PS-WP4 Recommendations

6. **Ability to implement lower performance low-cost ATV receivers (comparable price/performance options to current NTSC receivers)**
7. **Ability to implement low cost ATV consumer VCR**
8. **System architecture and implementation that will allow improvements and extensions to be incorporated as technology advances while maintaining backward compatibility**
9. **Square pixels or at least the option to select square pixel presentation**
10. **Compatibility with relevant international standards or committment to this objective**
11. **Easily implementable and user-accessible "still/motion multi-window transmission"**

Source: PS-WP4 Final Report

System Overview

GA Interoperability Overview

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

- The GA HDTV system is a layered digital system with three primary layers:
  - compression
  - transport (packet format)
  - transmission

- Each layer provides important interoperability characteristics and capabilities

- The GA HDTV system takes full advantage of the potential flexibility of digital systems by using header/descriptors to provide powerful capabilities

Key GA Principles

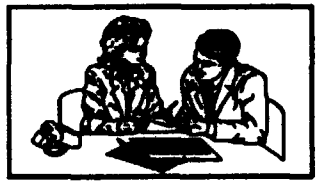
...fundamental system principles for HDTV simulcast...

- **Layered digital architecture**
- **Multiple picture formats (with header/descriptors)**
- **Video data compression based on MPEG-2 with GA extensions**
- **Audio data compression for 5 channel CD quality audio**
- **ATM-like transport layer (packet format with header/descriptors) that is a compatible subset of MPEG-2 transport**
- **Digital simulcast transmission of about 18 Mbps (net) in the 6 MHz channel**
- **Designed to be highly interoperable and extensible**

GA HDTV System Layers

...layered digital system design provides flexibility..

