Interoperability Aspects of the Grand Alliance HDTV System

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Interoperability

...HDTV is more than better entertainment television...

PS/WP4 Definition:

**"The capability of providing useful and cost-effective interchange of electronic image, audio and associated data:
among different signal formats,
among different transmission media,
among different applications,
among different industries,
among different performance levels."**

Interoperability - Who Cares?

...interoperability will impact the bottom line...

- **The Public (consumers)**
  - **demands products and services that make sense**

- **Producers**
  - **programming that can be delivered to new audiences on both HDTV and computer appliances**

- **Post-Production companies**
  - **new and growing markets for their services**

- **Broadcasters**
  - **new audiences, new services, new revenues**
  - **reduced cost of operations and equipment**

- **Equipment manufacturers**
  - **new and growing markets for equipment**

Interoperability Introduction

- **The Grand Alliance HDTV system was designed to provide a high degree of interoperability with other image-based media, ranging from computers to film**

- **Grand Alliance HDTV is a layered digital system**
  - **picture**
  - **compression**
  - **transport (packet format)**
  - **transmission**

- **Layered architecture is fundamental to interoperability**

- **Header/descriptors provide flexibility**

- **Each individual layer provides important capabilities and interoperability characteristics**

HDTV System Layers

...layered system with header/descriptors provides flexibility...

