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IBM

Digital Television Broadcasting in Brazil

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Television is one of the most popular communication mediums in Brazil, where more than 94.6 percent of households have at least one television set. This percentage corresponds to more than 80 million TV sets. Besides providing free access to entertainment and culture, broadcast television acts as a unifying factor of fundamental importance to a country the size of Brazil.

After 50 years of existence, Brazilian television is undergoing significant changes with the arrival of digital television. Digital television not only represents progress in terms of communication technology, but also offers a new way of accessing information. Digital television will enable the transmission of different types of programs that might include high-definition shows, standard-definition programs, audio broadcasts, or any type of multimedia content. One of the major novelties of digital television is the advent of interactivity between users, broadcasters, and content providers. With digital television, users can participate in polls, play games, search the Web, and send and receive email, for example.

Action to implement digital television in Brazil started in the late 1990s with the work of the Brazilian Commission of Communications of the National Telecommunications Agency (Anatel). From November 1998 to May 2000, researchers conducted extensive field and laboratory tests with the three digital television standards available at that time:[1]

- Advanced Television System Committee (ATSC) developed in the US.[2]
- Digital Video Broadcasting—Terrestrial (DVB-T) developed in the European Union.[3]
- Integrated Services Digital Broadcasting—Terrestrial (ISDB-T) developed in Japan.[4]

Besides comparing the performance of the available standards, these tests provided insights on the technologies appropriate to the unique environmental, economic, and social conditions of Brazil.

In November 2003, the project for the development of the Brazilian Digital Television System—which is now known as the International System for Digital Television (ISDTV)—was officially launched. The ISDTV's main objective was to define the reference model for the Brazilian digital television standard, which includes not only the technology itself but also the ways of exploiting the rights to transmit and the transition model from analog to digital. The ISDTV project aims to provide the population with access to digital television and to promote social inclusion. A total of 105 institutions, including industry, universities, research centers, and broadcasting companies, participated in the ISDTV project.

In June 2006, the Brazilian president, Luiz Inácio Lula da Silva, signed the decree that officially defines the transition period from analog to digital television. According to the decree, ISDTV allows digital transmission of standard- and high-definition video; simulta-

Editor's Note

With the broad penetration of television in Brazil, the country's adoption of a new broadcast digital television standard is important technologically and economically. Already the biggest market in South America, the switch to digital television is expected have a fiscal impact on the order of \$100 billion. The International System for Digital television (ISDTV) standard was inaugurated in December 2007. ISDTV was selected from today's best-known individual technologies for video and audio coding, transport and channel coding and modulation. The transmission of ISDTV signals has started in Sao Paulo and rollout will continue across the country through 2013. Other countries across South America are also considering adoption of ISDTV.

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neous transmission for fixed, mobile, and portable devices; and interactivity. The features of ISDTV include

- the more advanced H.264 standard for digital video coding, as opposed to the MPEG-2 standard used in the ATSC, DVB-T, and ISDB-T standards;
- Ginga middleware, which has been specifically designed for ISDTV; and
- WiMAX technology as the communications platform for the interactivity channel.

Figure 1. President Luiz Inácio Lula da Silva speaks at the ISDTV inauguration ceremony. (Courtesy Ricardo Stuckert / Agência Brasil.)

ISDTV signal transmission started in São Paulo on 2 December 2007. Figure 1 shows a photo from the inauguration ceremony. ISDTV maintains the same characteristics of analog television: each broadcast company is assigned a 6-MHz channel in the VHF/UHF band, and users receive the television signal free of charge. ISDTV rollout plans mandate that all state capitals must be covered by the end of 2009, while the rest of the Brazilian cities should be done by the end of 2013. During this period, analog and digital signals will be transmitted simultaneously.

The ISDTV standard

Figure 2 (next page) presents a block diagram of the ISDTV standard. ISDTV is fully compliant with the reference digital-television terrestrial-transmission model defined by the International Telecommunications Union (ITU).[5] Table 1 shows the technical specifications of each of the stages of the ISDTV.

