Whole Home Audio and Video Switching Using HDMI

By Vaughn Petraglia CCDP

Ask an electronics systems designer about using HDMI (High Definition Multimedia Interface) for an integrated residential application and you are likely to get a range of discouraging responses. They’ll tell you that HDMI is fine to connect a cable box and DVD player to a TV, but not ready for more complicated applications like whole house integration. They’ll mention that major control systems vendors do not yet support HDMI, or they only support it at the edges of their systems. Most designers today still consider it to be on the “bleeding edge”. In fact one of our competitors turned this project down and said it could not be done with today’s technology. However, HDMI technology and products have improved dramatically in the past year. Could it be that we have reached a tipping point where the technology may be an excellent choice for broader applications, and that HDMI is ready for “real” whole home applications?

In this paper, I will describe a complex system relying heavily on HDMI switching and delivery. This project was designed and implemented in the summer of 2007 and while some aspects of the design might seem cumbersome, recall that many of the products on the market today did not exist at the time. Leveraging recent technology makes implementation of solutions like this one far easier today than a few short months ago, and might change the way we all think about HDMI.

The customer for this application wanted a state of the art system throughout his house to provide entertainment (music, HDTV, movies, etc.), access internet-based media, screen HD videos that he produces, and monitor security cameras around the house.

The high level system requirements were to make all sources (audio, video, digital, and analog) available at all destinations. To provide the highest quality, all transmissions must support at least the resolution of the source and all digital signals must remain digital and in full resolution all the way to the processing destination. As much equipment as possible would be located in the racks at the head end and not in the destination rooms.

To meet these requirements we had to use a completely digital transmission and switching protocol for the core of the application, and in the early stages of system design, we considered HDMI and IP (Internet Protocol) based systems. While IP could have been easier to distribute and switch, all of our digital sources and displays used HDMI as their native connection. Therefore, it did not make sense go to the effort and expense to convert from HDMI to IP and back to HDMI. Using an IP based system would have also required us to locate significant equipment at the destination rooms.

Global source components included:
1. Motorola HD Cable Box 1 *
2. Motorola HD Cable Box 2 *
3. Up-Converting DVD Player *
4. Niveus Media Center with 2 HD Cable Cards *
5. Russound Distributed Audio System using analog stereo audio
6. 6 Security Cameras with composite analog video
7. Composite View of Security Cameras
8. XM Radio Tuner with S/PDIF Output
* For the cable boxes, DVD player, and media center, HDMI was used for video only and S/PDIF was used for digital audio. It was simpler to keep the audio and video separate so they could be processed in different physical locations: the video was processed in the TVs at the destination rooms and the audio was processed in receivers located in the racks at the head end.

The destination rooms include:
1. Great Room with a flat panel HDTV and a 5.1 surround sound
2. Master Bedroom with a flat panel HDTV behind a VuTec Art Screen and stereo sound
3. Office with flat panel HDTV and 5.1 surround sound
4. Play Room with flat panel HDTV and 5.1 surround sound

The system design presented a number of challenges: switching HDMI with no reliable HDMI matrix switches available at this time; destination locations at long distances from the head end; controlling a large number of components reliably; a very large number of physical connections; and being one of the first installations of HD cable cards in a Windows Media Center PC. (See Figure 1 for a block diagram of the design)
After spending time researching HDMI switching products, I found only one brand of HDMI matrix switch was available that could be shipped in the time frame we needed. Further investigation showed this product to be brand new to the market with some of the early users reporting a number of implementation problems and compatibility issues.

So instead of using this matrix switch, we decided to “build” a switch using more mature products: 4 KeyDigital 4 way HDMI distribution amplifiers and 4 KeyDigital 1 X 4 HDMI switches (see figure 2). We were also very careful to insure that the video destinations had similar video characteristics to simplify the EDID (Extended Display Identification Data) handshakes, since this allowed us to set up the distribution amplifiers to always perform the EDID hand shake on output port 1 no matter where we were truly passing the HDMI signal.

To carry the HDMI signals from the “matrix switch” to the destinations we used HDMI to Cat5e and Cat5e to HDMI baluns. There were very few of these baluns on the market at the time and KeyDigital was not among them. We chose another vendor’s baluns and this became our first major compatibility problem. In our lab we successfully tested the “matrix switch” consisting of the KeyDigital distribution amplifiers and switches. We also tested the baluns over the required distances and they worked as well, but when we connected the baluns to the switches we could only get a picture very briefly before screens went blank.

It looked like we had a problem with the HDCP (High-bandwidth Digital Content Protection) handshake because we would get a picture then lose it in a few seconds. It seemed that somehow the handshake was not being passed from one vendor to the other correctly. After a couple of weeks working with the customer support organizations of both companies we were no closer to an answer than when we started.

At that point we were spinning our wheels and the project threatened to go over budget. We could not wait for a technical resolution — we had to do something fast. Fortunately, and just in time, KeyDigital began shipping baluns that met our specifications. KeyDigital’s baluns, distribution amplifiers, and switches all worked together properly, reinforcing my long held belief that designs should always use as few vendors as possible.

Due to the need to control a large number of switching components (4 distribution amplifiers, 4 switches, an analog matrix switch and receivers), we concluded that using RF and IR would not have sufficient reliability to control this application. We used 2 Universal Remote Control MCS-400s to contain all the complex switching macros to communicate via RS-232 to all the critical components. We also chose 4 Universal Remote MX-3000s to control each of the 4 destination rooms communicating through RF to 2 Universal Remote MSC-400s.

Our second major compatibility problem was now exposed, the MSC-400s were not controlling the KeyDigital HDMI distribution amplifiers reliably using RS-232. After debugging the problem, we
determined that the MSC-400s were not transmitting RS-232 correctly at 56K baud, the only transmission rate that the distribution amplifiers were able to receive. According to their support group, this problem was a function of the RS-232 chip used in the MCS-400 and was not quickly correctable. We were able to work around this problem by locating a supplier of inexpensive RS-232 buffers that allowed us to receive a lower baud rate transmission from the MSC-400s and output it at 56K baud to control the distribution amplifiers.

We also installed the first Windows Media Center PC (Niveus) with HD cable cards in our Comcast region. Both Niveus and Comcast were very supportive. But the installation of the media center and its setup is a topic for another paper.

The completed project was a success; we were able to meet all the customer’s requirements both technically and functionally. The implementation took more labor than we expected, and we had to make a few technical of changes along the way, but the result was a very happy customer and an excellent reference for our company. Perhaps the more important overall result is a change in perception about the viability of HDMI as an interconnect workhorse for complex whole home applications. With the emergence of a few enabling products such as next generation switches and controls, the task is becoming easier and these great results more accessible. In a few months, the answers you get about the viability of HDMI in the applications might be a lot different.

I would like to thank our installation team and the excellent customer support from KeyDigital, Universal Remote Control, Niveus, and Comcast, without their help this system would not have been possible.

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