Approaches to Audio Editing in a Mixed Disk– and Tape–Based Environment

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Approaches to editing in a mixed disk- and tape-based environment

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Abstract

Audio editing systems are increasingly disk-based, whereas origination, mastering or transmission formats are often tape-based. The operational problems of working in mixed format environments are examined and a number of solutions are suggested in a proposal for a more streamlined and unified approach towards audio origination and editing. Particular reference is made to the editing of DAT recordings in broadcast environments.

1 Background

1.1 Tape-copy editing

Digital audio recording became established for professional use during the 1980s. Many users were prepared to tolerate the drawbacks of first generation systems for the key benefits of improved sound quality and loss-free copying. The launch of the Compact Disc in the early 1980s stimulated the growth of digital audio recording in the music industry, particularly in the field of classical music, and electronic tape-copy editing systems were developed, based on the principles of videotape editing [1]. Music editors were, and still are, prepared to accept the real-time copying process required for such editing, and this is now an accepted stage of the music production process. Although such systems are inflexible in one way – in that modification of a finished master is laborious (requiring lengthy re-copying) – they offer more flexibility than tape-cut editing, in that rehearsal of an edit is possible without affecting the master. Also gain offsets and variable crossfade times are possible.

1.2 Tape-cut editing

Tape-cut editing [2], [3] of two-track digital recordings was introduced in the early- to mid-1980s to satisfy a requirement of broadcasters. Many insisted that digital audio recording would not be widely accepted in radio broadcasting until it was possible to edit tapes as simply and quickly as was already possible with

quarter-inch analogue tape (using a razor-blade and sticky tape). For radio broadcasters the sound quality advantage of digital recording was not in itself seen as a primary argument for its adoption, since much of the material to be edited was speech. Although open-reel digital recorders with quarter-inch tape and tape-cut editing appeared on the market, the take-up was disappointing, possibly due to the high cost of machines, the lack of portable recorders, and the unreliability of splices in some cases.

1.3 Direct-access editing

Editing technology progressed during the later part of the 1980s to result in a large number of commercial direct-access systems based predominantly around computer disk drives (sometimes called 'tapeless' workstations). An overview of this technology is given in [4]. These offered the key operational advantages of almost instantaneous access to stored audio recordings, and real-time assembly of edited masters from a collection of stored 'takes' (files) under control of an edit decision list (EDL), without the need for real-time copying of source files to a master file. A master could easily be modified thereafter by modification of the EDL. Such technology is now gaining widespread acceptance in many fields of professional audio recording and post-production, since it offers the sound quality advantages of digital audio, potentially coupled with the speed of tape-cut editing, and eliminates the spooling-time limitations of tape machines, allowing fast and easy location and comparison of stored material. Systems may also offer enhanced operational facilities previously unavailable with tape recording, such as infinitely variable crossfade times at edit points, organised filing and database structures, internal automated mixing and other forms of signal processing. Material to be edited on 'tapeless' systems must either be recorded directly to disk or copied from source tapes. The copying process is normally performed in real time, and critics often cite the unacceptable time penalty involved as a disadvantage of disk-based editing.

1.4 The problem to be solved

Most of the development effort in the electronics world is now concerned with digital systems, where the rate of progress still accelerates unabated. Audio stands to benefit considerably from developments in the computing world, and the two fields are now inextricably linked. As neatly summarised by Watkinson [5],

analogue storage and signal processing is now a mature technology in which any further development follows a law of diminishing returns. Since the future is undoubtedly 'digital', and the cost versus performance of digital systems will continue to become more favourable, there are good reasons to consider the gaps which exist in the technology, and to examine what still needs to be done to smooth the changeover from analogue to digital audio recording and post-production. One particular area of difficulty will be examined here.

Analogue mono and stereo recorders still predominate in radio broadcast environments, where the adoption of digital recording and editing equipment has yet to take place in a large-scale fashion, especially in the field of news and current affairs production. Nonetheless, increasing use is made of DAT machines for original recording, both in the studio and in the field, and interest is expressed by large broadcasters in the benefits of networked news editing systems based on digital 'tapeless' technology. Operational and also economic benefits must accrue to the broadcaster if he is to adopt such technology on a large scale, and this highlights an important issue yet to be properly addressed, which is that most original mono and stereo recording is still made using a tape format of some kind, whereas potentially the fastest and most flexible digital editing is only possible using disks or an equivalent direct-access store.