Picture Layer

1920 x 1080
1280 x 720
60,30, 24 Hz

Multiple Picture Formats and Frame Rates

Video Compression Layer

Data Headers | Motion Vectors | Chroma and Luma DCT Coefficients

Variable Length Codes

MPEG-2 compression syntax

Transport Layer

Packet Headers → **Flexible delivery of data**

Video packet | Audio packet | Video packet | Aux data

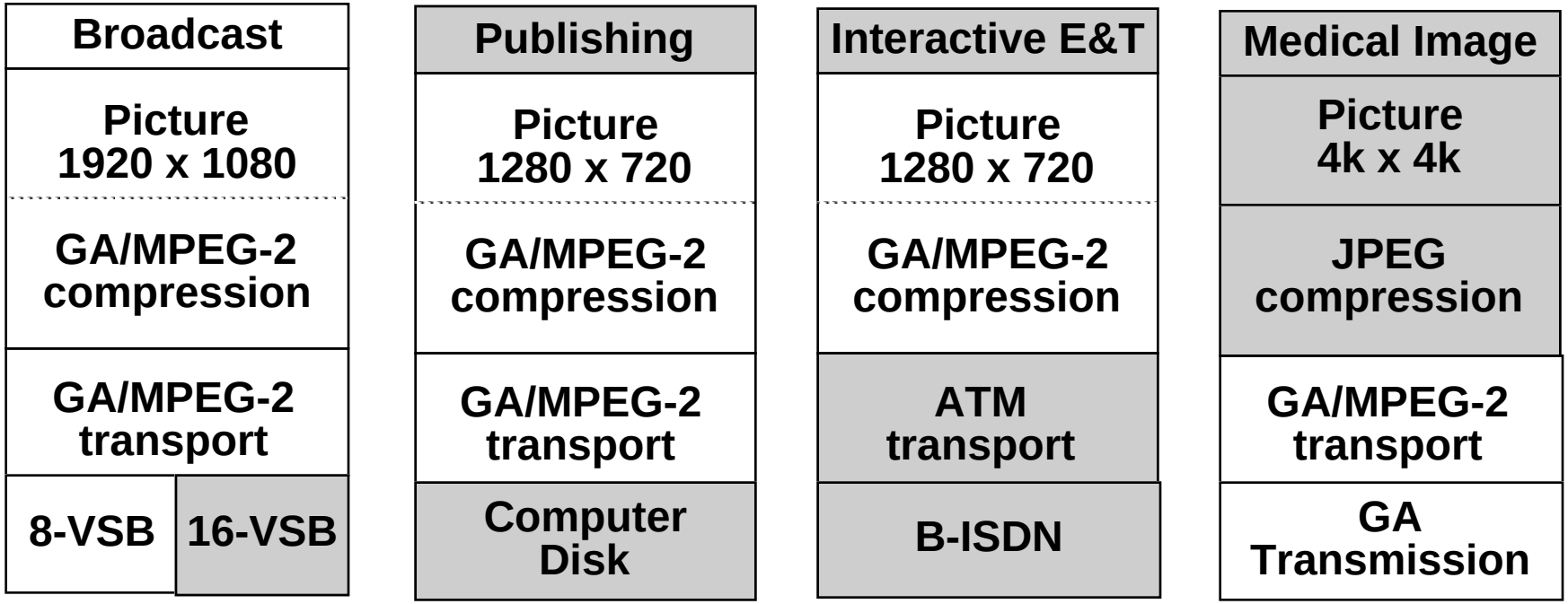
MPEG-2 packets

Transmission Layer

8-VSB

Benefits of Layered Systems

- **Many applications and delivery media share technology**
- **Creates mutual benefits and economies of scale**
- **Consumers will want many applications on an HDTV**



Picture Format Relationships

Cable/Satellite
Digital SDTV
based on CCIR-601
and lower
resoultions

Film
analog
progressive
24 frames/sec

NTSC
analog x 480
interlaced
59.94 fields/sec

CCIR 601
720 x 480
interlaced
59.94 fields/sec

CCIR 601
720 x 576
interlaced
50 fields/sec

U.S. Terrestrial HDTV

Multiple pixel formats and frame rates

US HDTV Production
1920 x 1080
interlaced
59.94/60 fields/sec

SMPTE 240M
1920 x 1035
interlaced
60 fields/sec

Computer Multimedia
wide variety of image sizes
square pixels, progressive scan
wide variety of display frame rates
VGA 640 x 480

PAL & SECAM
analog x 576
interlaced
50 fields/sec

Euro HDTV Production?
1440 x 1152 ?
interlaced
50 fields/sec

Multiple formats and frame rates provide interoperability with HDTV production, film, computers and NTSC