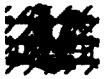
Production and Display



Multiple Picture Formats and Frame rates

Video Compression

Data Headers



Motion vectors

Chroma and Luma DCT Coefficients

Variable Length Codes

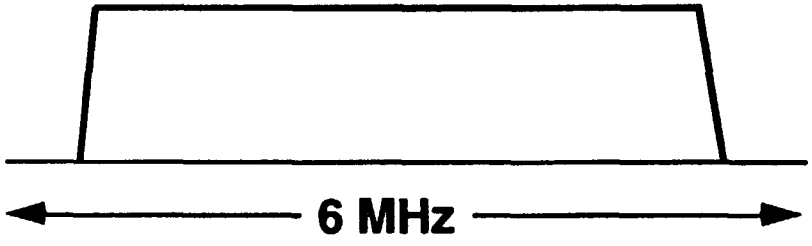
MPEG-2 with GA extensions

Data Transport

Video packet	Audio packet	Video packet	Aux data

Packets with header/descriptors

Transmission

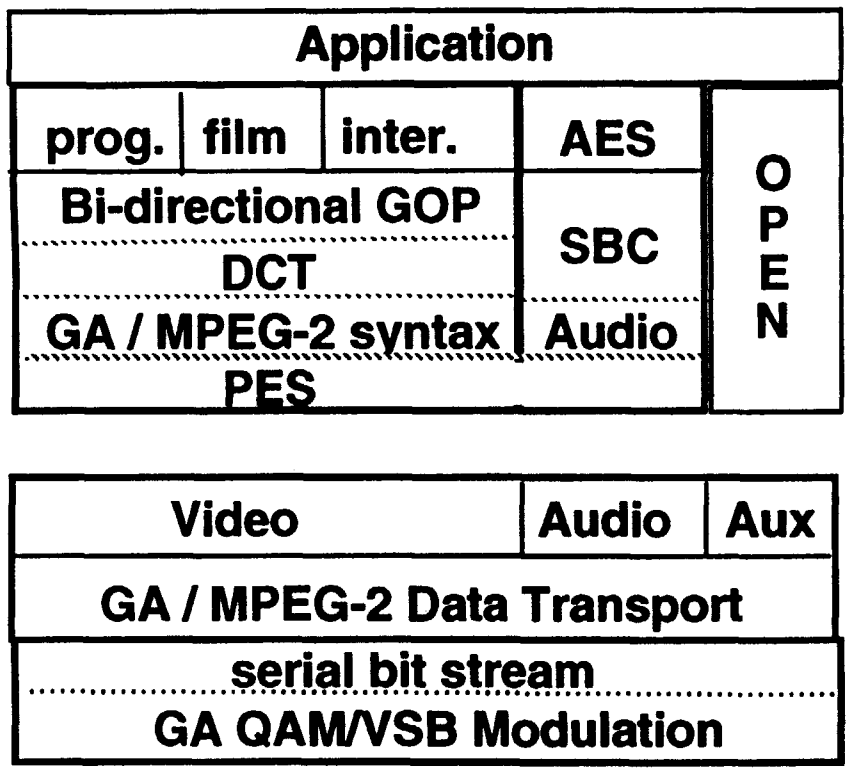


≈18 Mbps 6 MHz

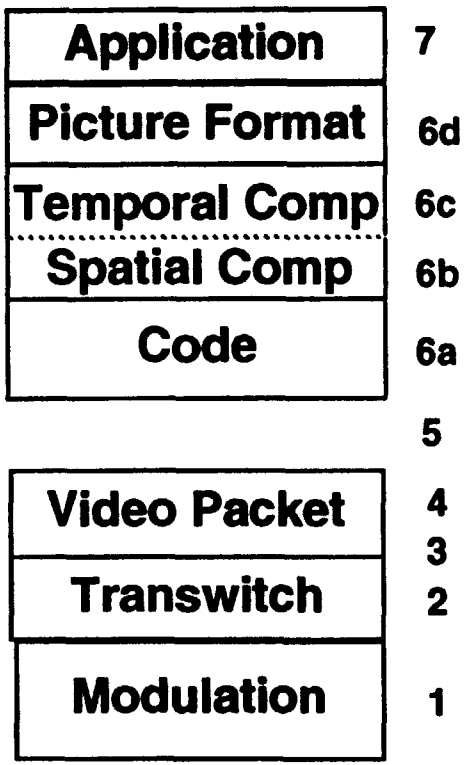
Layered Architecture

...GA System layers correspond to established reference models...

