Digital TV – The Software Components

**SIBGRAPI 2007** – Tutorial
October 7-10, 2007
Belo Horizonte, Minas Gerais, Brazil

**Author Contact Information**

- Alisson Sol
  Microsoft Research Cambridge
  Alisson.Sol@Microsoft.com
  http://research.microsoft.com/~asol/

- Paulo Sérgio Pinto
  Microsoft TV
  PauloP@Microsoft.com

**Disclaimers**

The views and opinions offered by individuals in this presentation do not necessarily represent the views of Microsoft. This work is intended for information and education only and is not guaranteed by Microsoft as to accuracy, completeness, nor any trading result.

All referenced company and product names are trademarks, registered trademarks or copyrights of their respective holders.
SIBGRAPI 2007
Digital TV: The Software Components
Demonstration & Motivation
Alisson Sol
Paulo Sérgio Pinto

What Consumers Like About TV
• Clearer Picture And Sound: 78%
• Variety of TV Channels: 72%
• Electronic Programming Guide: 44%
• DVR: 38%
• Digital/Music Channels [Audio Only]: 34%
• VOD: 32%
• Picture-in-Picture: 23%
• Metadata (Info about directors, etc.): 22%
• Sports Premium Channels: 20%
• Interactive TV Services: 13%

Learning From Customers
• Computer: “Do what I want!”
• Television: “Entertain me!”
• Distance
  – Computer: 2 feet (~0.6m)
  – Television: 10 feet (3m)

The Next Generation
• Beloit College’s Mindset List
  – The Class Of 2011 (Born 1989)
    1. What Berlin wall?
    9. Nelson Mandela has always been free...
    14. Music has always been “unplugged.”
    33. U2 has always been more than a spy plane.
    47. High definition television has always been available.
    66. The World Wide Web has been an online tool since they were born.
• What About Those Born on 1999?

Interactivity Video
• Notes
  – Nintendo Wii
  – Xbox 360
  – Xbox Live
  – YouTube.com

Television Would Have To Change
• This Generation (3 Top Features)
  – Clearer picture and sound
  – Variety of TV channels
  – Electronic program guide
• The Next Generation
  – Interactivity
Digital TV Myths
• Analog TV Systems Cannot Add Data
  — Closed captions, ...
• Digital TV Transmission Is “Digital”
  — The signal is still an electromagnetic wave, now
    encoding “digital” information
• Old TVs Have To Be Replaced
  — You can use a digital-to-analog converter to get
    digitally encoded signal to a traditional TV

Set Top Box
• STB (Set Top Box)
• IRD (Integrated Receiver Decoder)
• PT: URD (Unidade Receptora Decodificadora)

User Experience Video
• Notes
  — DVB (Digital Video Broadcasting)
  — Scanning and configuring
  — EPG (Electronic Programming Guide)
  — Interactivity (local)
  — DVR (Digital Video Recorder)

Erosion Of Terrestrial TV Revenue
• Competing TV Transmission Media
  — Satellite, Cable, Broadband
• DVR
  — 53% of DVR users skip commercials
    (Source: Jupiter Research)
• Alternative Ads Destination
  — Internet, Games, etc.
• “Digital Convergence”
  — Content available in computers and devices

Storage Convenience
• High Definition Content Formats
  — HD DVD: 30GB
  — Blu-Ray: 50GB
• TV Content (if all in HD)
  — Blu-Ray 2-hours movie = 50GB (Max)
  — 1 day = 1200GB
  — 1 year = 427TB
  — At $1/GB: 1 year ~ $437,000
  — Compare to 4380 2-hour tapes...