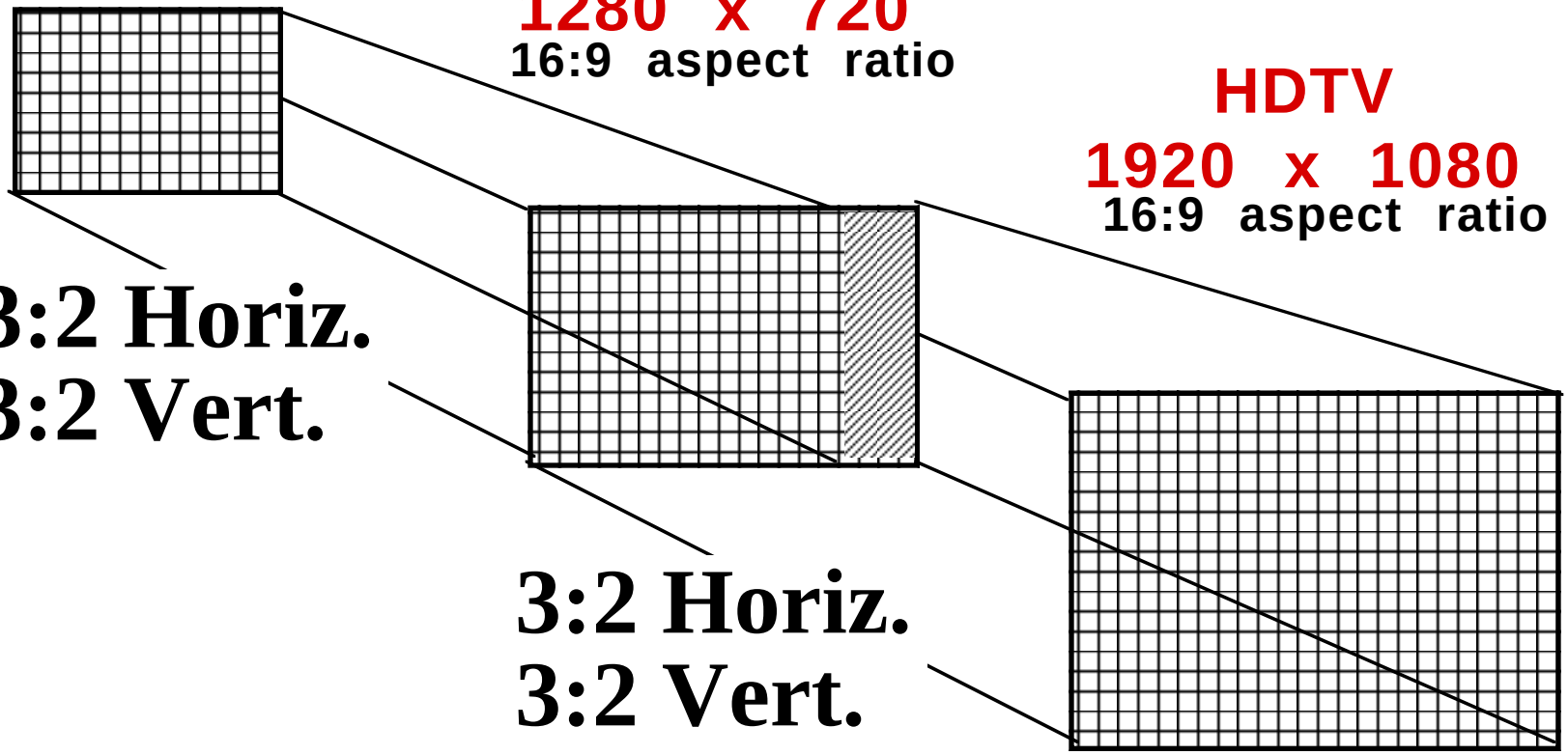
GA Format Relationships

...HDTV and other formats have simple conversion...

NTSC and VGA
640 x 480
4:3 aspect ratio

HDTV
1280 x 720
16:9 aspect ratio

HDTV
1920 x 1080
16:9 aspect ratio



3:2 Horiz.
3:2 Vert.

3:2 Horiz.
3:2 Vert.

GA Picture Formats and HD Production

Spatial	Temporal
1920 x 1080 (square pixels)	59.94 / 60 interlaced 29.97 / 30 progressive 23.97 / 24 progressive
1280 x 720 (square pixels)	59.94 / 60 progressive 29.97 / 30 progressive 23.97 / 24 progressive

3:2 relation

- For the short term
  - 1080 interlaced production, 59.94 Hz based frame rates
- For the long term
  - square pixels for computer interoperability
  - 60 Hz based frame rates are avantageous
  - 720 and 1080 progressive production

GA Picture Formats and Film

Spatial	Temporal	
1920 x 1080 (square pixels)	**59.94 / 60**	**interlaced**
	29.97 / 30	**progressive**
	23.97 / 24	**progressive**
1280 x 720 (square pixels)	**59.94 / 60**	**progressive**
	29.97 / 30	**progressive**
	23.97 / 24	**progressive**

- **The 24 Hz film formats allow efficient encoding of movies**
- **The 30 Hz film formats provide for higher frame rate progressive capture than conventional 24 Hz film**
  - **often used in production of commercials**

GA Picture Formats and Computers

Spatial	Temporal	
1920 x 1080 (square pixels)	59.94 / 60	interlaced
	29.97 / 30	progressive
	23.97 / 24	progressive
1280 x 720 (square pixels)	59.94 / 60	progressive
	29.97 / 30	progressive
	23.97 / 24	progressive

- **Square pixels and progressive scanning provide interoperability with computers**
  - **computer graphics in production**
  - **HDTV receivers as information appliances**