The question therefore arises as to whether it will always remain acceptable to copy source material to disks prior to editing and then back again to tape for transmission, or whether original recordings could be made directly onto disks and transmitted from them. If one or more copying stages are acceptable, then they should be made as straightforward and fast as possible, preferably with a degree of automation. There are economic and operational considerations in both cases.

In the following paper this issue is addressed in the light of currently available and soon-to-be-available technology, with particular reference to the problems of the radio broadcaster. Recommendations for product development are also made, based on an analysis of operational requirements. Attention is paid principally to mono and stereo operation as opposed to multi-channel operation. The operational requirements for editing in a radio broadcast environment vary widely depending on the type of programme concerned. For the purpose of this paper discussion will be restricted principally to the particularly stringent editing requirements of material which must be transmitted within a relatively short time of original recording, such as is the situation in news and current affairs environments and in local radio. Any system which was able to handle this task with ease and speed would also have considerable appeal in other less demanding applications. For an overview of the editing practices common in other operational situations the reader is referred to McNally [6].

2 Current practice

There is a natural tendency for a broadcaster to attempt to transfer existing operational techniques to new technology, but, although this may have short-term benefits in terms of training requirements, a leap of imagination may be required when considering how best to make use of new technology. In order to make that leap of imagination it is necessary to understand current operational practice.

2.1 Origination

In the environment under consideration much of the source material is speech, and arrives to be edited in a variety of forms. Recorded material from the field (reporters' interviews, etc.) arrives either on quarter-inch tape, or on analogue compact cassette (due to the high quality now available from small 'Pro Walkman' recorders). Now that reasonably-priced portable DAT recorders are available there is also an increasing tendency for source material to arrive in the DAT format.

Material from remote locations may arrive over land-lines, over RF and satellite links, or increasingly over ISDN (the Integrated Services Digital Network). This is recorded at the broadcast studio centre, normally onto quarter-inch analogue tape. In the same way, material originating from within the studio centre is recorded.

The cost of tape accounts for a sizeable proportion of the budget of any broadcaster, and thus any digital approach which might reduce this cost would have advantages.

2.2 Editing

Editing of speech is primarily concerned with the disposal of unwanted sections, and the 'humanisation' of available source material by inserting additional 'breaths'. In the majority of cases more source material is disposed of than is retained in the final programme, which is important when considering copying procedures (below). Currently, tape-cut editing is used almost universally, due to the high speed which can be achieved (an edit every ten seconds is not uncommon with experienced operators). (An interesting exception to this rule is found in the case of the Dutch broadcaster NOB –*Nederlande Omroepproduktie Bedrijf*– which uses copy editing universally. Owing to the exceptionally fast and

repeatable start-up times of the Telefunken M15 analogue recorders used, it was found possible to devise the so-called *Doesberg disk* as a means of accurately aligning an edit point at the record head, having been manually cued at the replay head, thereafter starting the record and play machines in synchronism and assembling the final programme by copying. This is an example of a highly-developed but simple manual skill which is difficult to emulate with today's digital machines.)

Editing of speech may be an urgent task, performed under pressure with short deadlines, and thus the simplest approach is usually the best. In some cases there is a requirement for multiple copies of important source material, to be edited differently for a selection of destination programmes. This is an important factor when considering the merits of a networked disk-based editing system (see below).

2.3 Transmission

Currently, the edited tape is loaded onto one of a number of quarter-inch analogue machines dedicated to the purpose of transmission. It will normally be physically carried from the edit suite to the transmission area. Again this is of importance when considering the merits of a networked disk-based editing system.

2.4 Archiving

Although a large amount of speech material is redundant once transmitted, the majority of it is kept for a small number of weeks, with important material being long-term archived in tape form. Medium- and long-term backup must thus be an important feature of any new approach.

3 New approaches to editing

As introduced in section 1.4, it is necessary to examine the best approach to editing *digital* recordings. The best approach, it is suggested, will be the one which is simplest, fastest, and which preferably offers increased flexibility over analogue tape-cut editing, with no overall cost increase – in fact preferably a cost

saving. (Overall cost increase is hard to assess, since costs include storage media, staff efficiency, capital outlay and training costs, amongst other things.)