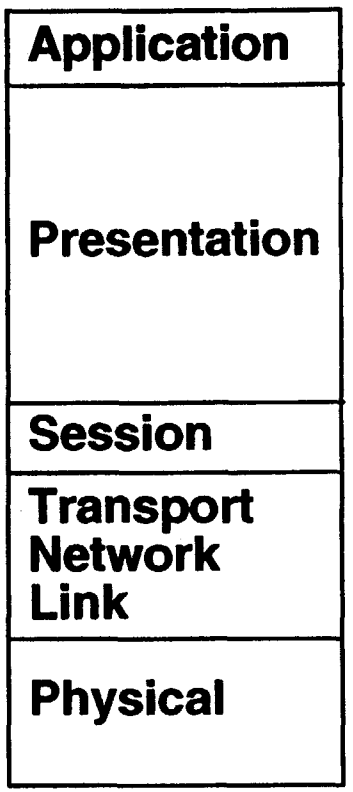
Grand Alliance HDTV Protocol Stack



PS-WP4 Reference Model Protocol Stack



ISO Reference Model Protocol Stack



Building New Applications on the GA System

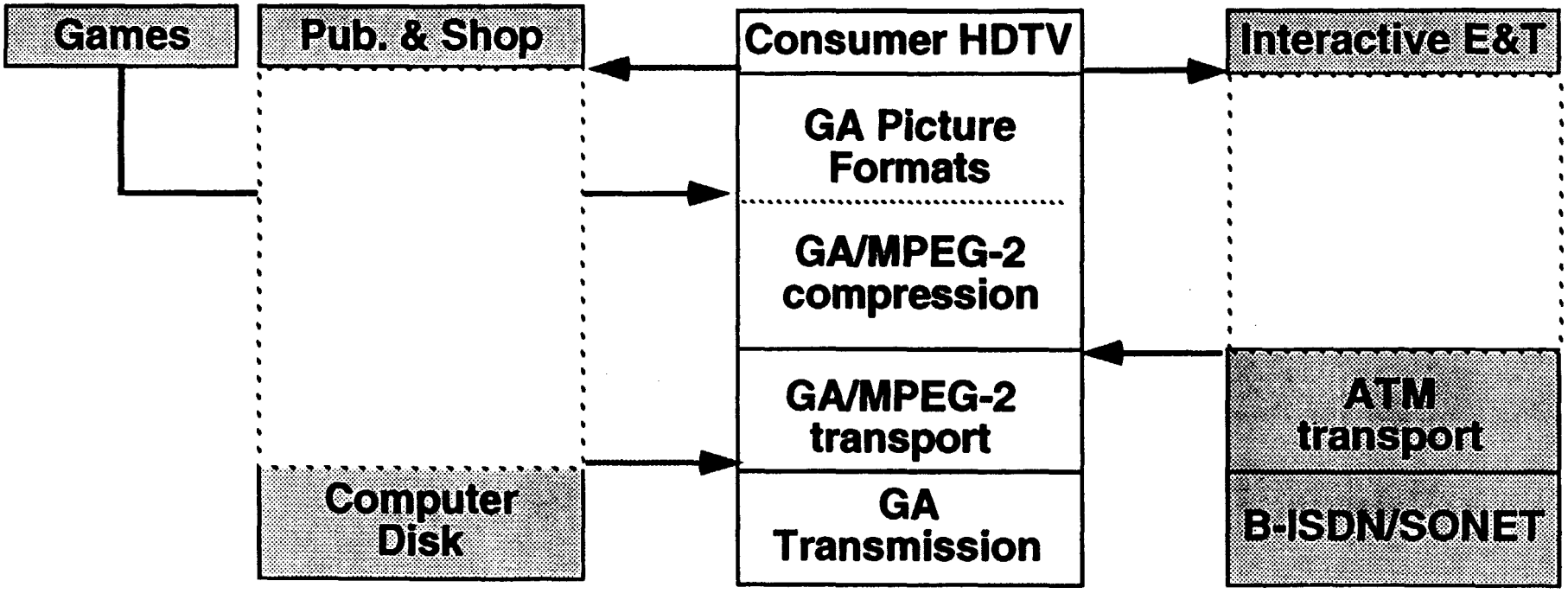
...any layer of the GA System can be used by other applications...

PDA-TV	Pub. & Shop	Interactive E&T	Medical Image
GA Picture Formats	GA Picture Formats	GA Picture Formats	Picture 4k x 4k
GA/MPEG-2 compression	GA/MPEG-2 compression	GA/MPEG-2 compression	JPEG compression
GA/MPEG-2 transport	GA/MPEG-2 transport	ATM transport	GA/MPEG-2 transport
GA Transmission	Computer Disk	B-ISDN/SONET	GA Transmission

Cross-Device Applications

...the GA architecture enables cross-device applications...

- **Ideally, applications can run across devices (but only if standard logical and physical interfaces exist at each layer)**



HDTV Receiver Interfaces

...outside the scope of the Grand Alliance...

FCC usually requires:

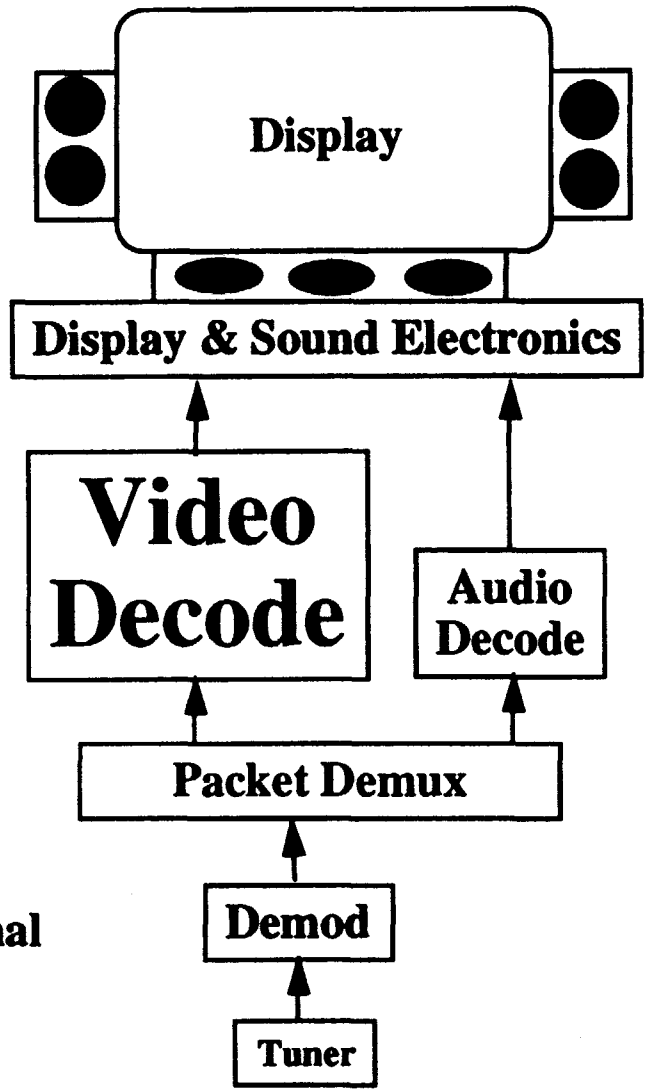
receivers to tune a signal and make a picture