Video coding

The Motion Picture Experts Group (MPEG) and the Video Coding Experts Group (VCEG) have produced the most popular video compression standards to date. MPEG-2 is a popular standard used not only for broadcasting, but also in applications such as DVDs. The main advantage of MPEG-2 is the low cost of the decoders. With respect to reliability, MPEG-2 is undoubtedly a mature technology. The H.264 standard, also known as MPEG-4 Part 10 or Advanced Video Coding,[6] is a more recent standard produced from a joint collaboration between MPEG and VCEG. H.264 represents a major advance in video compression technology because it delivers a considerable bit-rate reduction in comparison to other standards. For a given quality level, H.264 provides a bit rate of almost half of that provided by MPEG-2.

The ISDTV adopted H.264 as its video compression standard and will use it to code both standard- and high-definition video as well as reduced-resolution videos targeted at mobile or portable receivers. The adoption of H.264 is a key innovation of ISDTV in relation to all other digital television standards.

Audio coding

ISDTV is expected to transmit in stereo and 5.1 multichannel simultaneously. When necessary, receivers should convert from multichannel to stereo using a down-mixing technique, as described in ISO/IEC 14496-3 (Table 4.70).[7] Both signals will be coded using the MPEG-2 Advanced Audio Coding (AAC) standard, which is formally known as ISO/IEC 13818-7.[8] MPEG-2 AAC incorporates recent developments in audio coding, delivering CD-quality sound with bit rates around 96 kilobits per second and allows up to 48 audio streams and up to 15 distinct programs. The ISDTV audio coding standard allows for the following profiles of MPEG-2 AAC:

- low complexity, level 2,
- low complexity, level 4;
- high efficiency, level 2 for stereo, and
- high efficiency, level 4 for multichannel.

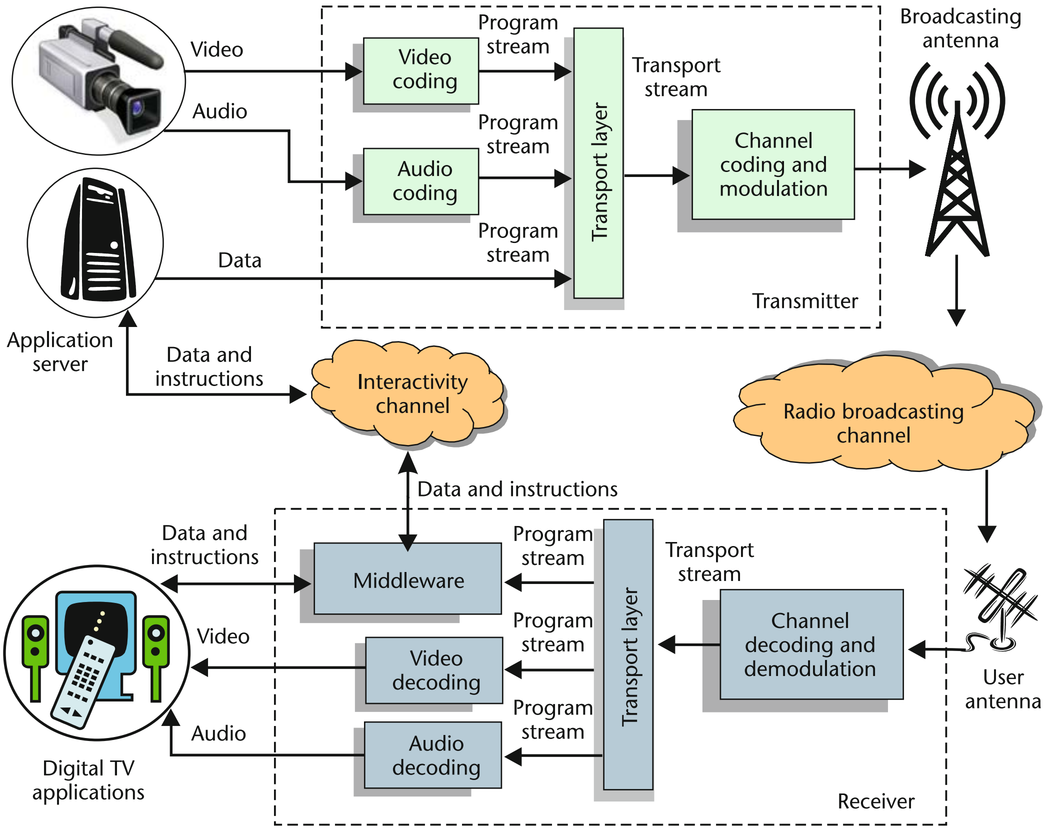

Figure. 2. Digital television system.