3.1 Summary of the potential for tape-cut editing

As outlined in section 1.2, digital tape machines offering tape-cut editing facilities (in the DASH and PD formats) have so far proved too expensive for adoption on a large scale in radio broadcasting (a professional studio machine may cost four to five times as much as the equivalent analogue recorder). No portable machines exist, and thus the formats cannot be used in mobile and outdoor work. Tape-cut edits, although more reliable in later machines, are still less robust than their analogue counterparts, and tape is more easily damaged since it is thinner. Greater care is required when editing than with analogue machine, and edits, once made, cannot easily be picked apart and re-made. It is therefore unlikely that a significant future exists for such machines in radio broadcasting, although it should be acknowledged that uses have been found in specialised projects.

The future for tape-cut editing in a professional digital format is unclear. Although it is possible, it is currently not economically nor operationally acceptable. Nagra-Kudelski expects to allow it for 'rough cutting' in later digital machines [7], but the cost of Nagra-D machines may preclude their use as general-purpose recorders for speech. Furthermore, 20-bit, 4 track recording is rarely necessary for such material. It is more likely that news and current affairs recording will rely on relatively cheap origination formats and recording media, such as digital cassettes.

3.2 Summary of the potential for tape-copy editing

The basic limitations of tape-copy editing were outlined in section 1. Currently, real-time copy editing is the principal method for editing video tapes, and this is used even in short-deadline news situations. It has, however, not been widely accepted for sound-only broadcasting (with occasional exceptions such as the *NOB* example described above). The benefits of video recording (when it largely replaced film recording in television) were seen to outweigh the speed penalty in editing, since other disadvantages had previously existed in film recording such as the need to develop film and the cost of film stock. In sound-only recording there is no basic economical or operational disadvantage in the current analogue process, and thus there is a less pressing need to adopt new technology. Any new technology replacement, therefore, should not introduce a

speed penalty.

The arguments for and against copy editing of sound are put into a different light when one considers that a large amount of field-recorded source material currently arrives at a studio centre on cassette, and thus has to be copied in real time onto quarter-inch tape. *One is therefore dealing with a situation in which at least a one-time copying process is already acceptable.* Only the required sections of the source material are copied, since the process of total copying followed by disposal of unwanted parts is slower. This is important when considering the combined tape–disk editing system proposed below.

As far as tape-to-tape copy editing is concerned, it is suggested that a solution based around DAT could be adopted which, in terms of total time involved in editing, might match the time taken to copy a cassette onto tape and then cut-edit the programme. This would require a pair of machines with a controller capable of allowing the operator to work in a similar way to the *NOB* technique described above, wherein source and master tapes could be quickly cued by hand (probably using a 'search wheel' or equivalent, controlling replay from a RAM store containing a number of seconds around the point at which the tape was last stopped) and then immediately dropped into play and record respectively and simultaneously, beginning to record on the master tape from the precise point located manually. If this involved lengthy pre-rolling, transport delays, multiple-stage edit-point location or any other unnecessary encumbrance it would probably become unacceptable, since editors expect immediacy from a system designed for fast-paced work. The user interface could be simple, cheap and straightforward, and would not look like a typical classical music editor.

Such a system must be designed on the basis that the operator is capable of a certain degree of skill, provided that the equipment can be relied upon to perform the same operation repeatably each time. The system should be a vehicle for the operator's skill, there being little need for expensive 'frills' which simply serve to hinder the process. Other design features important for such a system are the facility for two- or four-times normal speed play modes (audible), since analogue machines are often used in this way for fast location of edit points and editors have learned to interpret what they hear at non-normal speeds; also preferably the facility for copying at twice or four-times normal speed. (This feature is likely to be possible in the next generation of DAT machines, and is discussed further below.) Start and Skip ID markers in the DAT subcode could be used for fast location of previously marked points on the source tape. A disadvantage of this approach is that DAT transports do not have a physical likeness to analogue reels, and thus editors would not get the same visual feedback and physical interaction with moving tape which allows them to judge very

accurately the passage of time and position of material.