GA Picture Formats and NTSC

	Spatial	Temporal
3:2 relation	1920 x 1080 (square pixels)	59.94 / 60 interlaced 29.97 / 30 progressive 23.97 / 24 progressive
3:2 relation to "wide-NTSC"	1280 x 720 (square pixels)	59.94 / 60 progressive 29.97 / 30 progressive 23.97 / 24 progressive

- Initial 59.94 Hz based temporal rates of all formats simplify transcoding and dual standard receivers
- 3:2 relationship between NTSC and HDTV formats simplifies transcoding and dual standard receivers

Compression Relationships

Cable/Satellite SDTV & HDTV
MPEG-2
≈4 Mbps and greater
a few standard image sizes and frame rates
> VHS quality

Computer Multimedia
MPEG-1 and MPEG-2
1.5 Mbps and greater
wide variety of image sizes and display frame rates
wide range of quality

U.S. HDTV Transmission
GA/MPEG-2

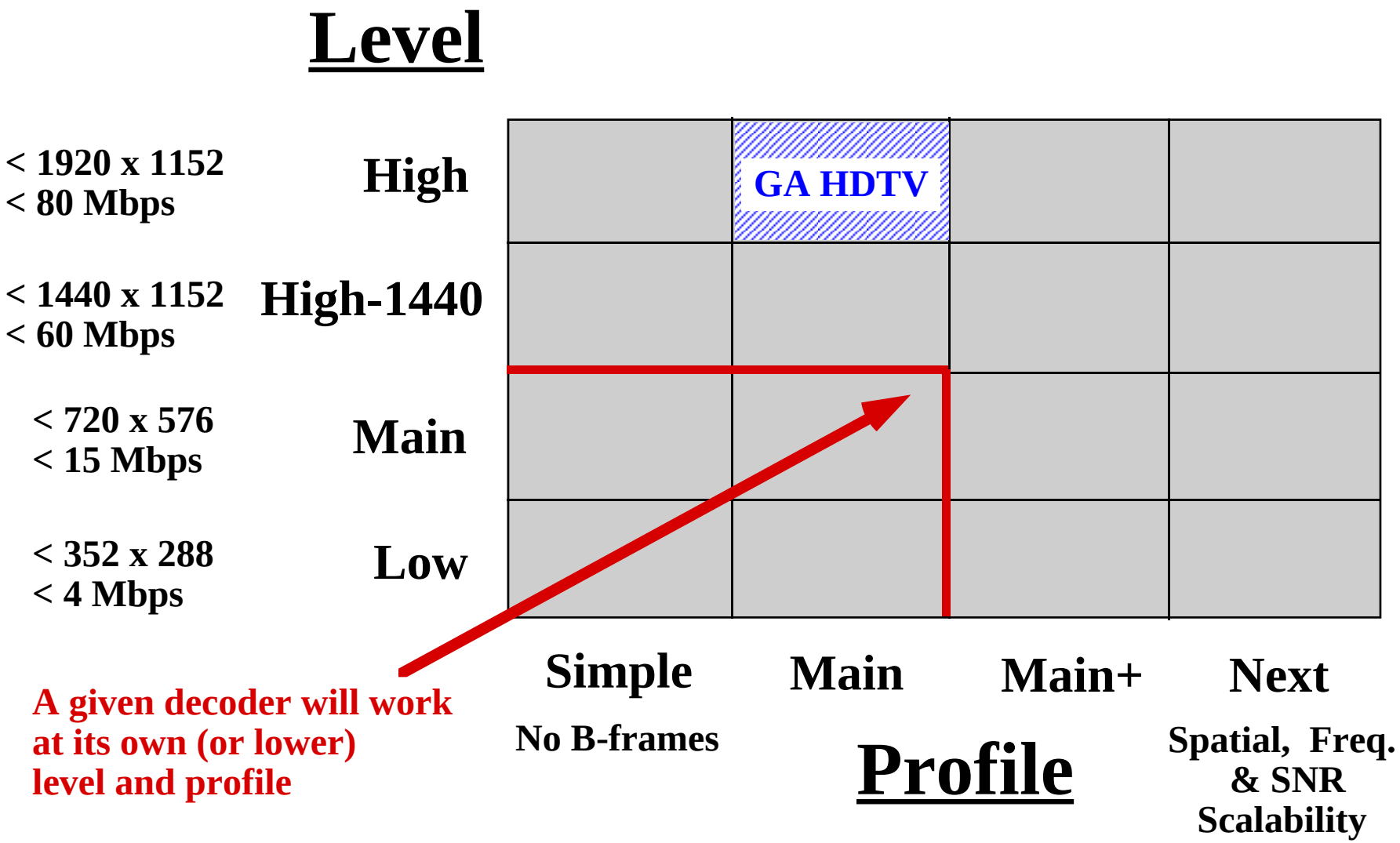
≈19 Mbps
a few standard image sizes and frame rates