Transport layer

On the transmission side, the transport layer is located between the source-coding, channel-coding, and modulation stages. The transport layer's main goal is to multiplex the several program streams in a unique transport stream to prepare them for transmission. On the receiver side, the transport layer decomposes the transport stream into the audio, video, and data program streams. Besides multiplexing and demultiplexing data, some of the functions of the transport layer are

- supporting conditional access;
- buffering administration to guarantee that data is not lost;
- supporting any data information not considered conventional television content;
- supporting add-drop functionality, that is, the ability to substitute part of the original content by other content.

ISDTV uses MPEG-2 Systems (ITU-T Recommendation H.222[9]) as the standard for the transport-layer functions. MPEG-2 Systems provide a set of tools that can be employed in the transport layer for a digital television system. This set of tools consists of general functionalities that can be used partially or altogether. Semantic restrictions can be specified to reflect local requirements and necessities.

Table 1. International System for Digital Television technical overview.

Stage	ISDTV choice
Video coding	H.264
Audio coding	MPEG-2 Advanced Audio Coding
Middleware	Ginga (Nested Content Language and Java)
Transport layer	MPEG-2 systems
Channel coding and modulation	Band segmented transmission-orthogonal frequency-division multiplexing, differential quadrature phase shift keying, quadrature phase shift keying, quadrature amplitude modulation with eight symbols, and quadrature amplitude modulation with 64 symbols

One of the MPEG-2 Systems features is its high capacity to absorb and adapt to local requirements of a given digital television system. Because it's a widely used system, its adoption provides compatibility between ISDTV and other digital television standards at the transport level.

Channel coding and modulation

The ISDTV adopted the same technology used by the ISDB-T for coding and modulating the digital television signals, which means that the signals are transmitted with the band segmented transmission (BST) technique and orthogonal frequency-division multiplexing (OFDM). This Japanese model was chosen because it's the most advanced among the three available standards (ISDB, DVB, and ATSC). In the field and laboratory tests performed in Brazil, the modulation and coding scheme of ISDB-T presented the best performance.[1]

The BST-OFDM scheme allows flexibility and mobility, making it possible to receive television signals in fixed and mobile receivers. It allows for high-quality digital modulation and supports high-definition television. The subdivision of the digital channel allows simultaneous transmission of multiple services.

Middleware

The greatest technology novelty introduced by digital television is interactivity. While the user experience in analog television is passive, digital television allows interaction between users and broadcasting companies. Because the application data is transmitted along with the traditional television content, digital television receivers need to separate and process the different information formats and interpret and execute instructions.

One of the biggest challenges of digital television systems is to guarantee the interpretation and execution of instructions in a wide variety of heterogeneous receivers that have different resources and capacities and come from different manufacturers. Another challenge is to allow software updates or upgrades, as needed. The type of middleware used by a digital television standard generally defines the types of services available at the receiver. The choice of middleware affects the interactivity resources and the implementation complexity. In the case of ISDTV, choosing which technologies to use in the middleware subsystem was a big step toward establishing a digital television standard suited to Brazil's needs. A significant part of the technological advances developed by Brazilian researchers was in the area of middleware.

The middleware adopted by ISDTV was developed jointly by researchers at the Catholic University of Rio de Janeiro and the Federal University of Paraíba. Called *Ginga* (see Figure 3, next page), the middleware meets the requirements of the ITU J.200, ITU J.201, and ITU J.202 recommendations.[10–12] Additionally, Ginga is compatible with the Globally Executable-Multimedia Home Platform (GEM) standard. GEM is a unified digital television middleware specification that the DVB group proposed and the ISDB[13] and ATSC standards[14] adopted later.

The Ginga standard specifies a set of common functionalities (Ginga-Core) that supports the Ginga application environments. The Ginga-Core consists of common content decoders and procedures that prepare the data to be transported through the interactivity channel. The Ginga-Core also supports the ISDTV conceptual display model, and its specifications for the architecture and applications were designed to work on digital television receivers as well as other systems, such as satellite or cable digital television systems.