Must decode syntax and make "electronic picture" for all formats

Must follow packet protocol and follow a few simple "rules" to enable extensibility

Must demod. transmitted signal

Must tune to all channels



FCC usually does not mandate:

The display or speaker type or performance

Receiver architecture

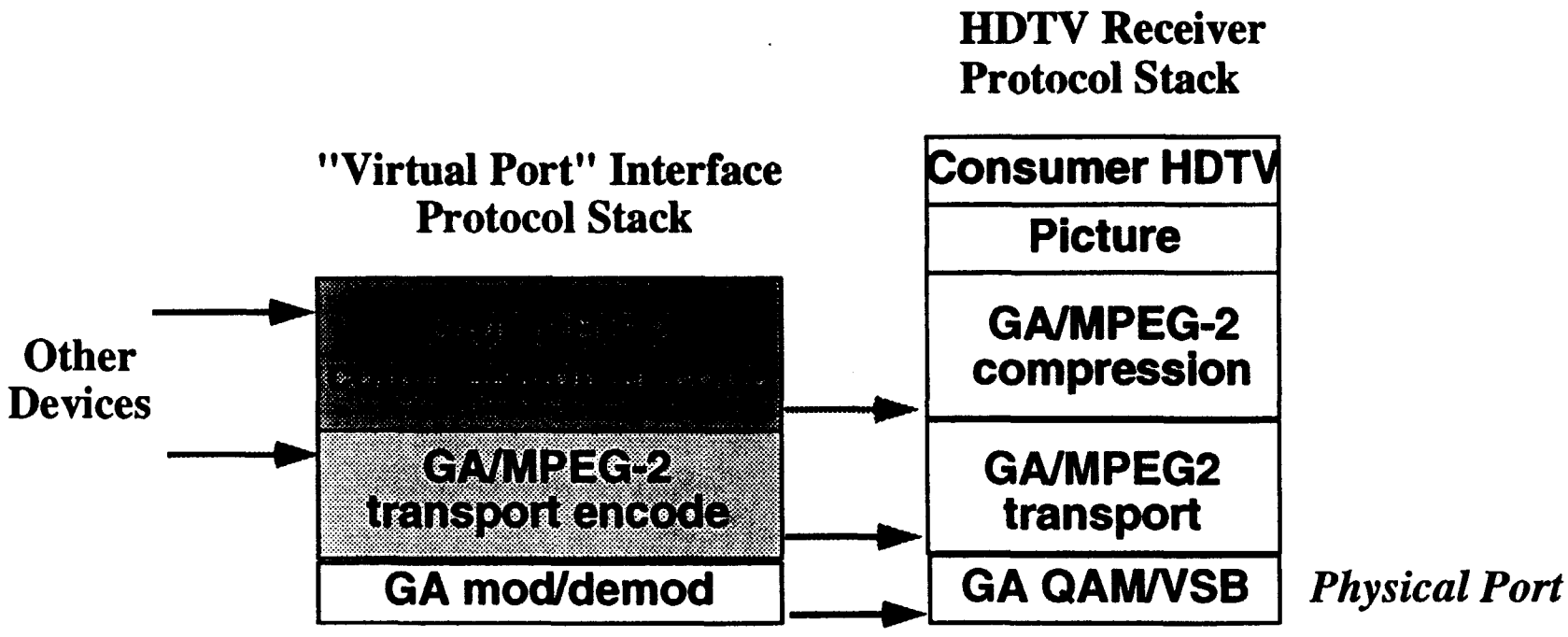
External interfaces other than RF signal

Performance limits

"Virtual Ports"

...the unavailability of a device interface is easily overcome...

