vision White Paper

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   * *{increases visibility of difficult engineering issues}*
   * *{fundamentally different motivations}*

## Introduction

Utilization of simulation-based training for healthcare providers has expanded rapidly since the early 2000’s, when the first “high fidelity” patient simulator mannequins were made available by manufacturers at price points accessible to smaller programs. Over that time, simulation technology has diviersified considerably, lowering per-item cost while deepening the technology “stack” required for an appropriately-equipped laboratory.[[2]](#footnote-26) Though buy-in costs have remained high, the health education sector views simulation technology as valuable,[[3]](#footnote-27) and there is growing evidence improved education outcomes are beginning to show across an increasing spectrum of psychomotor skills.[[4]](#footnote-28)[[5]](#footnote-29)[[6]](#footnote-30)

Audiovisual (AV) systems are an essential part of the technology stack for modern simulation laboratories; they are complex, expensive, specialized services which are difficult to maintain without access to a network or AV specialist. In addition to engineering challenges, the decoding, encoding, and transmission of AV data is deeply mired in a crytpic network of patent protections and proprietary technologies.[[7]](#footnote-31) Simulation laboratories in need of AV services have few options: select one of several commercially available products, contract for a customized system, or develop their own.

These items encourage vendor dependence, especially in resource limited laboratories, and increase the dfficulty of accurate decision-making by consumers. Vendors are not forthcoming on details related to the architecture, implementation, or performance of their service, and, if it is made available, the information is generally written in a marketing language that conflates and obfuscates technical details.[[8]](#footnote-33)

Given that AV systems are an essential debriefing tool, and that debriefing is the most important part of simulation,[[9]](#footnote-34) difficulty matching tool to task is likely to degrade Return on Investment (ROI) for a simulation laboratory and its constituents.

*vision*, an open-source data and audiovisual (AV) platform for medical simulation, offers a service-equivalent model for the capture and utilization of AV data in medical simulation laboratories. It is based on patent- and royalty-free technologies, implemented with modern architecture patterns, and targeted at commodity hardware. In all, *vision* lowers the cost-of-entry for simulation laboratories seeking an AV solution and provides a needed focal point for the medical simulation community to examine critical issues related to AV service.

### Nomenclature

* format
* codec
* encoder
* decoder

## Summary of Current Issues

The AV marketplace is largely composed of small, specialized companies investigating problems of well-defined scope. By-and-large, however, market activity is directed by the small number of large companies with deep interests in AV transmission. This state likely owes to the blurry line between *technology which processes signals* and ownership of the *content encoded in those signals*. In brief, technology is used to sell content: the market for consumers of content exponentially larger than the market for specialized hardware and software, thus the bulk of revenue is available to the advertisers who use AV processing technology as an encapsulated service.

However, capture and delivery of AV data is decidedly *not* an encapsulated service; it relies on an extensive technology stack crossing many domains[[10]](#footnote-37) that evolve independently and according to their own needs. Thus AV vendors are consumers and users of a wide range of technology products used to deliver a service to *their* customers, who implicitly “buy in” to these decisions when they deploy a given service. Though there is nothing inherently wrong with this practice, it is heavily obfuscated in marketing and sales materials, which focus on per-device specification and leave the buyer to discern whether their deployment environment can accommodate those devices *{REWORD}*. Given the cost and specificity of deploying an AV service within a medical simulation laboratory, consumers deserve a chance to review and question decisions ostensibly made on their behalf.

For convenience, this paper summarizes current issues and challenges facing developers and consumers of AV services using three broad categories of interest to both parties: *Engineering and Technical*, *Patents and Ownership*, and *Market Pressures*. It is the author’s opinion the interaction of these categories accurately depicts the realities and peculiarities of the market vendors and consumers of AV services for medical simulation laboratories find themselves in. *vision* is built to make these issues clear, and address as many of them as is practical in an *open* and *collaborative* way.

### Engineering and Technical

The following table summarizes engineering and technical challenges to the development of an audiovisual service for medical simulation.

***{TABLE}***

### Patents and Ownership

The first digital AV format, H.120, was published by a telecommunications industry group in 1984.[[11]](#footnote-40) It was not usable, but a revision to it, H.261, became the first production-ready standard when it was published in 1988. A number of formats were introduced as digital audio and video data proliferated throughout the 1990s but none found the traction of H.261 and its successors, which emerged as the de facto industry standard–studied, licensed, or re-implemented by a majority of avaialble AV formats.

