From Synchronous to Asynchronous Design

by *Gerrit Muller* HSN-NISE
e-mail: gaudisite@gmail.com
www.gaudisite.nl

Abstract

The most simple real time programming paradigm is a synchronous loop. This is an effective approach for simple systems, but at a certain level of concurrent activities an asynchronous design, based on scheduling tasks, becomes more effective. We will use a conventional television as case to show real time design strategies, starting with a straightforward analog television based on a synchronous design and incrementally extending the television to become a full-fledged digital TV with many concurrent functions.

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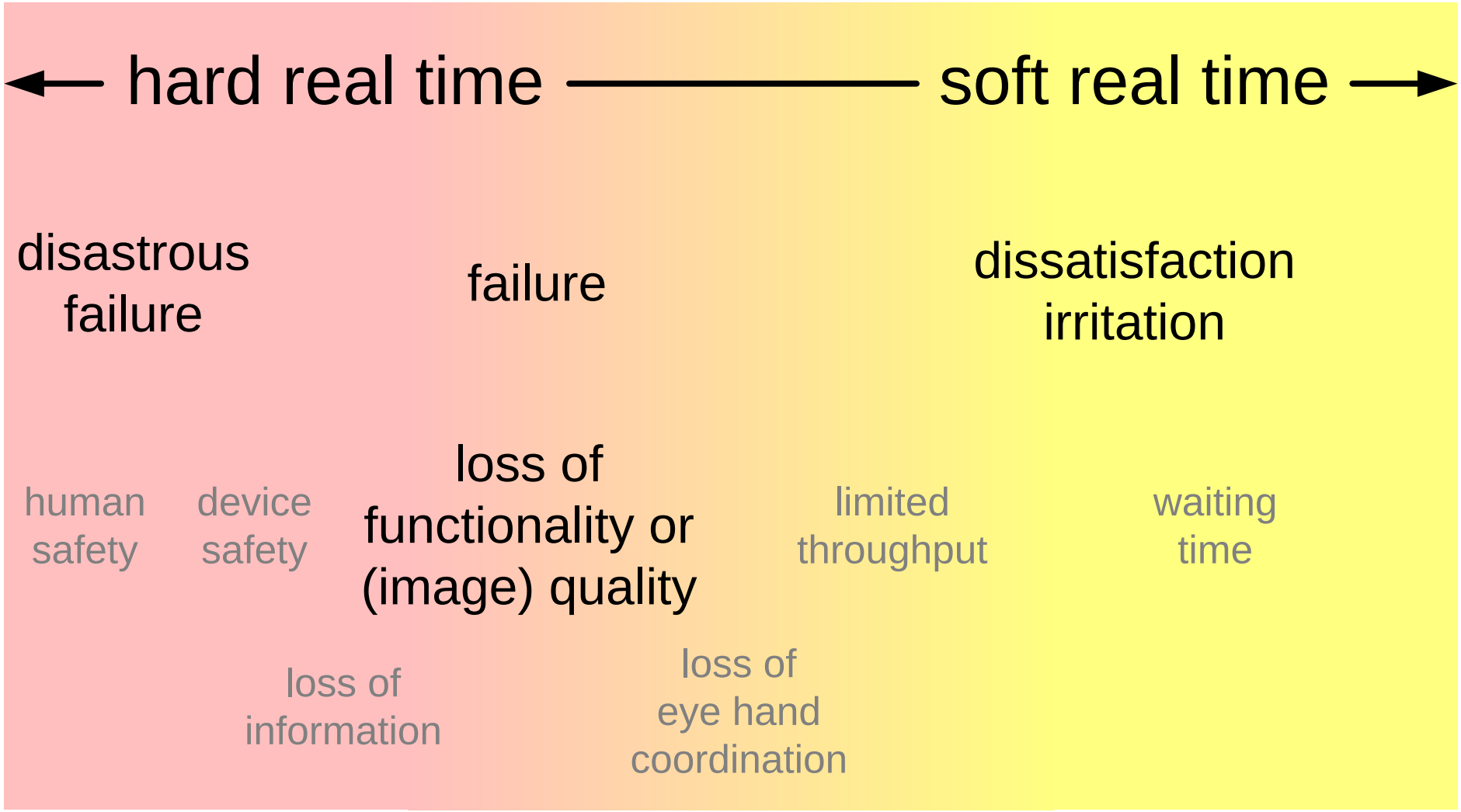
version: 0