- **A Layered Digital System approach allows lossless "virtual ports" to be created for any layer of the architecture using a layered interface device**

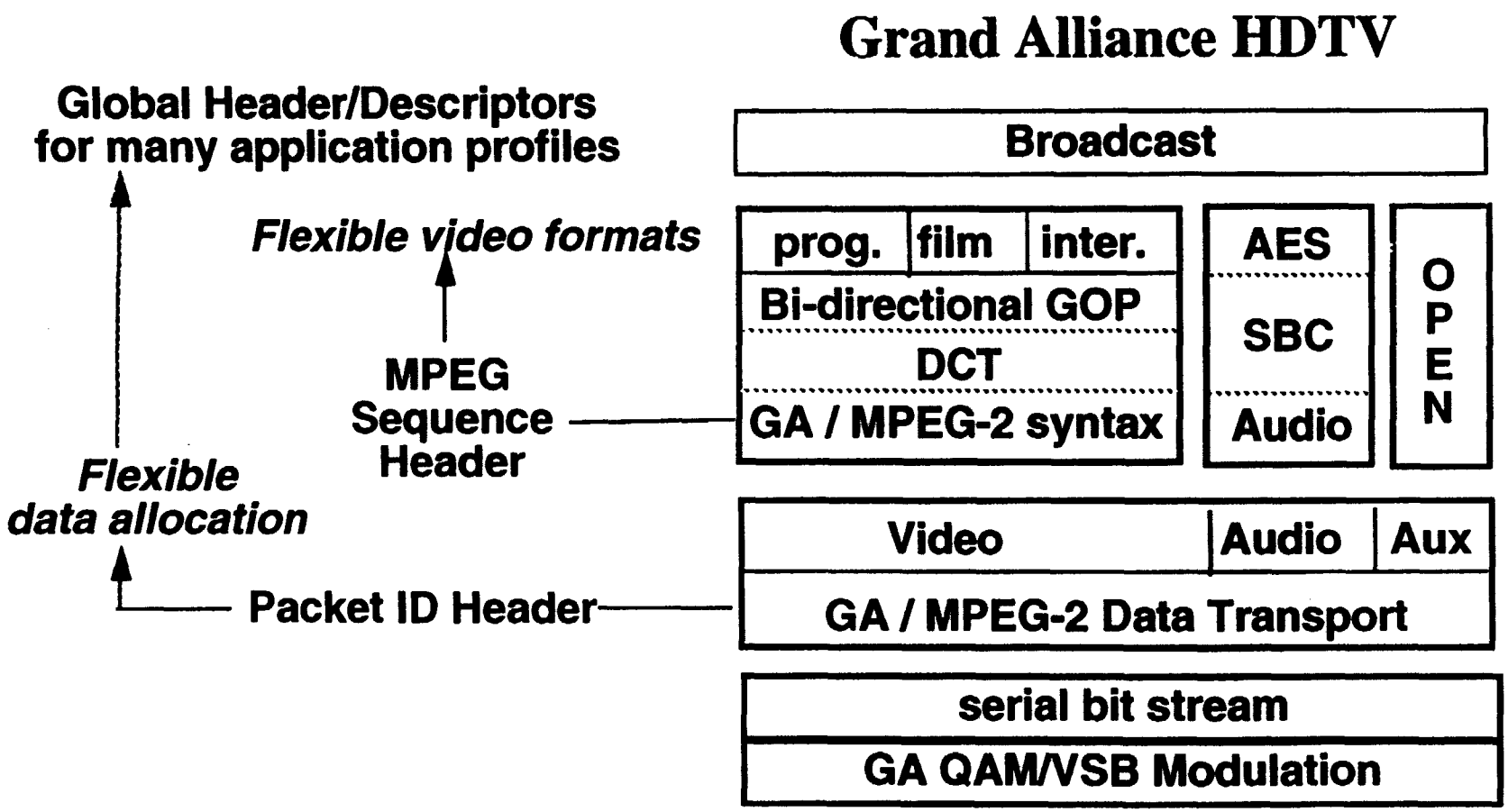


Header/Descriptors

- The GA system uses header/descriptors in two layers
- MPEG Sequence Header
  - provides video format flexibility
- Transport packet headers
  - Packet ID (PID) header provides ATM-like capabilities
- Global header/descriptors that expand current GA system capabilities by adding high-level application profiles are easily added as a separate PID type

Header/Descriptors

...powerful Headers/Descriptors are built into the Grand Alliance System..



System Overview Summary

- **The GA System has been designed with a heavy emphasis on interoperability**
- **Within the context of a transmission standard, we immediately create a high degree of interoperability among very different industries**
- **The Grand Alliance approach is to provide flexibility that simultaneously meets different needs and *facilitates* interoperability, rather than attempting to force a particular approach on a given application**
- **This flexible approach will allow natural economic forces to promote the migration to products with the greatest interoperability**

Transmission Layer

Transmission Influences

...each delivery medium has unique capabilities and constraints...

