And So On...

So now it's time to see where recording technology may be headed. Several new directions are emerging, based in part on the continued increase in personal computer power and in part on the Internet as an audio delivery system. And then there's the DVD-audio.

Optical discs

Let's start with the DVD (Digital Video [or Versatile] Disk). CDs have been around long enough to be established as the main method of music distribution, replacing the vinyl LP and analog cassette tape. After many years of service, the shortcomings of the CD are becoming limiting factors: the obligatory 16-bit/44.1kHz quantization limits the dynamic range and frequency content below that which we are now capable of delivering. And the continuous-playback design makes computer access more difficult. All of these limitations are addressed by the DVD. The DVD is designed as a file-oriented system with random access. It can hold up to 7 times the content of the CD. And finally there has been agreement on a standard for audio DVDs. So we can deliver multi-channel, high-resolution, high sample rate audio in a standard format. Hopefully this will lead to widespread improvement in audio sample rates and quantization levels that are easily delivered to the consumer. DVDs are defined in three types: DVD-ROM, DVD-video, and DVD-audio. The file structures are the same, but the content is allocated differently. DVD-ROMs contain computer files, DVD-video holds video with limited audio, and DVD-audio contains mainly audio data with limited video and still video content. Due to the flexible allocation of DVD storage space, the DVD can be an effective delivery medium for everything from computer files to video. It is technically capable of serving the audio market for a considerable length of time, but the audio application of the DVD was delayed long enough for other options to come to market that threaten its acceptance as an audio-only medium.

While the DVD is the physical same size as a CD, it uses denser data packing and enhanced error detection/correction techniques to increase the reliability from that of the CD-DA to that of a CD-ROM. No more error concealment is necessary with the DVD: its EFMPlus modulation technique allows increased data density over the CD, which uses less efficient EFM modulation. The DVD also uses RS-PC error correction, which is more powerful than the CIRC used on the CD. With its greater data capacity, the DVD-audio format allows higher sample rates and quantization levels: up to 192 kHz/24-bit stereo or 96 kHz/20-bit, 5-channel surround. The DVD-audio disk also allows still and moving video data to be included, depending on the amount of audio data. The DVD-video specification also allows for 5.1 channel audio, but limits the types of audio files. Both types of DVD provide audio content, but the DVD-audio gives more audio file flexibility. And the added ability to display video information as well means song lyrics or still photographs may be displayed as the music plays. Of course, this requires a player capable of extracting the extra data for display. The simplest players will still produce only the stereo audio signals.

The DVD is read optically, like the CD, but uses smaller geometry pits and optics, requiring a shorter wavelength laser. This makes it difficult for some DVD players to read CD-Rs, although replicated CDs are not as much a problem. Newer DVD players may have a second laser pickup to optimize CD and CD-R playback. DVDs may also be double-sided, increasing their capacity even further. The more open architecture of the DVD allows greater flexibility in the types of encoded material than does the CD, while the increased data capacity facilitates the inclusion of higher-quality audio.

While the DVD-audio disc was under development an alternative delivery medium, the Super Audio Compact Disc or SACD, was created by Sony. This medium is radically different from the CD-DA and DVD-audio that use PCM modulation. SACD uses Direct Stream Digital (DSD) encoding, a form of sigma-delta modulation to write the bit stream directly to the medium. SACD is therefore incompatible with the other optical disc audio

formats and cannot be copied like the PCM discs. It simplifies some of the A/D and D/A circuitry, resulting in an open-sounding audio playback many listeners favor as more similar to analog media. Since there is no multi-bit signal output from DSD, SACD players lack S/PDIF digital outputs. The copy protection features of the newer disc technologies contribute to the desire of the manufacturers for their success.

Recording systems that employ DSD are now available, from Tascam's stereo-only high-definition hard disc recorders to the Sony spin-off multi-channel DSD Sonoma workstation. Although the SACD has been adopted by some artists and producers seeking a higher-quality delivery medium, its small market share and the need for consumers to buy a dedicated SACD player make its long-term prospects uncertain.