We can divide the Ginga applications into declarative (Ginga-Nested Content Language, or NCL[15]), procedural (Ginga-J[15]), and hybrid. An application is hybrid when it contains both declarative and procedural content types. For example, declarative applications often make use of script content, which is procedural in nature, or reference an embedded JavaTV Xlet. Also, a procedural application might reference declarative content, such as graphic content, or construct and initiate the declarative content presentation.

Ginga-NCL is the declarative application environment of the Ginga middleware that has NCL as the core language. NCL is a declarative language, developed at the Catholic University of Rio de Janeiro, that focuses on how media objects are structured and related in time and space.[16] NCL doesn't restrict or prescribe the media content object types and it can include XHTML-based media objects, as defined in other common digital television

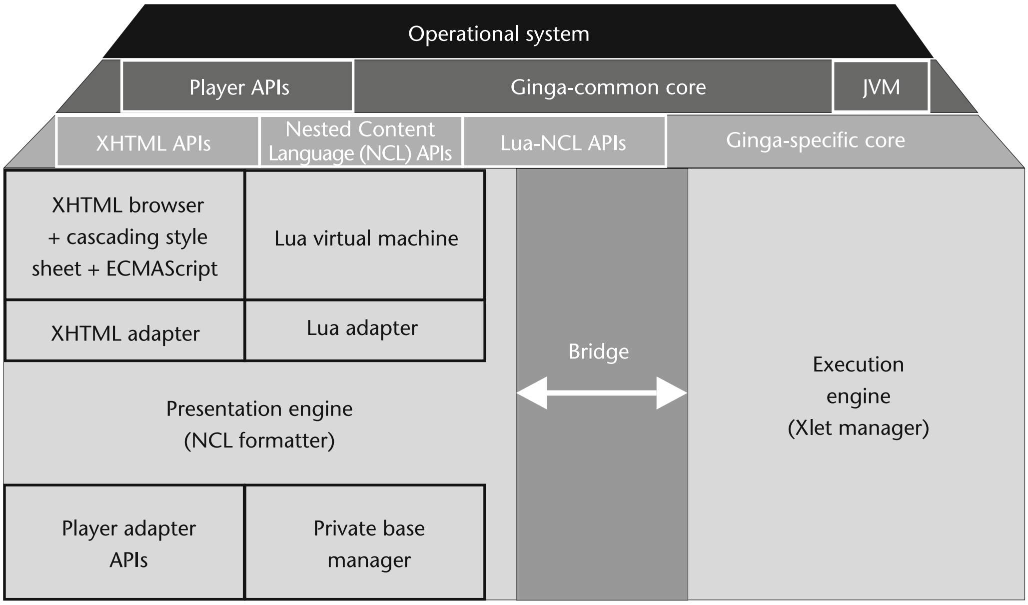

Figure. 3. Ginga middleware architecture.

standards. A main component of Ginga-NCL is the declarative content-decoding engine (NCL formatter). Other important modules include the XHTML-based user agent, which includes a cascading style sheet, an ECMAScript interpreter, and the Lua programming language engine (responsible for interpreting Lua scripts).

Ginga-J is the Ginga middleware's procedural application environment. An important component of Ginga-J is the procedural content-execution engine, made of a Java virtual machine. We can use common content decoders for both procedural and declarative applications, for decoding and presenting common content types, such as PNG, JPEG, MPEG, H.264, and others.

Interactivity channel

The interactivity channel is responsible for all information exchange between the interactive applications running on users' receivers and the application servers run by TV stations. The interactivity channel consists of several components, as the simplified diagram in Figure 4 shows. The interactivity channel's two main components are the return channel and the downstream channel. Broadcasting companies and content providers use the downstream channel to deliver data to end users. The downstream channel consists of the broadcasting channel and the communications platform adopted for the return channel, which can act as an extra downstream channel. Viewers use the return channel to request or send information to broadcasting companies or content providers. The return channel can be built out of any access network technology, such as Ethernet, Wi-Fi, General Packet Radio Service, and so forth.

The ISDTV standard hasn't specified any particular technology for the return channel. Consequently, manufacturers are free to build TVs and set-top boxes tailored to any network platform currently available. But, unlike the situation in some countries where the return channel can be implemented over already installed cable networks, such an option is not always readily available in Brazil. Therefore, its broad adoption can become costly, especially in some of the remote areas of Brazil. For Brazil to accomplish its goals of promoting digital inclusion through educational and government services, as well as through large-scale (and free) Internet access, the country must implement a far-reaching access technology.