U.S. Cable
GA QAM/VSB
≈6 MHz
≈15 dB CNR
≈18 Mbps

Direct-carry

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

U.S. Terrestrial
GA QAM/VSB

6 MHz
≈15 dB CNR
≈18 Mbps

Internat'l Terrestrial & Cable
?????
7-8 MHz
15 CNR
24 Mbps

U.S. Cable (High Capacity)
64-256 QAM/16 VSB
≈6 MHz
>30 dB CNR
>40 Mbps

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

FDDI LAN
baseband
BER < 10^-9
125 Mbps

Ethernet

The Simulcast Problem

...three fundamentally conflicting goals, any two of which can be readily achieved...

Picture Quality
(Data Rate)

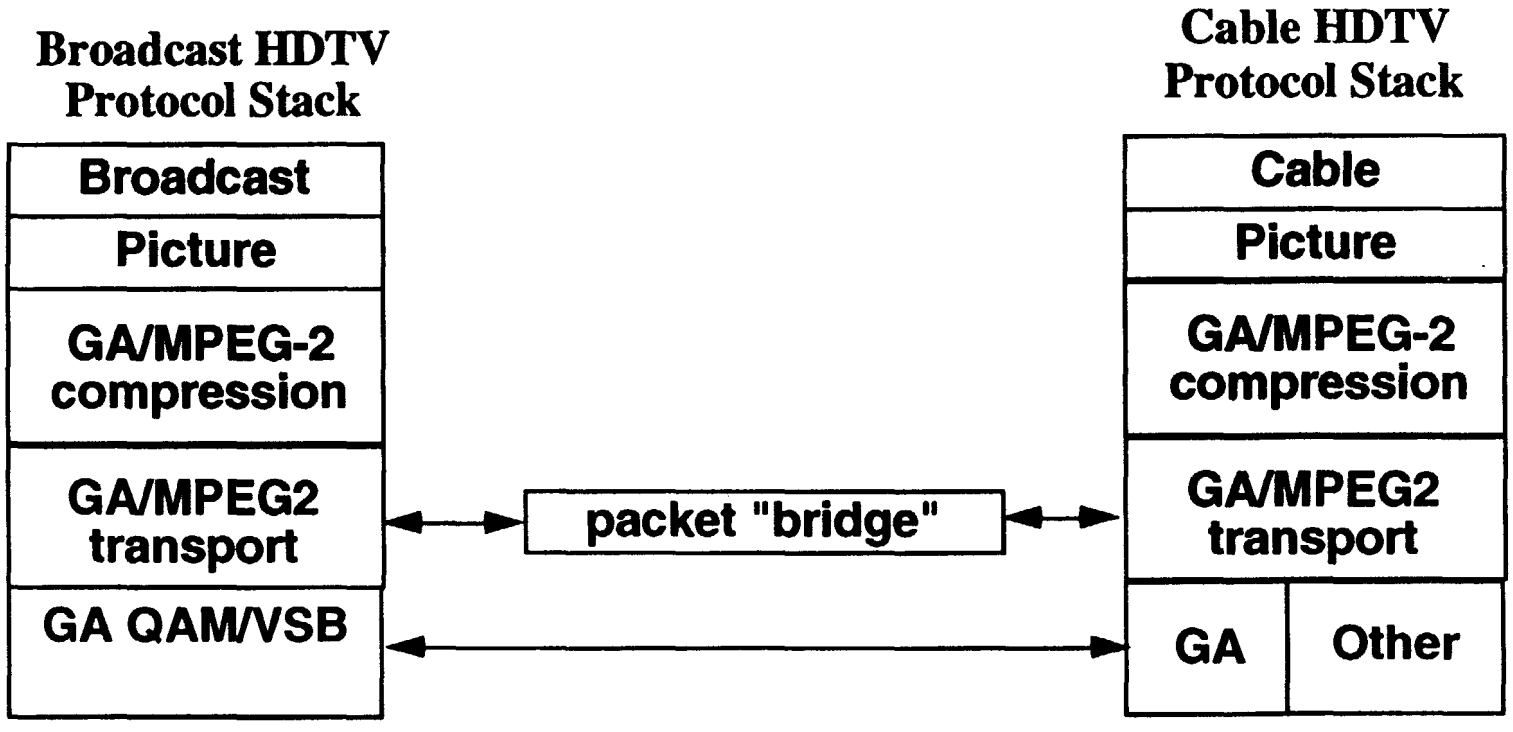
HDTV Service Area ⟷ **Low NTSC Interference**