There are two new high-density optical disc formats just coming to the market: Blu-ray and HD-DVD. While each offers greater data density than DVD, neither has clear advantages over the other and the memory of the fight between VHS and Beta videotape formats is brought to mind. Whether either of these formats takes over the market or the original DVD continues to be acceptable to the majority of users is not clear. Whatever the outcome, optical disc technology seems likely to persist for the foreseeable future.

Internet Audio

The explosive growth of the Internet has opened up the possibility of distributing music and other content directly to the world. The major limitation right now is bandwidth: it is impossible to guarantee an uninterrupted stream of 44.1kHz/16-bit stereo over most connections (a 3-minute uncompressed CD track takes over an hour to download on a 56K modem.) Therefore, most audio now on the Internet uses some form of data compression, like MP3. Since data distribution on the Internet is done with packets of information that are relayed along variable pathways and reassembled at the receiver, a lot can go wrong along the way. Audio files may be handled as normal downloaded files, which must be completely reassembled before playback is possible, or as streaming data, which is played as it is received.

Systems employing download, data-compression techniques include MP3 (formally MPEG Layer III) and Liquid Audio. Both systems use perceptual coding to eliminate sending information that is effectively masked by higher-level sounds of similar frequency. This reduces the bandwidth demands and speeds download times. It does alter the sound, to an extent determined by the algorithm used, the required amount of data reduction, and the spectral content of the sounds encoded.

MP3s have become very popular, in part due to their inherent lack of copy protection mechanisms. The ability to control the copying of downloaded files is presenting a major hurdle to the acceptance of Internet content distribution. File encryption and digitally encoded watermarks and other forms of file identification are included in the DVD specifications to reduce such problems. Standards for the Internet are less promising. The Internet in some ways resembles the Wild West. The file-sharing culture of the Internet has stymied the development of music distribution models that offer a chance to make money without sacrificing the convenience of downloading.

If the file size can be greatly reduced, the data may be streamed and played while it is still downloading. RealAudio is an example of this system. As the packets are received, a buffer is filled and playback begins. While playing, the program continues to download the file and fill the buffer. When packets are lost, they must be re-sent; if the buffer is emptied, playback may be interrupted. For low-quality sounds, this system works pretty well. It is not a high-fidelity playback.

With the promise of increasing Internet speeds, the ability to transport audio over the networks is likely to improve. With the Internet II, for example, it is possible to do real-time interchange of several 16-bit/44.1 kHz channels at a time. This will make possible musical interactions between two studios separated by great

distances, not to mention the distribution of high-quality audio files to distant listeners.

Computers

As general-purpose computer systems become ever more powerful, the use of dedicated audio gear may eventually diminish. The ability to model analog equipment like equalizers and compressors may steer the audio practitioner towards the computer for more and more of the job of audio processing and storage. Where we now use systems like ProTools, which provide extra hardware for enhanced computing power and I/O, we will likely see computers powerful enough to do the required processing on the host with inputs and outputs on inexpensive sound cards or external converters that interface with the analog world. Such systems are already on the market.

The need for human-computer interaction still offers an area for development. We are still stuck to the mixing board paradigm of controlling channel gains, panning, sends, etc. with dedicated knobs and sliders. Perhaps a direct brain-to-computer interface will someday allow us to handle this with a simple thought or two. More likely, we will still use a physical interface with haptic feedback, since that seems to be the most efficient way we humans operate. The development of such interfaces is still one of the interesting and problematic areas of computer—based recording systems.

We can be sure of changes in the technical aspects of the systems we use to record sound. By understanding the underlying theories associated with the process of acquiring, storing and manipulating sound recordings we should be able to adapt to the changes that will undoubtedly come. And regardless of changes in the technologies used to record sound, the initial interaction between sounds and electromechanical transducers will continue to be the most challenging aspect of sound recording and there will be no substitute for experience, guaranteeing the accomplished sound recordist a future in the business.