Motivations Summary
• Customer Features
  — More Channels
  — Better picture and sound
  — Interactivity
• Revenue Model
• Industry Pressure
Terminology

Alisson Sol
Paulo Sérgio Pinto

Agenda

- Browse Terminology
  - Define acronyms that will be used, but are mostly out of scope
  - Have broad view before going deeper into specific areas of interest

Video Frame Definitions
- Frame
  - Single image from video
- Field
  - Half of the frame from interlaced video
- Video scanning
  - Progressive x Interlaced
- Interlacing: getting fields from frame
- Deinterlacing: getting frame from fields

Initial B&W TV System
- Scanning: Progressive
- VBS: Video Baseband Signal
  - Black level
  - White level
  - Synchronization
    - Per line
    - Per frame (retrace)

Video Signal Line

STB and Modulation
- Different Technologies
  - AM: Amplitude Modulation
  - FM: Frequency Modulation
  - QAM: Quadrature Amplitude Modulation
  - QPSK: Quadrature Phase Shift Keying
  - VSB: Vestigial Sideband Modulation
  - DQPSK: Differential Quadrature Phase Shift Keying
  - COFDM: Coded Orthogonal Frequency-Division Multiplexing
  - BST-OSDM: Band Segmented Transmission Orthogonal Frequency Division Multiplexing
### Modulation Technologies

- **Amplitude**:
  - 0
  - 1

- **Frequency**: 0 1

- **Phase Modulation**: 0 1 00

- **Quadrature Phase Shift Keying**: 01 10 11

### Color TV Channels

- **Video**
- **Chroma**
- **Audio**

### Video Resolution

- **Lines And Scanning**
  - 480i, 480p
  - 576i, 576p
  - 720i, 720p
  - 1080i, 1080p

- **Aspect Ratio**
  - 4:3
  - 16:9

- **Conversion**
  - Upcaling
  - Downscaling

### Analog Color TV Systems

- **NTSC (National Television Systems Committee)**
  - Chroma: 3.579MHz
  - QAM (Quadrature amplitude modulation)

- **SECAM (Séquentiel couleur avec mémoire)**
  - Same color information for two consecutive lines

- **PAL (Phase Alteration Line)**
  - Inversion of carrier every second line
  - PAL M: 525 lines/59.94 Hz, subcarrier 3.576 MHz

### Transmission of Video

<table>
<thead>
<tr>
<th>Technology</th>
<th>Bandwidth (Mbps)</th>
</tr>
</thead>
<tbody>
<tr>
<td>640x480x24 bits * 24fps</td>
<td>168.75</td>
</tr>
<tr>
<td>Wired Cable (100BaseT)</td>
<td>100</td>
</tr>
<tr>
<td>802.11b/g/n</td>
<td>11/54/248</td>
</tr>
<tr>
<td>xDSL</td>
<td>8</td>
</tr>
<tr>
<td>WiMax (802.16)</td>
<td>70</td>
</tr>
</tbody>
</table>

Bandwidth is maximum from standards

### Viable Digital TV Transmission

- **Source Coding**
  - Maximize compression and minimize information loss during video digitization

- **Channel Coding**
  - Limit bandwidth utilization and minimize effect of errors during transmission
Source Coding

- JPEG: Joint Photographic Experts Group
- DCT: Discrete Cosine Transform
- MPEG: Moving Picture Experts Group
  - MPEG-1: Video/Audio (MPEG-1, layer 3 = MP3)
  - MPEG-2: Program Streams
  - MPEG-4: AV + objects, HD
  - MPEG-7: XML metadata
  - MPEG-21: Multimedia framework

Channel Coding

- Stream Multiplexing
- Scrambling
- CAM (Conditional Access Messages)
- FEC (Forward Error Correction)

Digital TV System

- DVB-S: Digital Video Broadcasting – Satellite
- DVB-C: Digital Video Broadcasting – Cable
- DVB-T: Digital Video Broadcasting – Terrestrial
- ATSC: Advanced Television Systems Committee
- ISDB: Integrated Services Digital Broadcasting
- SBTVD: Sistema Brasileiro de Televisão Digital

Connections

- RCA connector (Composite Cable)
- S-Video
- Component Cable
- SCART (Syndicat des Constructeurs d’Appareils Radiorecepteurs et Téléviseurs)
- HDMI (High-Definition Multimedia Interface)
- DVI (Digital Visual Interface)