A first generation DAT editor embodies some of these features, but has a number of limitations, as documented in a recent user report [8]. The need for timecode on source tapes makes it inadvisable to originate material from consumer portable DAT machines (without timecode facilities), since the time needed to post-stripe or copy a tape before editing would normally be unacceptable. It is, though, difficult to implement a digital tape-copy editing system without a means of synchronisation and positional location such as timecode. Although the situation would be much aided with the introduction of a cheap and simple DAT transport with timecode facilities, much source material is likely to be originated by reporters and journalists without technical training, thus field recorders need to be straightforward to operate.

3.3 Combining taped source material with direct-access editing

A number of possibilities exist for combining the flexibility of direct-access editing with taped source material. The first proposal concerns a low-cost local editing system coupled with a DAT or future equivalent tape transport, and the second concerns a networked news editing system with tape drive interfaces. DAT is used below as an example of a low-cost digital tape recorder with some desirable operational features, but it is not ideal. There is further scope for development of a cheap digital tape recorder capable of data transfer at some multiple of real time, with a computer-style filing structure, as discussed later.

3.3.1 Low-cost local editor

Two approaches are feasible here. The first proposal is intended as ideal for DAT-sourced material of speech, such as might be received from reporters or journalists. DAT machines are equipped with facilities for easy marking of points on the tape, in the form of 'start ID' and 'skip ID' codes, these being used in this situation to mark the rough beginnings and ends of the source material required for editing. To save time, the marking operation could even be performed whilst a reporter was returning to the studio in a taxi, by monitoring on headphones.

In the studio a remote-controlled DAT machine is interfaced via RS422 to a simple stand-alone direct-access editor such that status information from the DAT machine (including the status of start and skip IDs) is available to the editor, and such that the editor may control the DAT machine. The marked sections are then automatically loaded into the editor with a new disk file being created each time a

skip ID is encountered. The DAT machine is set to skip on to the next start ID each time it encounters a skip ID, thus loading only the wanted material. An alternative semi-automated loading process could involve the location and loading of specified DAT track numbers, which are often slated automatically by the recorder at the start of a take. Material is auditioned during the transfer, and then edited to create the final programme. The speed of editing could be made to match that of tape-cut editing with a suitably-designed user interface. The question of what to do with the edited material for transmission is dealt with shortly.

A number of design features are important. Firstly, the tape-to-disk dumping process must happen in the background. Secondly, it must be possible to begin editing the first file as soon as it has been loaded, rather than having to wait for the whole tape to load. Thirdly, as with the tape-to-tape system described earlier, replay from disk at two or four-times speed would be required for fast location of edit points. Fourthly, reel-rocking simulation ('scrubbing') would be vital in ensuring the fast location of edit points. Fifthly, there would be great advantages in being able to transfer material from tape at two- or four-times play speed.

High-speed data transfer would pose design problems, since a means would have to be devised of transferring the data from the tape machine to the editor at non-normal speeds. A digital audio interface such as AES/EBU is not the solution, since it can only accept deviations of ±12.5% from play speed, and thus a standard high-speed computer interface would be preferable. Since the aim is simply to extract audio data from the tape as fast as possible, the ideal solution would be to format the audio data in such a way as to make it transferrable over SCSI, or another high-speed data interface. (This implies the need for an audio tape recorder capable of storing sound recordings in a standard computer file format, much as happens in a disk-based audio system, as discussed in section 5).

The approach as described would still be valid with normal play speed transfer, using today's technology, the final proposals being for future development. Simple stand-alone direct-access stereo editors are now available for only a few thousand pounds, and PC- or Apple Mac-based hardware and software is capable of adaption to this purpose. A key to success lies in the development of a very simple user interface dedicated to the purpose of editing speech, and the author is currently working on the development of some prototype interfaces in conjunction with a serially-controlled DAT machine. The total cost of such a system could be low enough to be comparable to that of a high-quality quarter-inch analogue tape machine, and could accept source tapes without timecode.

The second approach is only at a preliminary stage of consideration, and uses

a DAT or equivalent drive capable of faster-than-realtime transfer buffered via either a Winchester disk drive (of only moderate size) or large RAM. The approach is a modified form of 'jump' editing, as described a number of years ago by Lagadec [9] for improving tape-cut editing, and as suggested for future development of the Nagra-D format [7]. Whether or not such an approach is possible depends on the characteristics of the next generation of DAT or equivalent systems. It is possible to envisage a system in which edit points could be defined via a dedicated user interface, much as described above. During replay of the 'soft-edited' master the buffer would be used to provide audio output during periods while the DAT machine located the next section of source material. Once located, material would be transferred faster than real time to make up for the discontinuity and replenish the buffer.