Hard Real Time Design



Case Simple Analog TV

Simple Analog TV

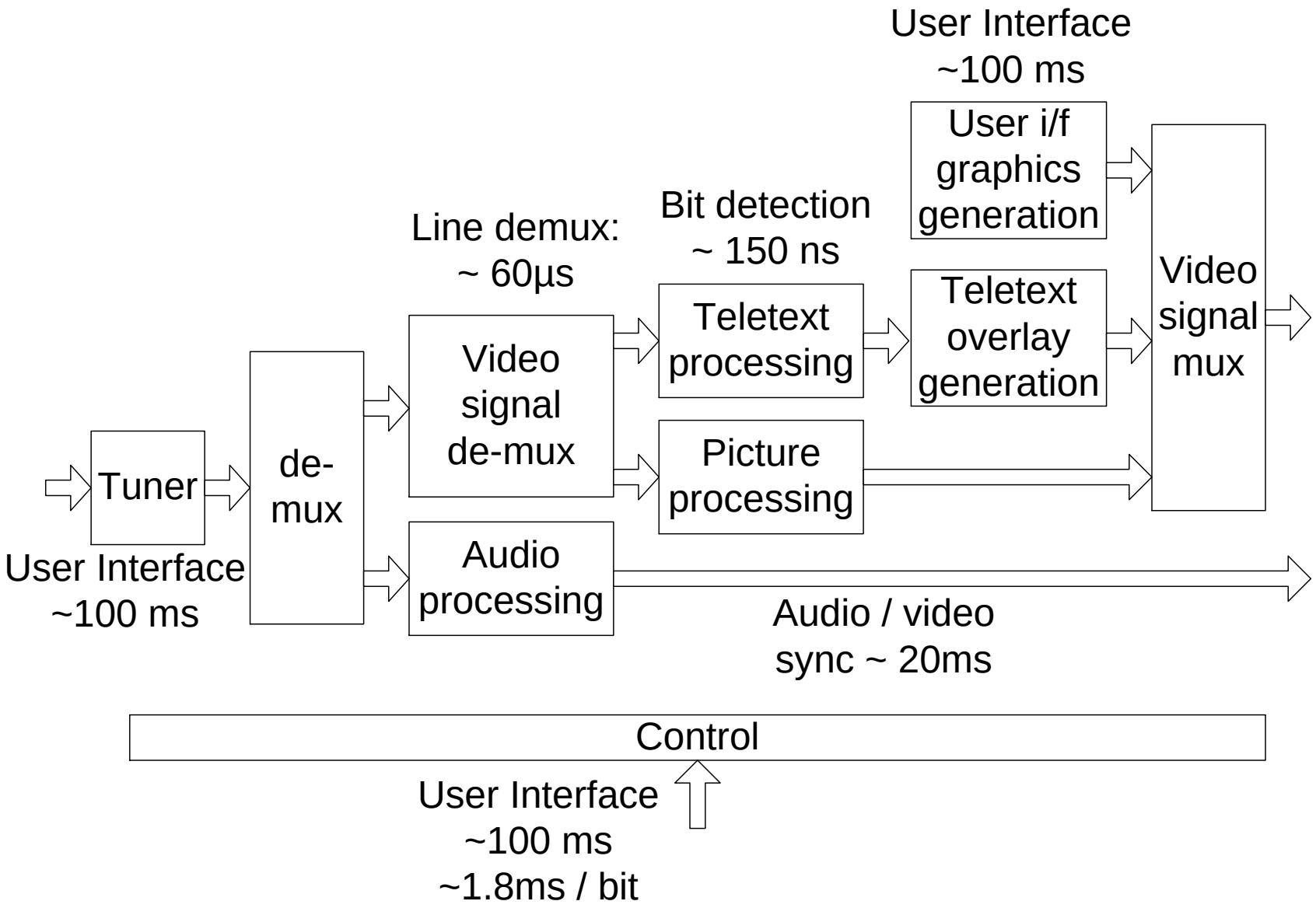
Multiple views on system