Content Protection

- HDCP (High-bandwidth Digital Content Protection)
- Region Coding
  - DVD (Digital Video Disc) Region Codes
    - DVD-9 (1 to 6; 7 future, 8 international)
  - Blu-Ray Region Codes
    - Regions A, B, C
  - HD DVD
    - Currently Region Free
Audio

- Surround Sound
  - 3.0, 4.0, 5.1, 6.1, 7.1, 10.2, 22.2
- 3D Audio Effect

Interactivity

- Middleware - Application Environments
  - DASE (Digital TV Applications Software Environment)
  - BML (Broadcast Markup Language)
  - MHP (Multimedia Home Platform)
  - GEM (Globally Executable MHP)
  - OCAP (OpenCable Applications Platform)
  - Ginga
- Profiles
  - Enhanced Broadcast
  - Interactive Broadcast
  - Internet Access

Recording

- DVR (Digital Video Recorder)
  - PVR (Personal Video Recorder)
  - TiVo
- EPG (Electronic Programming Guide)
- Tuners
  - Dual Tuners
- VOD (Video On Demand)

Mobility

- DVB-H (Digital Video Broadcasting – Handheld)
- DVB-IPDC (DVB specifications for IP Datacasting)
- GPRS (General Packet Radio Service)
- EDGE (Enhanced Data rates for GSM Evolution)
- 3GPP (3rd Generation Partnership Project)
Agenda

- Historic Reasons for Different TV Systems
- Digital TV Systems Factors and Choices

World Electrical/Electronic Issues

- Differences
  - Power outlet
  - Voltage
  - Frequency
  - Analog TV systems
    - “Regions”: DVD regions, Blu-Ray regions, Internet content regions

Terrestrial TV System Factors

- Frame/Field Rate
- Color Information
- Channel Regulatory Issues
- Standard Committees

Electromagnetic Spectrum

- Analog Color TV Systems
  - NTSC (National Television Systems Committee)
    - Chroma: 3.579 MHz
    - QAM (Quadrature amplitude modulation)
  - SECAM (Séquentiel couleur à mémoire)
    - Same color information for two consecutive lines
  - PAL (Phase Alteration Line)
    - Inversion of carrier every second line
    - PAL M: 525 lines/59.94 Hz, subcarrier 3.576 MHz
Digital TV Systems Factors

- Current Installed Base
  - Compatibility
  - Transition Phase
- Economical and Political Factors

ATSC

- Advanced Television Systems Committee
- Main Usage: North America
- Channel Bandwidth: 6 MHz
- Modulation: 8-VSB, 16-VSB
- Bit rate: Up to ~19Megabits/second

DVB-T

- Digital Video Broadcasting
- Main Usage: Europe
- Channel Bandwidth: 5, 6, 7 or 8 MHz
- Modulation: COFDM, QPSK, 16-QAM, 64-QAM
- Bit rate: Up to ~32Megabits/second
  - 31.668Mbps in 8MHz channel using 64-QAM

ISDB-T

- Integrated Services Digital Broadcasting
- Main Usage: Japan
- Channel Bandwidth: 6 MHz
- Modulation: BST-OSDM, QPSK, DQPSK, 16-QAM, 64-QAM
- Bit rate: Up to ~19Megabits/second (62-QAM)

SBTVD-T

- Sistema Brasileiro de Televisão Digital
- Main usage: Brazil
- Channel Bandwidth: 6 MHz
- Modulation: BST-OSDM, QPSK, DQPSK, 16-QAM, 64-QAM
- Bit rate: Up to ~19Megabits/second (62-QAM)
Digital TV Systems Choices

<table>
<thead>
<tr>
<th>System</th>
<th>Video Coded</th>
<th>Middleware</th>
</tr>
</thead>
<tbody>
<tr>
<td>ATSC</td>
<td>MPEG-2</td>
<td>DASE, ACAP</td>
</tr>
<tr>
<td>DVB-T</td>
<td>MPEG-2</td>
<td>MHEG, MHP, SMS</td>
</tr>
<tr>
<td>ISDB-T</td>
<td>MPEG-2</td>
<td>ARIB BML</td>
</tr>
<tr>
<td>SBTVD-T</td>
<td>MPEG-4 (H.264)</td>
<td>Ginga</td>
</tr>
</tbody>
</table>