Transmission Layer

- Each delivery medium is unique, and has its own capabilities and constraints
- GA transmission layer considerations are dominated by the FCC requirement for 6 MHz simulcasting in the existing TV spectrum
- Transmission Candidates:
  - QAM, SS-QAM, 6-VSB/trellis, 4-VSB
- The Grand Alliance has agreed on a selection procedure
- Paper analysis and possibly hardware tests will be performed
- Also, ACATS will conduct a paper analysis of COFDM

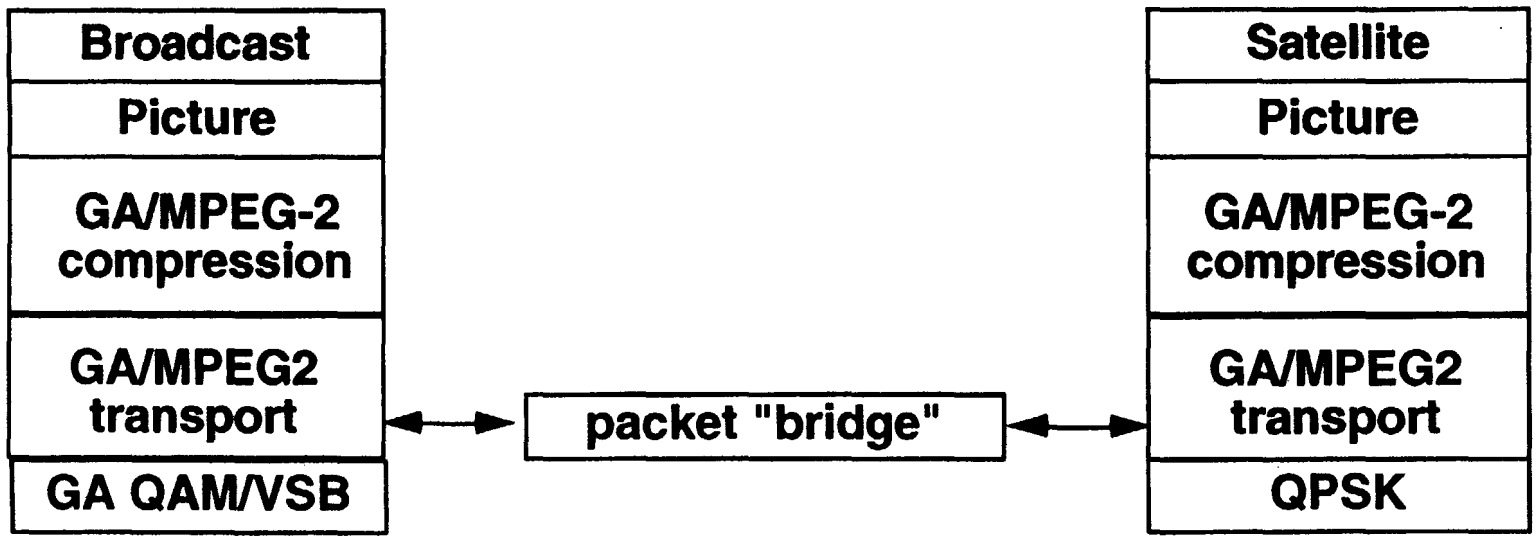
Cable Interoperability

- The GA signal can be carried directly in a cable channel
- Some cable systems may adopt another transmission approach that has higher a bit rate in 6 MHz
- GA packets can be merged into the cable packet stream



Satellite, B-ISDN and Other

- The GA packet stream can be merged into the packet stream of other delivery media



Transport Layer Interoperability

Fundamental Transport Principles

- Transport is a communications layer that encapsulates the compressed video and audio and aux data bit streams in fixed-size transport packets. This is standard practice in data communications.
- Multiplexes elements of a program: video, audio, data, etc.
- Packages and synchronizes data for transmission
- Provides Flexibility and Extensibility

HDTV Packet Stream

The GA HDTV System separately packages video, audio and auxiliary data in fixed-length packets

video 1	TEXT	video 1	audio 1	video 2	audio 2	video 1	video 2	PGM GD	audio 3

- **The HDTV data stream consists of a flow of packets**
  - **each packet contains a single type of data**
  - **there is no predetermined mix of video, audio, or aux data**
  - **service type mix can change *dynamically***
  - **packets with unrecognized PIDs are disregarded**