The approach would only succeed if the average data transfer rate from the tape drive, taking into account discontinuities, was equal to the rate at which audio was read out of the system. This would require very fast location and the highest possible data transfer rate from the tape. It would also require a number of seconds of material to be pre-loaded into the buffer so that there would always be a substantial delay between the replay from tape and the audio output. It has the advantage, though, that if this facility were incorporated within the DAT machine a real-time edited replay could be achieved after having marked the edit points, without the need to copy the source material. It would also be possible to produce a number of edited masters from one source tape without copying.

3.3.2 Networked editing system

The above proposals assume a cheap and simple local editor, coupled with a tape drive. In large organisations there may be benefits in adopting a networked editing strategy with central disk storage provision and local workstations. This approach is analogous to a large office adopting a mainframe computer with multiple terminals, as opposed to placing a personal computer on each worker's desk. There could be economies in scale, and the systems specification and software customisation would be approached in a similar way to any other large computer network. Such a solution assumes a completely new approach to news and current affairs production.

Many of the ideas outlined above could be adopted, such as the semi-automatic loading of source material and the simple user interface for editors, but additional possibilities would arise. It was mentioned earlier that multiple copies of a news story might be required, for editing into different versions and use in different programmes, and this would be easily achieved in a networked system

by allowing multi-user access to stored files. Clearly a multi-user system would require disk drives with a high transfer rate (probably in excess of that achievable using SCSI), but such parallel-read drives are already used in digital video editing systems and mainframe computers. Once the raw material for a story was loaded, it could be edited into a multiplicity of different versions without the need for further copying. Again, only the one-time initial copy of taped material onto the central storage would be required, which would involve no more time than is currently used to copy analogue cassette material onto quarter-inch tape.

Remote source material arriving over lines, satellite links and ISDN could be recorded directly onto central storage, with immediate availability to the team of editors and newsroom staff. Studio-originated material would also be recorded in this way.

4 Producing a transmission master

There arises the question of how to generate a final transmission master of edited material. In conventional procedures, the cut-edited master is physically taken to the tape machine which is used for transmission purposes. The proposal for tape-to-tape copy editing in section 3.2 results in an immediately usable DAT master which can be cued-up and transmitted in the conventional way – this is one of the strongest points in favour of copy editing. The first combined tape–disk proposal in section 3.3.1 results in an edited master on disk which would then either have to be copied back to a DAT tape for transmission or played out of the disk system from the editing suite and routed to the transmission mixer (this would require a substantial change in operational practice). The dump of a disk master to DAT could be performed in the background, and this process might be made more acceptable if high speed transfer were possible.

The second proposal in section 3.3.2, involving a RAM or disk buffer combined with a DAT machine, would provide real-time replay from a suitably-equipped DAT machine via a buffer, based on a stored edit list. This edit list could be stored on the tape in subcode and read by a transmission replay machine having similar facilities, but the unfortunate disadvantage of this approach is that a delay would always exist between pressing the start button and hearing the first audio, since the buffer would normally have to be pre-loaded with a number of seconds of audio. This would be potentially disastrous in a pressurised environment, where there is a need for almost instantaneous cueing-up and replay on demand. (Alternatively, the DAT transport could automatically pre-cue the

first so-many seconds of audio into the buffer when the tape was loaded, thereafter transferring material to the buffer at maximum rate once the tape started to play. This would be subject to potential failure if an edit occurred within the first few seconds of the start of the item, since insufficient material would have been loaded into the buffer to cope with the discontinuity.)

The networked solution is a good one, as it already assumes that the whole approach to news material production has to be changed. There would be a number of editing stations on the network, and there would also be a transmission control station. The network operating system would allow finished material to be made immediately available for transmission, and edited news items could be transmitted directly from the central store without first copying to tape. The data throughput capacity of the network would be designed so as to have sufficient margin for the worst case situation of loading, editing by multiple users, and also final output by the maximum number of channels.