Fundamentals of *periodic* or *streaming* Hard Real-Time applications

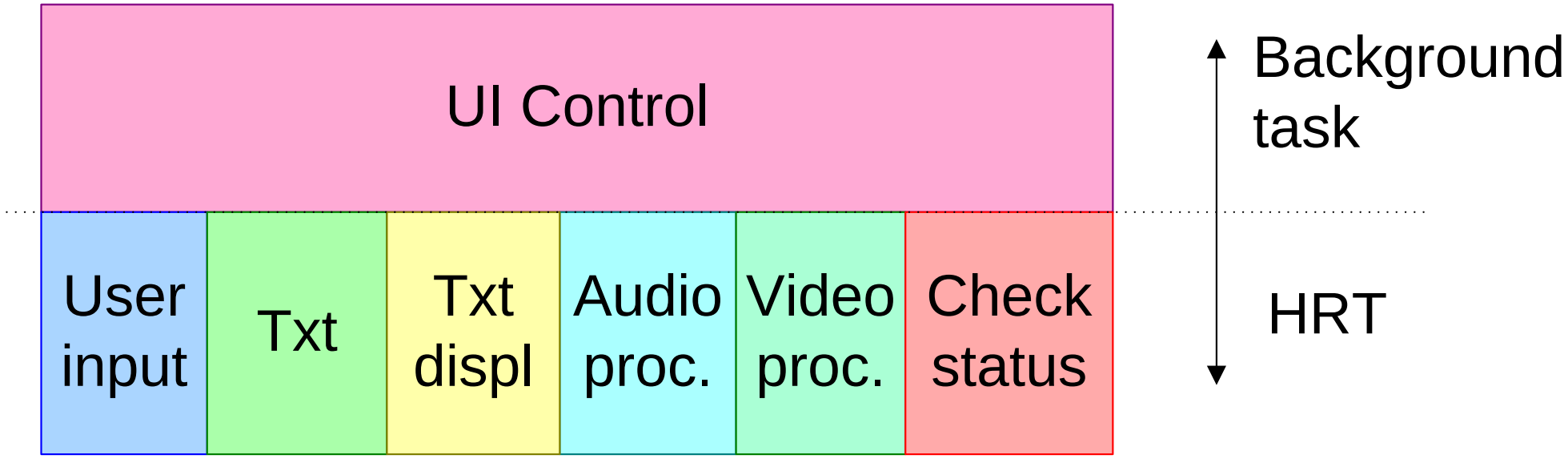
System performance characterisation: Performance model