Switchover

- Simulcast
- Analog Turn Off
  - Luxembourg: September 1, 2006
  - Netherlands: December 11, 2006
  - Finland: September 1, 2007
- Population Guidance
  - Schedule
  - Example: Japan (ISDB) analog terrestrial broadcast ends on July 24, 2011

Technologies Out Of Scope

- But Worth A Brief Citation
  - Satellite TV Systems
  - Cable TV Systems
  - Terrestrial Return Channel
Digital Images
- Raw Format
- Encoding
  - RLE: Run Length Encoding
- JPEG
  - Color Quantization
    - RGB: Red, Green, Blue
    - YCbCr: Luminance, Chrominance Blue, Chrominance Red
  - DCT (Discrete Cosine Transform)

Video Digitization
- Digitization in the Analog Lines
- Video Signal in 4:2:2 YCbCr format
- Other formats

MPEG Video Coding
- Picture Types
  - Intra pictures: all information for reconstruction
  - Predicted pictures: motion from previous I or P
  - Bidirectional pictures: bidirectional interpolation
- Movement Estimator
  - Prediction
  - Motion estimation
  - Compensation

Video Broadcasting
- Source coding and modulation
  - Forward link
  - Backward link
  - Multiplexing
  - Broadcast
MPEG Video Layers

- Sequence
  - Group of pictures
    - Picture
      - Macroblock
        - (4 blocks)
        - Block (8 x 8 pixels)

MPEG Video Layers

- MPEG-2 Broadcasting
  - Levels (Resolution)
    - Low: 360x288
    - Main: 720x576
    - High-1440: 1440x1152
    - High: 1920x1152
  - Profiles
    - Simple: No B pictures
    - Main: I, P, B
    - Scalable
    - Spatial
    - Temporal
      - High: HDTV

Transport Streams

- Video, Audio, Data
- Transport Packet
- Scrambling and Conditional Access

Transport Streams

- Video, Audio, Data
- Transport Packet
- Scrambling and Conditional Access

SBTVD Reference Model

- Access Terminal
  - Services, Applications & Content
    - Source Signal Decoding
      - Audio Decoder
      - Video Decoder
      - Middleware
    - Transport Layer
      - Demultiplexing, Demodulation and Channel Decoding
      - Transport Stream
    - Return Channel

SBTVD Reference Model

- Transport/Reception Chain
  - Digital Video
  - Multiplexing
  - FEC
  - Demultiplexing

Transmission/Reception Chain

- Digital Video
  - Multiplexing
  - FEC
  - Demultiplexing
  - Demodulation
  - Uplink/Downlink

Aerial Transmission

- Error Factors
- BET (Bit Error Rate)
- Super Channel
- Error Correction

Aerial Transmission
Streaming Over IP

- IPTV
- Broadband Internet
- Routing Schemes
  - Anycast
  - Broadcast
  - Multicast
  - Unicast

Video On Demand

- Content Storage
- VOD on Private Networks
- Push Video On Demand
- Content Protection

Video Database Applications

- Metadata Search
  - Actors, directors, producers...
  - Keywords
  - Script, director comments
  - Rating
- Metadata Issues
  - Mistakes
  - Globalization/Localization

Internet Applications

- Content Distribution
  - Video streaming
  - Movie download
- Content Management
- Content Distribution Network
  - Mirroring
  - P2P (Peer-To-Peer)

Peer To Peer Systems

- Concepts
  - Seeds
  - Registrar
- Algorithms
- Live Content Distribution
**Digital TV: The Software Components**

**Programmability And Interactivity**

Alisson Sol
Paulo Sérgio Pinto

---

**Agenda**

- Interactive Television Standards
- International Scenario
- SBTVD Middleware Overview

---

**TV Video Audience Safety**

- "TV Safe"
  - Colors
  - Action area
  - Title area
  - Movement speed
  - London 2012 motion graphics causing people epileptic seizures...
- Video Games
  - Action-packed video games have warnings...