Teleconferencing
H.261
≈64 kbps
low frame rate
<< VHS quality
low latency

MPEG-2 is an emerging multi-industry, international (ISO) video compression standard that provides efficient encoding for both progressive and interlaced sources

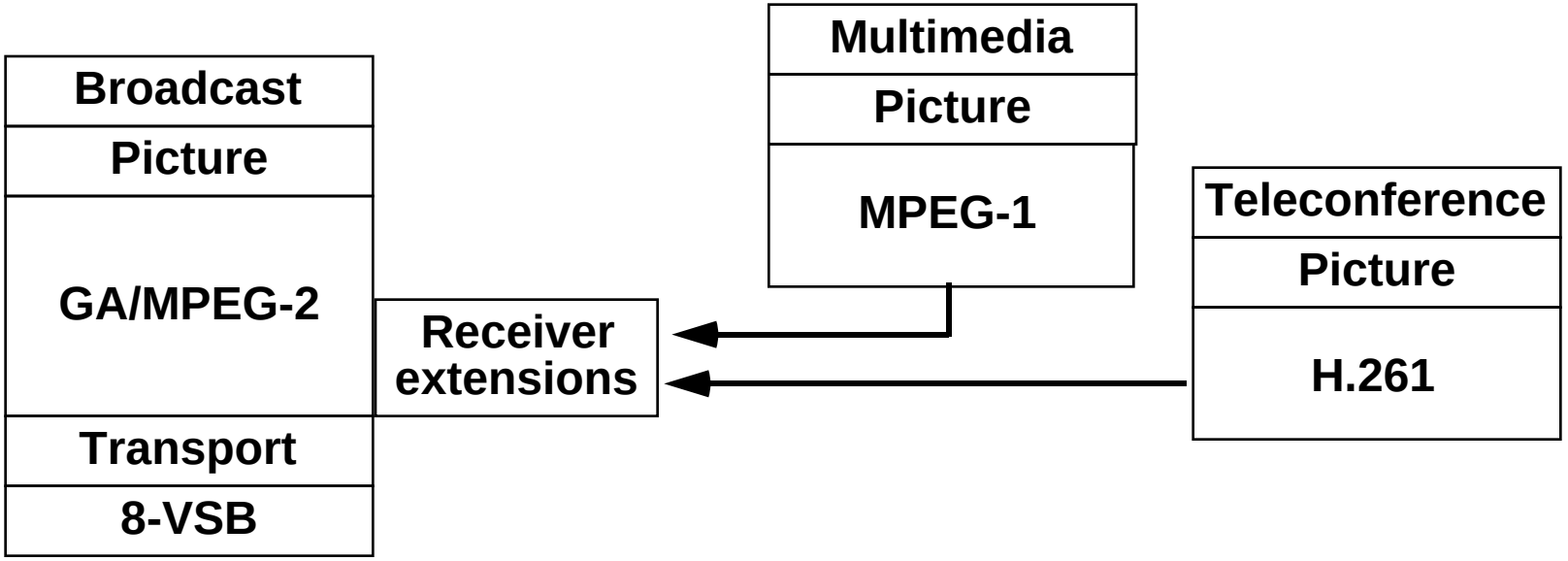
MPEG-2 Levels and Profiles

... MPEG-2 is a toolkit that addresses a variety of cost/performance grades...