5 Origination considerations

The approaches to editing outlined imply the need to reconsider how source material is originated. If it is accepted that some form of direct access editing is preferable to tape-copy editing, then one should consider the best and most economically viable method for originating recordings in the field. Although currently recordings are sourced universally on tape, it is worth considering the merits of other potential solutions. The discussion below is concerned principally with the design criteria for a field recorder which could be cheap, rugged, and capable of high-speed data transfer.

It can be imagined that there would be considerable advantages in a portable field recorder capable of recording directly to disk. If this disk were removable, all the better. The field-recorded disk could then be edited directly at the studio centre, without the need for initial transfer, either by inserting the disk into the drive of an editor or by interfacing the field recorder via SCSI to the editor.

The problems that currently exist in implementing such a solution are: (a) the need for ruggedness in disk drives; (b) the cost of removable disk media with sufficient capacity; (c) the lack of standardisation in audio file formats on disk. Of these, there is evidence to suggest that recently-developed 3.5" optical disk media with 128 Mbyte capacity are considerably more rugged than their 5.25" counterparts, although they have yet to be proved in a portable recording application. Such a capacity would allow over 20 minutes of mono recording time, and many times more than this in a data-reduced form. The cost per Mbyte

of removable optical disk media has already dropped considerably, and will drop further. Since such disks may be re-used many times, the cost factor may cease to be a problem. Concerning the file format, it is probable that in the absence of formal standardisation a number of *de facto* formats will emerge, based on the file strategies of manufacturers who are prepared to adopt an 'open' policy on such information. (This is already happening in a small way.) A manufacturer offering a unified systems implementation of the above proposals would produce field recorders, studio recorders and editing equipment capable of operating in the same file format, and would publicise that format widely. The file format should ideally be the same on tape and disks.

A field recorder could also be based around a compact Winchester drive, such as that found in many laptop computers, provided that the drive could be made sufficiently shock-proof. The cost of such drives is now quite low, and data reduction could be used to optimise storage time. At the studio centre the field recorder could be interfaced to an editing system, either for a fast dump of stored audio to the editor, or for direct editing. The recorder could be re-used almost an infinite number of times, with no media costs.

The same would be true of a recorder based around solid-state RAM and data reduction. In such a device ruggedness would not be a consideration, and the transfer rate of data could be as high as required. Costs of RAM per Mbyte are still falling fast, and data reduction offering a sound quality adequate for speech could result in a storage-requirement saving of at least ten times over linear PCM recording. Using such data reduction, 1 hour of mono recording could be had from around 30 Mbytes of RAM at a realistic cost.

Low-cost digital tape recorders, exemplified today by DAT, will remain important as acquisition formats. For ease of incorporation into computer-based editing systems, it is desirable that audio recordings should made in a block-structured computer file format with addressing marks and a directory structure. Interestingly, an offshoot of the DAT recorder is used in computer data storage, known as DDS (Digital Data Storage) [10], [11]. The mechanical properties of a DDS drive are identical to DAT; it is the data formatting, error protection and addressing that are different. A layer of firmware devised by Hewlett Packard and Sony turns the DAT drive into a computer data streamer. It is intended that DDS drives should soon be able to transfer data at higher rates, and it is conceivable that such drives might be incorporated into audio systems. Just as multi-standard CD drives are able to replay CD-ROM and CD-Audio disks, it is possible that multi-standard DAT drives might be switchable between DDS-compatible data recording and conventional audio recording. It is principally a software and not a mechanical consideration.

6 Conclusion

The operational requirements for editing in radio news and current affairs broadcasting have been introduced, as an example of a field in which digital audio has yet to be widely adopted due to a lack of suitable equipment. A set of design criteria have been introduced which might be used in the development of digital audio products, in an attempt to arrive at a more unified approach to the recording and editing of digital audio in an environment where both tapes and disks are used as storage media. These criteria emphasise the importance of maximum commonality of audio system components with those of other computer systems, since this is the way to ensure that the audio industry can take advantage of developments in the rather larger computer industry, and also benefit from the economies which arise from the mass-production of storage media and drives. There is inertia in the user community which would make it difficult to move away from 'token-based' recording and replay (resulting in tapes or disks which may be physically handled) towards networked operation with 'invisible' storage, but networked computer systems are becoming widely used in other working environments, suggesting a gradual acceptance of the approach.

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