BBC

R&D White Paper

WHP 017

January 2002

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Research & Development
BRITISH BROADCASTING CORPORATION

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Abstract

When the BBC launched its digital services in 1998, it tripled the number of its public TV domestic channels and the number of delivery platforms it would be serving directly. It needed to install a means by which it could automatically and remotely monitor that it was delivering its digital content correctly. This paper describes monitoring facilities installed and under development that check the DVB transport streams for correct content as well as compliance with the Measurement Guidelines for DVB Systems published by ETSI as ETR290. The challenge of monitoring intermittent components such as DVB subtitles and Digital Text services is also considered, and a potential solution offered.

This document was originally published in the Conference Publication of the International Broadcasting Convention (IBC 2001) Amsterdam, 13–18 September 2001.

Key words: digital television, digital text, DVB, monitoring.

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ALL PRESENT AND CORRECT? MONITORING THE BBC'S MULTI-CHANNEL DIGITAL TV SERVICES

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ABSTRACT

When the BBC launched its digital services in 1998, it tripled the number of its public TV domestic channels and the number of delivery platforms it would be serving directly. It needed to install a means by which it could automatically and remotely monitor that it was delivering its digital content correctly. This paper describes monitoring facilities installed and under development that check the DVB transport streams for correct content as well as ETR290 compliance. The challenge of monitoring intermittent components such as DVB subtitles and Digital Text services is also considered, and a potential solution offered.

INTRODUCTION

When the BBC launched its digital services in 1998, it tripled the number of its public domestic service TV channels and the number of delivery platforms it would be serving directly. At the same time, it was containing staffing levels, and placing transmission contracts externally rather than in-house.

Monitoring continuity of service is a significant challenge. The network covers London and our National and regional studio centres located throughout the UK, the digital signal chain is more complex than the analogue one [1], and transmissions can be lost for a variety of very subtle reasons. Each digital multiplex carries at least five services, so there is more to lose from a single failure. Although equipment is duplicated, the automatic changeover switches rely on the fault being detected and located.

The distinction needs to be made between control, monitoring and analysis. Most DTV equipment has internal monitoring but this is usually an adjunct to its control and configuration system and too specialised for system monitoring, even assuming it can be trusted when the equipment fails. The BBC has bought specialised DVB transport steam analysers, which are invaluable for commissioning, but too expensive for widespread routine deployment throughout the network, being intended more for development and "hands-on" diagnosis.

Remote access and having a complete view of the situation is important. To ensure that a fault can be cleared quickly, it must be possible to locate it without having to visit remote sites or setting up a telephone conference between the various parties. Very often the process of tracing is one of elimination – can we confirm what is still working?

THE "BITMON" SYSTEM

An immediate challenge was to monitor the services and components in the transport stream. Integrity tests are defined in ETR290, but these do not guarantee that the correct content is present. A stream of null packets would probably pass ETR290 tests more easily than a stream containing real television services.

After compiling a technical specification and inviting tenders, a system was selected from Acterna [2]. In addition to ETR290 tests, this compares the contents of the PAT and PMT tables against a stored template, to ensure that the expected services and components and their PID values are present as expected. For each component, it can also check the bit rates are within the expected range. Alarms and logs are automatically generated, and summary status displays are available as password-protected HTML web pages, anywhere on the BBC's internal nation-wide IT network. Alarms from GPI outputs are wired into BBC Technology's Broadcast Network Control System (BNCS) network, and once alerted by this, an operator can analyse the transport stream remotely, using additional software running on selected terminals. This additional software offers the same functions as a full DVB transport stream analyser.

The system is known as "Bitmon". In all, about 50 Bitmon probes have been installed at the outputs of our London, National and regional studio centres.

Choosing the best connection points for the probes proved to be a compromise. Despite the core requirement of Bitmon to monitor at contractual boundaries (usually a broadband network termination point), literal implementation of this would have been disadvantageous. Figure 1 shows a typical output chain, with full redundancy and changeover switches ahead of the outgoing circuits. Because the switches are ganged, placing the monitoring probes at the contractual boundary – points "A" in the figure - means they are both monitoring the output of the same remultiplexer. This would be a serious deficiency – a fault on the reserve chain could go unnoticed until a fault on the in-service chain forced a changeover. It also makes poor use of two probes. Furthermore, creating monitoring feeds would require additional active equipment in the transmission chain. Even with the better reliability of modern equipment, it is still true that the fewer active devices in a signal chain the better.

