreme Definition". However this has a significant effect on hard-disk storage capacity. For example, a standard CD music track would occupy eight times more space on the hard-disk than the original CD. This would not be a problem for commercial 'master' recording, where the quality is needed to produce DVD-Audio discs, but it would not be a good choice for storing large quantities of audio programmes.

This leaves a choice between the two 'standard' sample rates, 44.1kS/s and 48kS/s, both of which are used in the broadcasting industry. 48kS/s appears, at first, to be the most pragmatic choice, because the digital transmission formats for DAB digital radio and DTT/DSat digital 'television' all use this. Therefore, 48kS/s would allow the hard-disk playout system to deliver directly into the transmitters.

However, considering the overall broadcasting chain suggests a different answer. Much of the audio is still delivered to the hard-disk system on CD, which is sampled at 44.1kS/s. BBC Radio chose to run the entire live studio and playout infrastructure at 44.1kS/s, because no sample rate converters are needed within studios; just one sample rate conversion needs to be made, at the final point where the signals enter the digital transmitter distribution systems.

Although today's sample rate converters have excellent specifications, converting audio many times in a broadcasting chain is not good practice because it will deteriorate the quality heard by the listener and increase costs.

4 SUMMARY

'Going Digital' is easy to say, but is difficult to achieve well. The BBC has successfully integrated a hard-disk audio system into the business, providing new benefits but without changing the nature of programmes heard by the listener.

BBC Radio's hard-disk audio system is a key component in modernising production, playout and archiving of radio programmes. Whilst this system has had to be configured to support existing working practices, it has led to significant changes in workflow. This has in turn improved the way programmes are made for many programme makers and other users. Nearly 90% of BBC Radio's output is now broadcast using the hard-disk audio system.

The concentration on reliability has paid off. For example, 'BBC7' – a new digital station – uses the automation facilities of the hard-disk system for more than twenty hours a day on-air. BBC7 has the highest record of reliability amongst the BBC national stations.

BBC Radio continues to engineer a balance between assuring audio quality for the listener and working within the technical constraints and business practicalities of evolving digital technology.