- **This allows flexibility in the services that can be provided**
  - **"second video program" in a user-selectable window**
  - **download program-related software to "smart receivers"**
  - **rapid enabling of pay-per-view decoders on cable**
  - **future enhancements such as compatible "1000" line progressive scan HDTV**

Transport Influences

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

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

FDDI

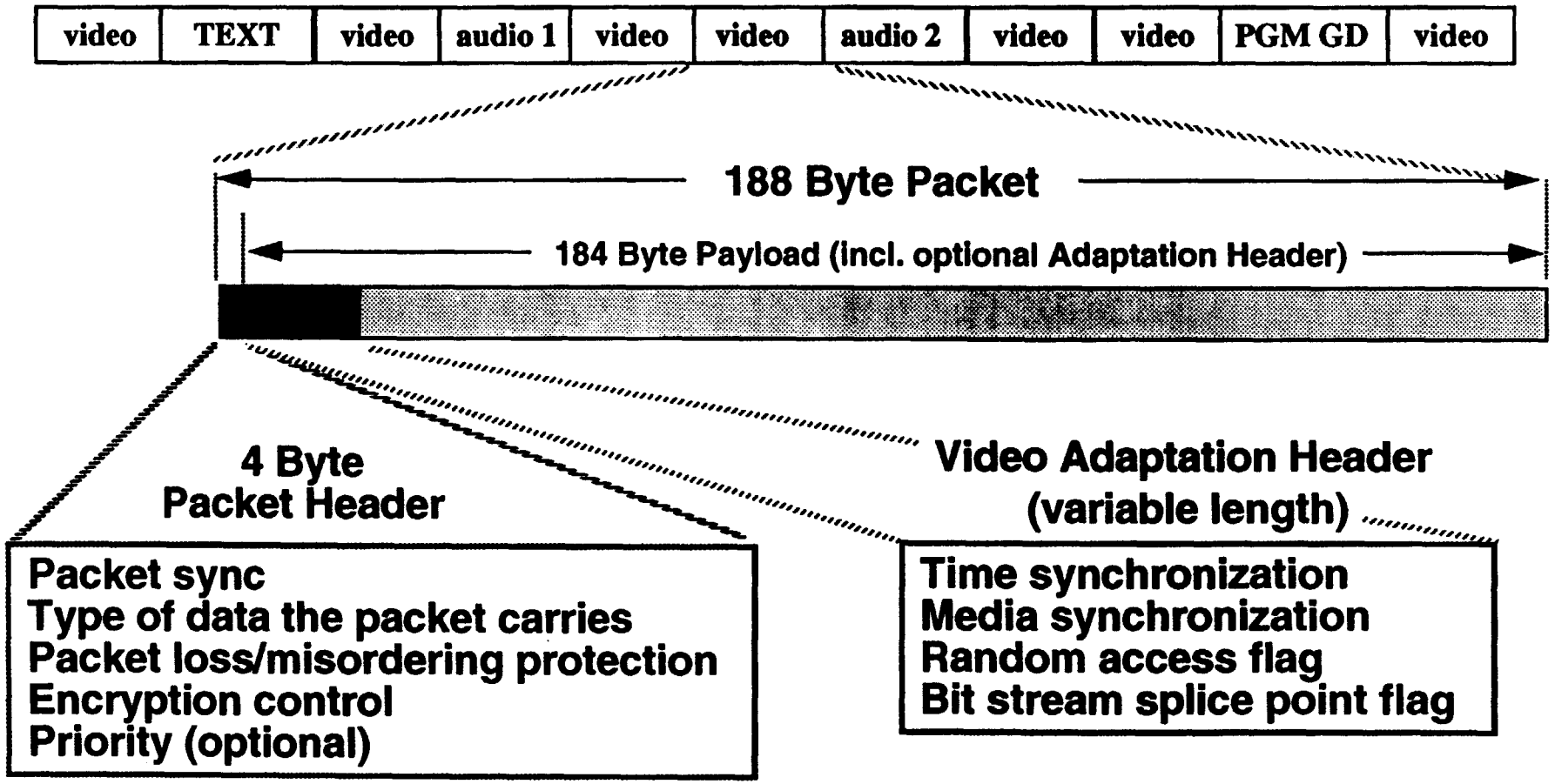
Ethernet

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

GA/MPEG-2 Transport

...packets with header/descriptors enable flexiblility and features...

Many services can be dynamically multiplexed and delivered to the viewer