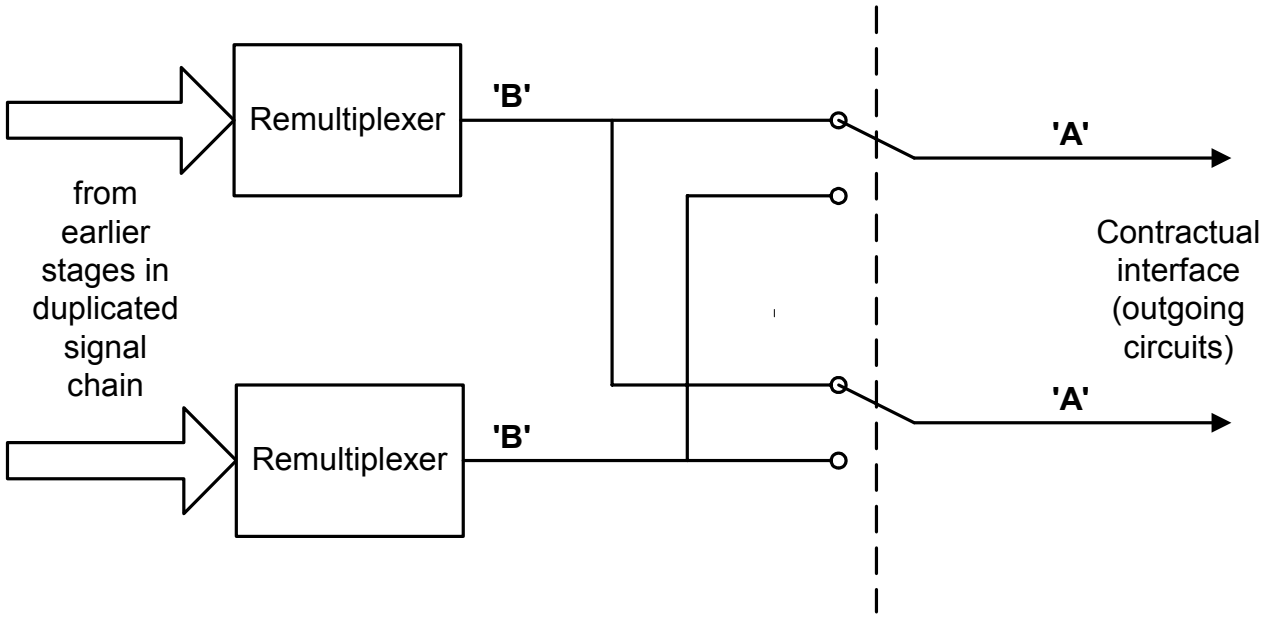

Figure 1 - Connection of the Bitmon probes at the studio-centre outputs

The compromise was adopted to place the probes ahead of the switches – points "B" – thus gaining access to both remultiplexers. This is acceptable because the changeover switches cannot corrupt the transport stream, only prevent it from reaching the outgoing circuits, a situation already covered by alarms from the telecommunications provider. It then also allows proposed system configuration changes to be tested on the out-of-service chain. An

added bonus was that spare outputs already existed on most of the remultiplexers, so no extra equipment was needed in the programme chain.

Bitmon was installed at the end of 2000 and commissioned in early 2001. It is now routinely used by operational staff.

CONTENT MONITORING

Although Bitmon confirms we are sending content with the correct references and identifiers, it cannot tell us if we have the correct picture and sound, or for example that we have a frozen image or an incorrect aspect ratio. We are therefore investigating how monitoring can be extended to cover this.

It is clearly not practical to compare transmitted and received signals directly when they are geographically separated or where there are significant timing differences. We believe it is feasible to extract “characteristic signatures” of the video and audio signals, and still achieve a reliable comparison. It is of course necessary to send the signature by a different route from the signal itself, and using a standard IT network for this also provides a means of returning or forwarding the alarms. Using “Media Fingerprint” software developed by Omnibus Systems we set up the arrangement shown in Figure 2.