---

**Taxonomy and Usage**

- Rigid Taxonomy
  - eTV (enhanced TV): features depend on content and data delivered to the STB
  - Personalized TV: user can change the TV appearance
    - iTV (interactive TV): there is a return channel to the content provider
  - User’s point-of-view
    - If the user can influence, it is “interactive”
    - Consider video games (few use a return channel)

---

**Digital TV System**

- Source Signal Decoding
  - Audio Decoder
  - Video Decoder

- Transport Layer

- Broadcasting: Reception, Demodulation and Channel Decoding

- Middleware: Source Signal Encoding
  - Audio Encoder
  - Video Encoder
  - Data Encoder

- Transmission, Modulation and Channel Encoding

- Return Channel

---

**Software Layers**

- Applications API
- Middleware API
- Platform API

- Application Layer
- Windows
- MS-DOS
- RTOS
- BIOS
- Hardware

---
Middleware Choices

- **ATSC**
  - DASE: DTV Applications Software Environment
  - OCAP: OpenCable Application Platform
  - ACAP: Advanced Common Application Platform
- **DVB**
  - MHP: Multimedia Home Platform
- **ISDB**
  - ARIB: Association of Radio Industries and Businesses
  - BML: Broadcast Mark-up Language (ARIB STD-B23)

Environments And “Standards”

<table>
<thead>
<tr>
<th>DVB (MHP)</th>
<th>ATSC</th>
<th>ARIB</th>
</tr>
</thead>
<tbody>
<tr>
<td>DVB-J</td>
<td>ATSC-J</td>
<td>ARIB-AE</td>
</tr>
<tr>
<td>DVB-X</td>
<td>ATSC-X</td>
<td>ACAP-X</td>
</tr>
<tr>
<td>DVB-H</td>
<td>BML</td>
<td>GEM</td>
</tr>
<tr>
<td>ES</td>
<td>GEM</td>
<td>J2ME</td>
</tr>
</tbody>
</table>

Harmonization

GEM MHP XLets

- **Package javax.tv.xlet**
  - public interface javax.tv.xlet.Xlet
    - public void initXlet(XletContext ctx) throws XletStateChangeException;
    - public void startXlet() throws XletStateChangeException;
    - public void pauseXlet();
    - public void destroyXlet(boolean unconditional) throws XletStateChangeException;
  - public interface XletContext
    - public static final String ARGS = "javax.tv.xlet.args";
    - public void notifyDestroyed();
    - public void notifyPaused();
    - public void resumeRequest();
    - public Object getXletProperty(String key);

Demo

- Xlet Applications
- XHTML Applications
- Microsoft Mediaroom ADK Simulator
Getting Applications to STB

- Data Broadcasting
- DSM-CC (Digital Storage Media - Command and Control)
- Data Carousel
- Application Environments
  - Native Application Environment
  - Java Application Environment
  - XHTML Application Environment

Middleware Engineering

- Updates
  - Service channels
- Software Deployment
  - Channel stream
- Security Issues

SBTVD Middleware

- Ginga
  - Ginga-CC (Common Core)
  - Ginga-J
  - Ginga-NCL
- Ferramentas
  - Composer
  - Scripting language: Lua

Enhanced TV Applications

- Multi Screen News
- Traffic Cameras
- Angle From Sports Show
  - Soccer/Football
    - Traditional view, reverse angle, goalkeeper
  - Car Race
    - Pilot view, choice from car
- Enhanced Ads

Return Channel

- Cable or Broadband
  - Wired Connection
- Satellite or Terrestrial
  - Mobile Phone Message
    - SIM card directly into STB
  - Internet
  - Traditional
  - Phone

Interactive Applications

- Voting
  - Audience influencing show
- Public Services
  - Internet-like applications
    - Utility bills, public service scheduling
    - Educational shows
Perception and Reality

• Customers Report Higher Satisfaction, But...
  – Most digital broadcasts are not in high definition
  – Most digital broadcasts have less resolution than traditional analog broadcasts
  – Depending on user location, the digital signal may be too weak