Synchronous design concept

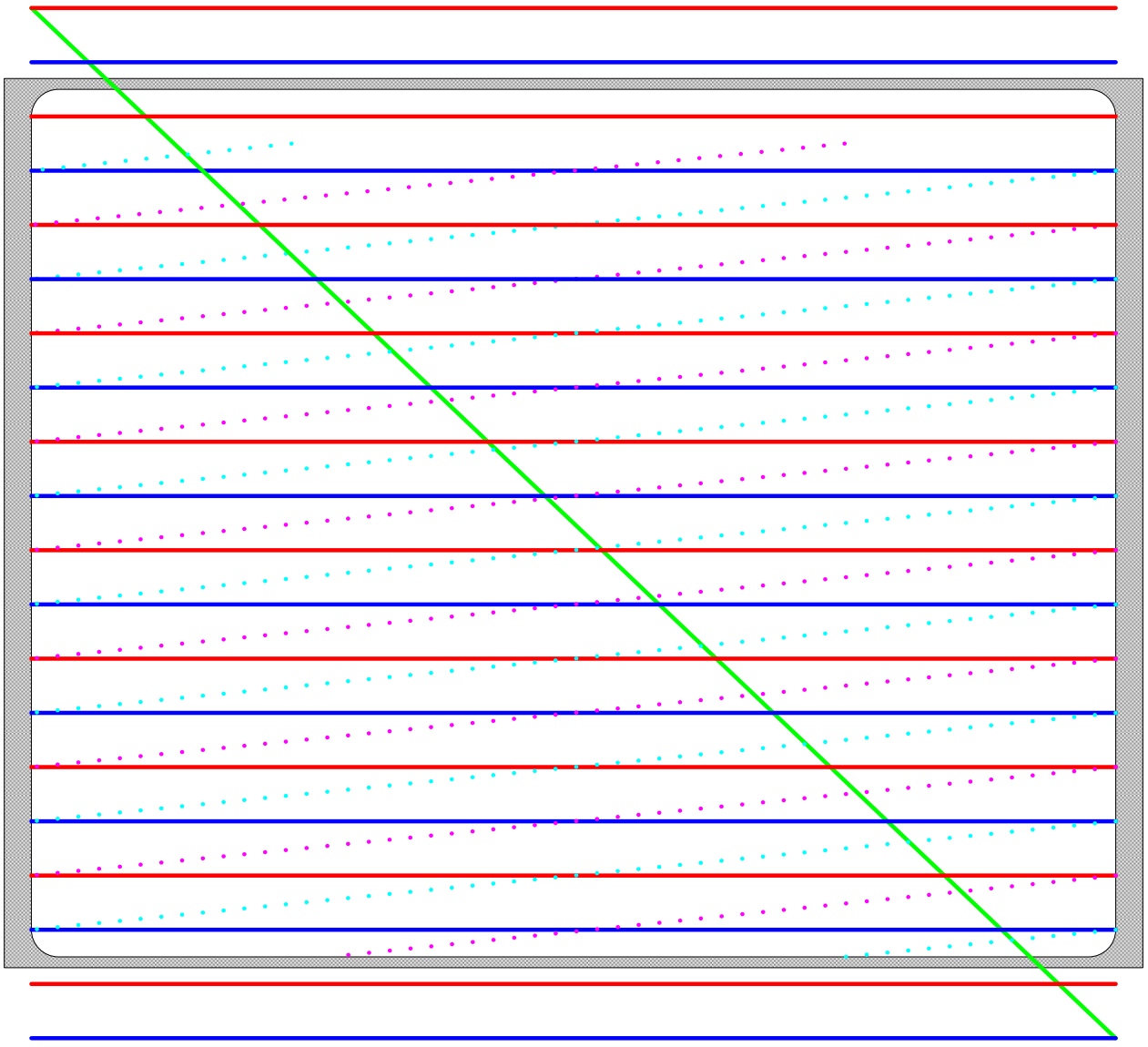
Functional Flow Simple Analog Television



SW Construction Diagram



Video Timing



Hidden lines
(can contain data)

Scan line even
Scan line odd
Retrace even
Retrace odd
Vertical retrace

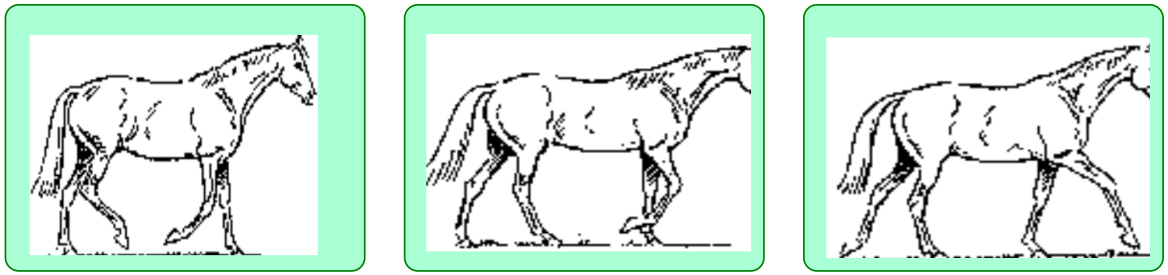
For PAL-625:

Line Frequency: 15.625 kHz
Scanning Lines: 625
Field Frequency: 50 Hz

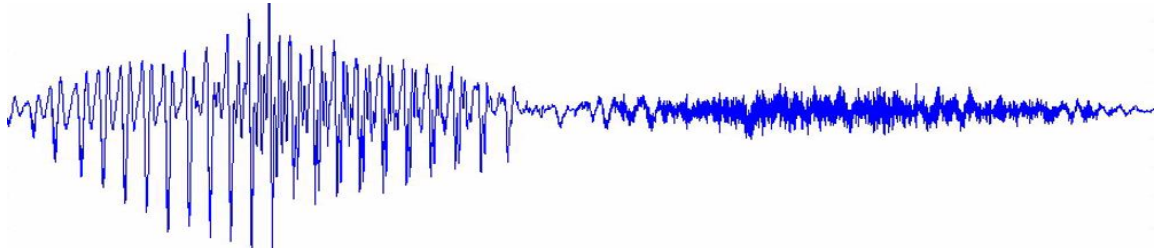
Hidden lines
(can contain data)

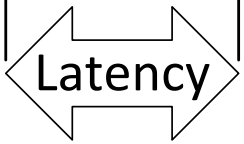
Audio-Video Synchronization Requirement

Images:
Discrete in time



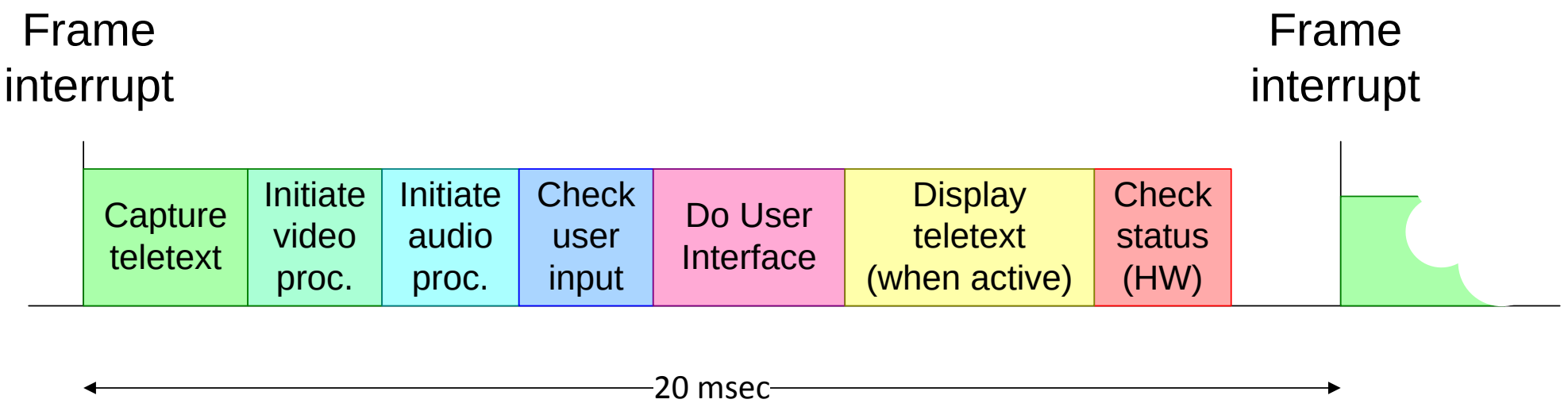
Sound:
Continuous in time