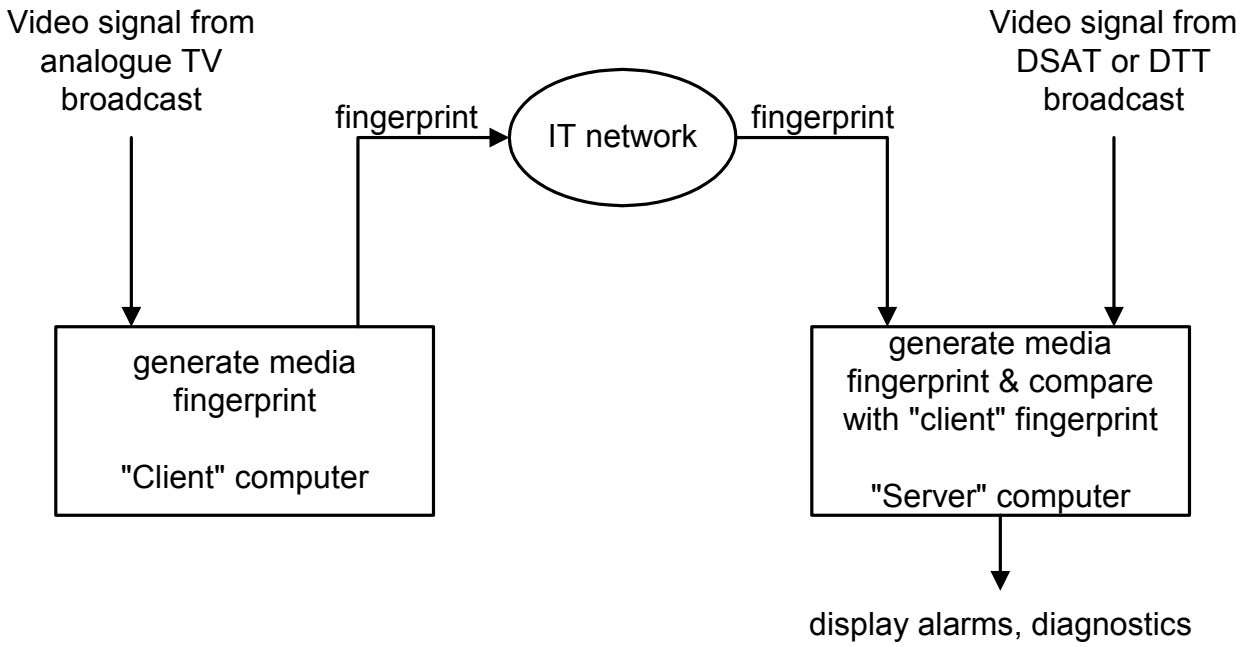

Figure 2 - Experimental arrangement for content signature investigation

To simulate typical conditions, signals were received off-air from both analogue and digital transmissions. It soon became apparent that making live comparisons in the presence of the different programme-chain and transmission-path delays and the uncertain latency of the IT network was a significant extra element, particularly the initial synchronisation. Extra software routines were written to augment the code from Omnibus, which was originally written to compare a live signal with signatures (Media Fingerprints) stored in a database. Extra software was also written to detect complete lack of a video input, the media fingerprints corresponding to black level, and lost data connections.

It was found that the rate at which the media fingerprints needed to be generated was a compromise between processor load in the computer making the comparison and the ability to gain initial synchronisation. It had been originally expected that the trade-off would be solely between response rate and network load. It was also found that a regular rate was needed, rather than generating the media fingerprints at every significant content change. This was partly because artefacts present in one signal but not the other influenced the detection of the changes, and hence the number of media fingerprints generated. The rate used was one media fingerprint per three frames, giving a data rate of 3.2 kb/s.

Although the media fingerprints are resistant to reasonable picture degradation, for example VHS replay or MPEG2 coding, they are not tolerant of aspect ratio changes. We were able to use this to our advantage to detect aspect ratio errors (converters have to be automatically switched in and out of the programme chain according to the format of the original material), but it does mean that media fingerprints must be generated for all likely formats. This is done on a single signal by the Omnibus software by anticipating the sampling grid after conversion.