MPEG and H.261 Interoperability

- **MPEG-2 is similar to MPEG-1 and H.261, and a programmable decoder could be built to handle them all**
- **Market demand will determine if manufacturers build this capability into HDTVs**



- **Interoperability in the reverse direction is less important, since no existing MPEG-1 or H.261 decoder can decode an MPEG-2 stream, much less at HDTV level**

Audio Relationships

Cable/Satellite SDTV
?????
2-ch composite
≈256 kbps

Prerecorded Media
?????
2-ch composite
≈256 kbps

U.S. Terrestrial HDTV
Dolby AC-3
5-channel surround sound
384 kbps

Film distribution
Dolby
5-ch composite
≈384 kbps

Computer Multimedia

MPEG-2
MPEG Surround
(Other as a non-backward compatible mode?)

MPEG-1
MPEG/MUSICAM
2-ch composite
256 kbps

Audio interoperability is significantly eased in comparison to video because its much lower speed requirements can be fulfilled with programmable devices (audio is about 2% the data rate of HD video)

Transport Relationships

MPEG-2 transport
188 Bytes
overhead critical
designed for severe error rate

Computer Multimedia
MPEG-1 and MPEG-2
generally have no transport layer

interoperates at compression layer or uses ATM

U.S. Terrestrial
GA/MPEG-2 transport
188 Bytes
overhead critical
severe error rate

4:1 packet ratio

Cable/Satellite SDTV & HDTV
GA/MPEG-2 transport?
188 Bytes
overhead critical
moderate error rate

Internet

Ethernet **FDDI**

B-ISDN/SONET
ATM transport
53 Bytes
low-latency switching
overhead not a serious issue
low error rate

MPEG-2 transport is an emerging standard that provides interoperability with ATM

Why Not ATM?

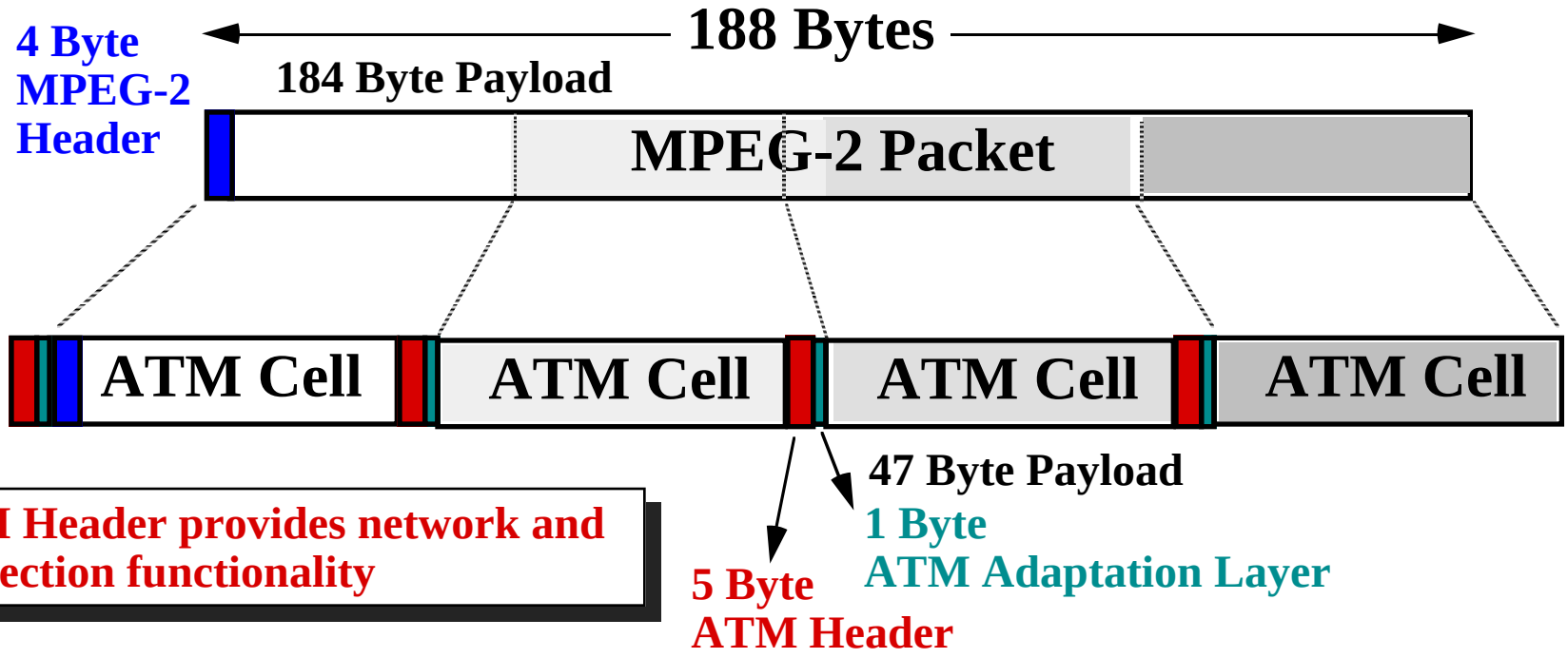
- **Efficiency and Functionality**
  - **ATM's ≈10% header overhead is too high for compressed HDTV in a 6 MHz simulcast channel (video quality is bit limited)**
  - **must survive in the poor RF transmission environment (Error Correction is more powerful with longer packets)**
  - **ATM does not provide certain services**