UK Ofcom Communications Market

• Office of Communications Report 2007
  – Converging Communication: >50% household have broadband
  – HDTV: 1.7% households
  – Freesat success sparked interest into Freesat
  – Quiz TV down (using telephone as return channel)
  – March/2007: 1000 hours/week
  – July/2007: 90 hours/week

Switchover to Digital TV

• Almost Always Slower Than Expected
  – Only Complete in Small Countries
• Regulatory Agencies Work
  – Consumer Education
  – Coupons
    – EUA: 2 US$40.00 coupons/house that relies on terrestrial
    – Coupon to get STB for digital-to-analog conversion

Content Protection

• In Some Countries, the STB Will Use DRM
  – DRM (Digital Rights Management) will limit ability to copy the digital content
• Tagging Digital Broadcasts
  – Lower resolution than normal
  – Inserting special frames

Privacy

• STB Identification Diminishes Privacy
  – Allow viewing habits to be tracked
  – Happening already in cable systems
• Enhanced/Interactive Advertisement
Enhanced Advertising
• Ad based on target for current show and...
  – ...time since switched channel...
  – ...shows recorded in digital recorder...
  – ...viewer gender...
• Ad pop-up when fast forwarding show
  • “Extended Ad”
    – Push extended ad to local storage
    – Offer extended ad during “normal ad”

Accessibility
• Current Interactivity: Mostly Visual
  • Issue Not Only For Disabled People
    – “Red button” confusion in DVRs
    – Text too small
    – Misunderstanding of “setup issues”
      • Wrong cables may prevent real high-definition
      • Black areas around picture
      • Buffer loss when switching channel (involuntarily happens when pressing wrong key)

HD Content
• Blu-Ray versus HD DVD
  – Several HDTVs will downscale resolution
  – Not able to really show 1080p or 1080i

Current Developments: Standards
• DVB-T Now 10 Years Old
• DVB-CPCM (DVB Content Protection & Copy Management)

Mobile Devices
• Terrestrial Broadcast to Mobile
  – DVB-H (Digital Video Broadcasting – Handheld)
  – DMB (Digital Multimedia Broadcasting)
  – ISDB-T (Integrated Services Digital Broadcasting)
  – MediaFlo

Mobile Specific Technologies
• WAP (Wireless Application Protocol)
  – New XML based language was created
  – Some sites had WAP versions
  – Several explications for failure, but mostly: mobiles simply got to “desktop level”
• Digital TV Development For Mobiles
  – Other than lower resolution, little should be different for developers at authoring level
Tutorial References

Books

  Herve Benoit  
  Focal Press, 2002

- Understanding Digital Television: An Introduction to DVB Systems with Satellite, Cable, Broadband and Terrestrial TV Distribution  
  Lars-Ingemar Lundstrom  
  Focal Press, 2006

- HDTV and the Transition to Digital Broadcasting: Understanding New Television Technologies  
  Philip J. Cianci  
  Focal Press, 2007

- Digital Interactive TV and Metadata: Future Broadcast Multimedia  
  Artur Lugmayr, Samuli Niiranen, Seppo Kalli  
  Springer-Verlag New York, 2004

- Interactive TV Standards: A Guide to MHP, OCAP, and JavaTV  
  Steven Morris, Anthony Smith-Chaigneau  
  Focal Press, 2005

- Mobile TV: DVB-H, DMB, 3G Systems and Rich Media Applications  
  Amitabh Kumar  
  Focal Press, 2007
Online References

- ARIB: http://www.arib.or.jp/english/
- ATSC: http://www.atsc.org
- Digital UK: http://www.digitaluk.co.uk/
- DVB Glossary: http://www.dvb.org/technology/dvb_glossary/
- DVB: http://www.dvb.org/
- ISDB-T: http://www.dibeg.org/techp/isdb/isdbt.htm
- MHP: http://www.mhp.org
- Microsoft Mediaroom: http://www.microsoftmediaroom.com/
- Middleware Ginga: http://www.ginga.org.br/
- Motion Picture Experts Group: http://www.chiariglione.org/mpeg/
- SBTVD: http://sbtvd.cpqd.com.br/
- YouTube: http://www.youtube.com/