For audio monitoring the lack of synchronising information at suitable intervals in the signal makes it more difficult for the server to lock to the client signatures transferred from the other site. If signatures are generated over a block of, say ten thousand samples, a considerable search is needed to find the same block boundaries at the receiving end. We have identified a potential commercial solution and are planning to investigate it.

Having proved the feasibility of the video content comparison and its working across a nation-wide distribution system, and also having found a possible solution for the audio content, the BBC will consider the installation of an operational system. In the same way as Bitmon, this will need to be integrated with existing alarm and monitoring systems. Further work is needed on applying similar techniques to the other service components.

ACCURATE BIT RATE MEASUREMENT - BEAGLE

Beagle is a tool developed at BBC Research & Development to generate detailed and accurate statistics about DVB transport streams, particularly for low bit-rate or bursty service components. It is a 1U self-contained hardware platform including an embedded PC, with software for data collection and processing. It measures the instantaneous bit-rate for each PID in the transport stream, on a second by second basis. The input to Beagle is an ASI-format DVB transport stream, and the output is a file suitable for export to an MS Excel spreadsheet via a LAN or WAN connection. By re-configuring the hardware, Beagle can also capture and store elements of the transport stream for later analysis.

The statistics are mainly used to plan the efficient use of the bit-rate in the transmitted transport streams. However, although Beagle was originally conceived as an analysis tool, it can also be used for monitoring. Needing only a network connection to receive commands and return the collected data it too can be easily deployed at a remote location.

USING BEAGLE TO DETECT DISCONTINUOUS COMPONENTS

We have been considering how Beagle might be used to detect errors in bursty or discontinuous components. The BBC's DTT transmissions generally carry DVB subtitles, and some programmes have an audio description track as a second audio component. In future, some programmes may carry a separate "signing" component rather than have the signer in vision [3]. These components are present only when there is information to carry, otherwise the bit rate should be zero. A Bitmon alarm is therefore not sufficient evidence of a

fault – it could be detecting the pause between successive subtitles or a programme that is not signed, sub-titled or audio-described. Text service components are also not necessarily continuous. (In practice, to avoid spurious alarms, the Bitmon probes have been configured not to check the bit rates of these components).

It is inappropriate to add a silent or invisible "place-holder" with the same PID value as the absent component. This would consume valuable bit rate, and would still be vulnerable because of the need to switch between it and the real information.

Beagle offers the means of measuring bit rate profiles, and of exchanging and comparing these across the network, in a similar manner to the content signature technique described earlier. The same hardware also offers the potential for remote content analysis.

INTEGRATION

Much of the monitoring has been added to the digital signal chain after its installation. This was partly because of the lack of availability of suitable equipment when DTV services were initially launched, and partly because of the priority to meet a tight launch schedule. Experience has shown that this retrospective approach is not ideal, and has demonstrated the need to take a holistic approach to monitoring. For example, the ability to compare information about the transport stream content taken from a scheduling system with the analysis of the transmitted signal itself would provide a valuable check of the entire chain.

One challenge is simplifying the display and collation of alarms. Many manufacturers of professional broadcasting equipment offer their own control and monitoring system, which although often capable of accepting inputs from other manufacturers' products, require additional code to be written to do so. This type of integration avoids having multiple computer terminals on a control desk or an excessive number of windows open on a single screen. For the success of this type of scheme, it is important that manufacturers make their control and monitoring protocols as simple as possible, and openly available.

CONCLUSIONS

The launch of the BBC's public DTV services presented a significant challenge in terms of monitoring. Equipment has now been installed to monitor the formal structure and indicated content, and a feasibility study of true content monitoring is giving encouraging results. Discontinuous components such as subtitles still await a solution, although the development by BBC Research and Development of the "Beagle" equipment to measure accurate instantaneous bit-rates is a significant step.

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ACKNOWLEDGEMENTS

The authors wish to thank the BBC and BBC Technology Limited for permission to publish this paper.

We also wish to thank Omnibus Systems, Loughborough, UK, for the loan of their “Media Fingerprint” software package, and for undertaking further developments of it on our behalf.