Researchers have studied several technologies for the return channel, including, for example, DVB-Return Channel Terrestrial, Evolution Data Only, Wi-Fi, WiMAX, and Power Line Communications. Considering the results of the analysis, the most adequate alternative for ISDTV is the WiMAX-700 technology, which is a new WiMAX specification.[17] The profile operates in the 400- to 900-MHz primary frequency band (UHF band) and, optionally, from 54 MHz to 400 MHz as a secondary band (VHF band). WiMAX-700

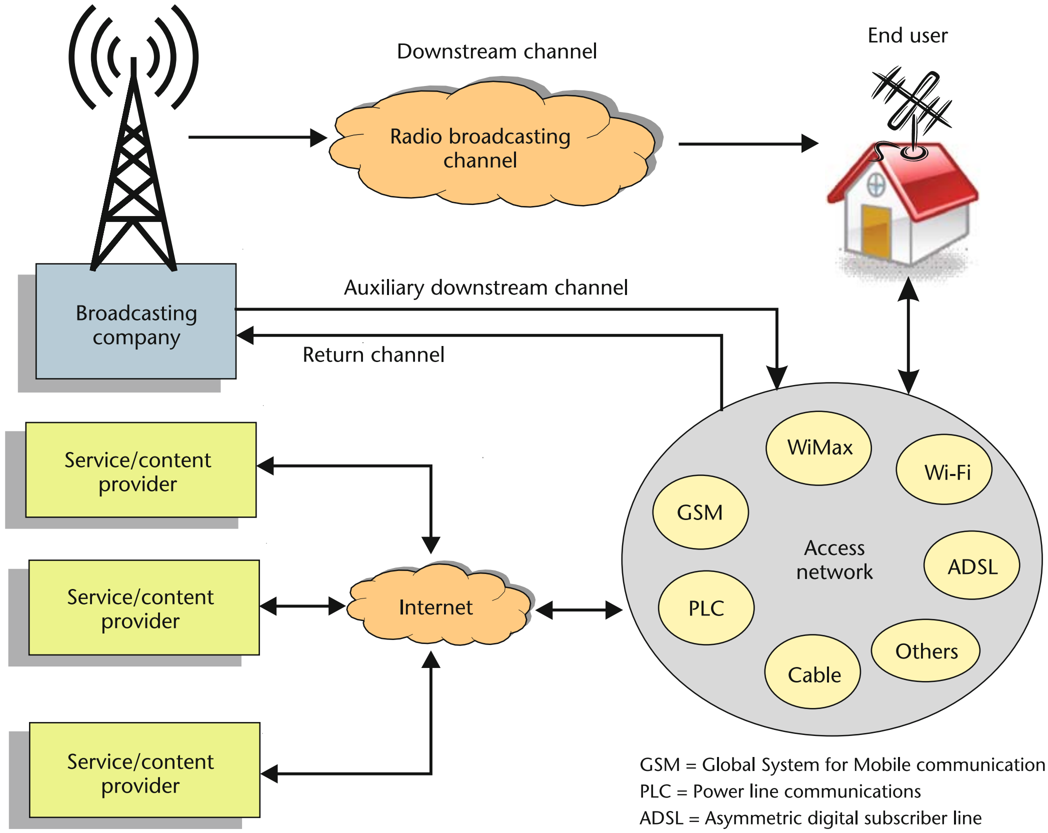

Figure 4. Block diagram of the interactivity channel.

presents several advantages over current WiMAX profiles, including better indoor penetration, higher propagation range (up to 65 km), and lower operational costs.

Conclusions

The ISDTV was designed to fulfill the challenging and unique demands of broadcasting television in Brazil while promoting digital inclusion throughout the country. With ISDTV, channels occupy the same 6-MHz bandwidth of old analog stations, and it can deliver high- and standard-definition videos to fixed, mobile, and portable devices. In 10 years, the market for digital television sets in the country is expected to reach $100 billion. The Brazilian market is the biggest in South America, and significant efforts have been made by the Brazilian Ministry of Communications to promote the Brazilian standard throughout South America. So far, Chile, Argentina, Paraguay, and Venezuela are considering its adoption. **MM**

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