Numerous free and/or open source options have been introduced concurrent to the rise in popularity of the H.26\* standards. Generally these can be divided into encoding **libraries**, such as *libx264*, *libx265*, and *libpvx*–for H.264, HEVC/H.265, and VP9 respectively–and **formats**, such as Matroska, Ogg, WebM, and VP9–which define data structures and are used to interpret individual AV files. Here some interesting catch-22s arise

1. While *libx264* and *libx265* are free and open sourced, the H.26\* family of formats is not. Anyone wishing to use them in production must negotiate a license agreement via
   * MPEG LA, LLC. Private, for-profit, licenses H.26\* patent pools.[[12]](#footnote-41)
   * HEVC Advance. Private, for-profit, licenses H.265/HEVC patent pools.[[13]](#footnote-42)
   * Velos Media. Private, for-profit, licenses H.265/HEVC patent pools.[[14]](#footnote-43)
   * Individual arrangements with associated patent holders.
2. H.26\* *and* VP9 include patent-protected technology.
   * In certain cases, patent pools and individual holders allow royalty-free use of H.26\* formats.[[15]](#footnote-44)
   * Google, the owner and developer of VP9, grants an “in-kind” license that terminates on patent litigation.[[16]](#footnote-45)
3. H.264 is ubiquitous and there is already widespread support for HEVC/H.265 *and* VP9. Exposure to royalty fees depends on the engineering of a particular content service.[[17]](#footnote-47)

As of this writing, there are at least three (3) patent pools for H.265/HEVC,[[18]](#footnote-49) one (1) for the H.26\* pools,[[19]](#footnote-51) and at least one significant patent holder which does not participate in any pool.[[20]](#footnote-52) Inconsistent participation by patent holders has been identifed as a barrier to adoption of the HEVC standard,[[21]](#footnote-54) and waiting in the wings is the Alliance for Open Media’s AV1

### Market Pressures

H.26\* formats are based heavily on patetented technology.[[22]](#footnote-57) And while a reasonable number of other formats are available, many require some type of licensing or implement part(s) of an H.26\* format. A majority of these agreements separate encoding, streaming, and decoding; which allows the introduction of fees at each step in the delivery chain.

Research and development of AV technology occurs in a niche market protective of Intellectual Property (IP) where there is no clear incentive for collaboration and large device manufacturers have considerable influence over standard adoption. Reporting in October 2017 for August 2017 data, smartphone market shares for Apple and Samsung were 35.0% and 35.2% respectively.[[23]](#footnote-60) Several of Samsung’s devices already support the High Efficiency Video Codec (HEVC), and Apple formally announced HEVC adoption for their devices in June of 2017.

AV transmission standards largely concern the owners of content delivery services, who charge for the privilege of access to users of their networks. From 2006 to 2016, internet advertising revenues in *the United States alone* grew approximately 429.0% from $16.9 billion to $72.5 billion,[[24]](#footnote-62) with the “top ten” (10) companies commanding 69-75% of revenue over the same period.[[25]](#footnote-64) In this case standardization is a revenue optimization strategy: the more devices end users own which support the standard, the larger the potential customer pool for advertisers.

Though VP9 is widespread, and the standard format for YouTube, Apple has repeatedly passed on implementing it in Safari for iOS or macOS.[[26]](#footnote-65) Thus Safari users cannot access VP9-encoded content and must change browsers or rely on vendors to support multiple formats, which introduces additional frustrations for users.

4K -[[27]](#footnote-66)

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2. Consider that in 2003, access to a mannequin such as SimMan (now SimMan Classic) *was the definition of* a “high fidelity” simulation program. Ten years later, a properly equipped program would have *one or more* “high fidelity” mannequins, several “mid”- and “low”- fidelity mannequins, dedicated simulation space, and an AV system able to capture at least one room. [↑](#footnote-ref-26)
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8. As an example, see advertisers’ use of megapixel calcuations for advertising digital cameras. [↑](#footnote-ref-33)
9. **THIS NEEDS A CITATION!!** [↑](#footnote-ref-34)
10. See *Engineering and Technical Challenges* below. [↑](#footnote-ref-37)
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12. http://www.mpegla.com/ [↑](#footnote-ref-41)
13. https://www.hevcadvance.com/ [↑](#footnote-ref-42)
14. http://velosmedia.com/ [↑](#footnote-ref-43)
15. See https://en.wikipedia.org/wiki/High\_Efficiency\_Video\_Coding#Patent\_license\_terms [↑](#footnote-ref-44)
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19. http://www.mpegla.com/ [↑](#footnote-ref-51)
20. IAM, “Technicolor CIPO Explains Why the Company Left the HEVC Advance Patent Pool,” May 16, 2016, <http://www.iam-media.com/Blog/Detail.aspx?g=353c0dad-4d43-46d9-8789-2e4605bccfee>. [↑](#footnote-ref-52)
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