- **GA /MPEG-2 Transport (an ATM-like approach with packet header/descriptors)**
  - **≈2% header overhead**
  - **better FEC efficiency**
  - **timing recovery and media synchronization services**
  - **encryption control**
  - **4 times the packet size of ATM**
  - **simple interoperability with ATM**

ATM Interoperability

- One MPEG-2 packet fits into 4 ATM cells
- MPEG-2 and ATM headers provide different functionality
- This allows HDTV to be easily used on ATM networks

MPEG-2 Header provides multiplexing, synchronization and encryption functionality



ATM Header provides network and connection functionality

188 Byte GA/MPEG-2 packet = 4 x 47 Byte ATM Payload

Transmission Relationships

U.S. Cable
8-VSB
≈6 MHz
≈15 dB CNR
≈19 Mbps

U.S. Cable (High Capacity)
16-VSB
≈6 MHz
>30 dB CNR
≈40 Mbps

U.S. Terrestrial
8-VSB
6 MHz
≈15 dB CNR
≈19 Mbps

Internat'l
Terrestrial, Cable & Satellite
?????

Satellite
QPSK
≈40 MHz
<6 dB CNR
≈25 Mbps

ATM Networks
SONET Interface
>1 GHz (Optical)
>30 dB CNR
≈1 Gbps

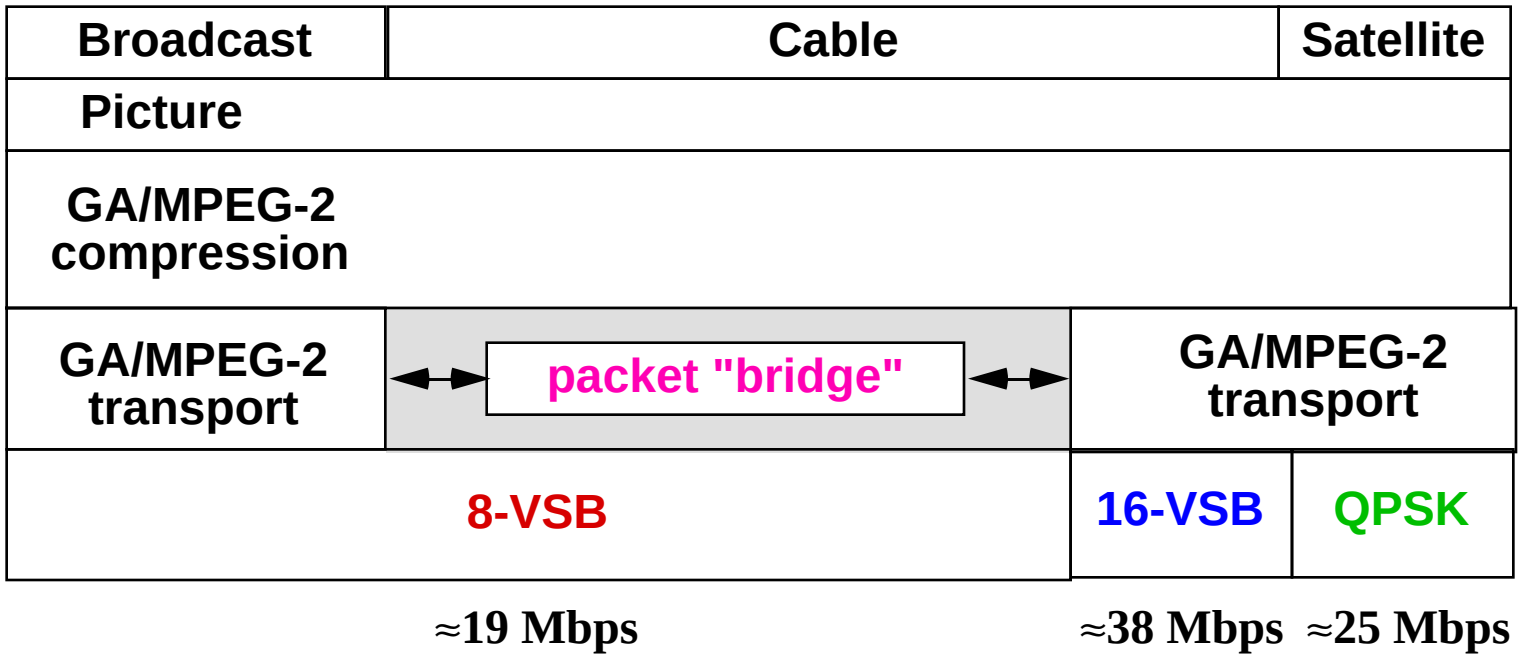
FDDI LAN
baseband
BER < 10^-9
125 Mbps

Ethernet

Each delivery medium has unique capabilities and constraints

Cable and Satellite Interoperability

- **Terrestrial 8-VSB signal can be carried directly by cable**
- **Packets can be merged into the packet stream of a higher rate transmission system, such as 16-VSB on cable and QPSK on satellite**



Interoperability Summary

...a layered system with flexibility and interoperability at each layer.

- **Picture Layer**
  - **multiple formats related to TV, film and computers**
  - **progressive and interlaced scan**
  - **square pixels**

- **Compression Layer**
  - **choice of MPEG-2 syntax enables international and interindustry exchange of bit streams**

- **Transport Layer**
  - **choice MPEG-2 packet format**
  - **relationship between MPEG-2 and ATM**

- **Transmission Layer**
  - **VSB for terrestrial and cable**
  - **bit stream exchange with other transmission media**

Conclusions

- **The Grand Alliance HDTV system is highly interoperable**
- **Interoperable HDTV will make broadcasters a vital part of the National Information Infrastructure**
  - **HDTV will deliver spectacular pictures...*and* data**
  - **multi-cast NTSC does not provoke consumer investment**
  - **data broadcast alone is an unclear business**
- **Interoperability will benefit the consumer**
  - **HDTV will be an information appliance in the home**
- **Interoperability will benefit the broadcast industry**
  - **new kinds of programming and services**
  - **new markets and new business opportunities**
- **Rapid adoption and deployment of the GA HDTV system is in the best interest of the broadcast industry and the nation**