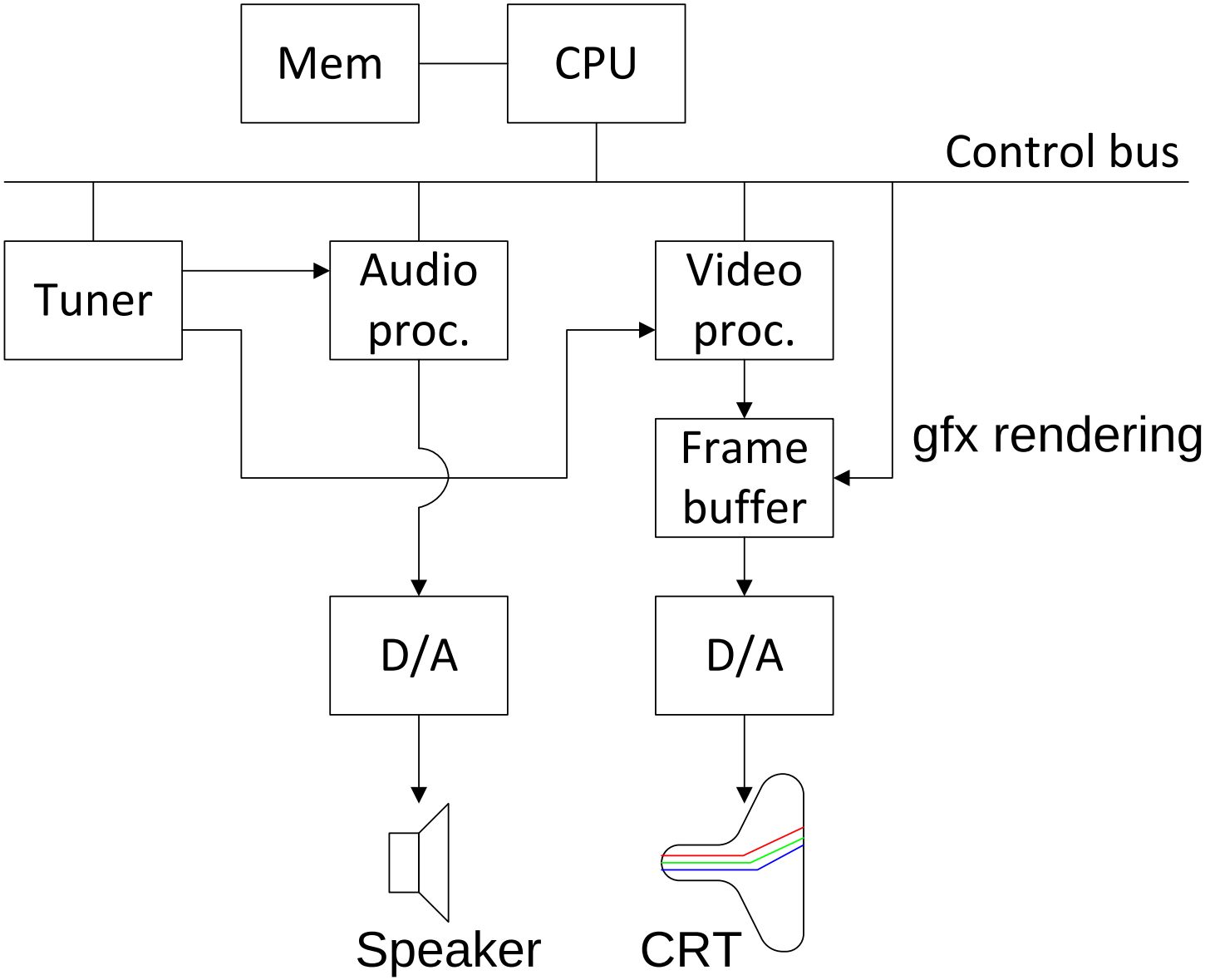


Sound and vision must be lip-sync or better
Maximum latency ~ +/- 100 msec

Synchronous design



HW Diagram


Mem
CPU
Control bus
Tuner
Audio proc.
Video proc.
Frame buffer
gfx rendering
D/A
D/A
Speaker
CRT

Synchronous design questions

Estimate processing time on a 100 MHz ARM core

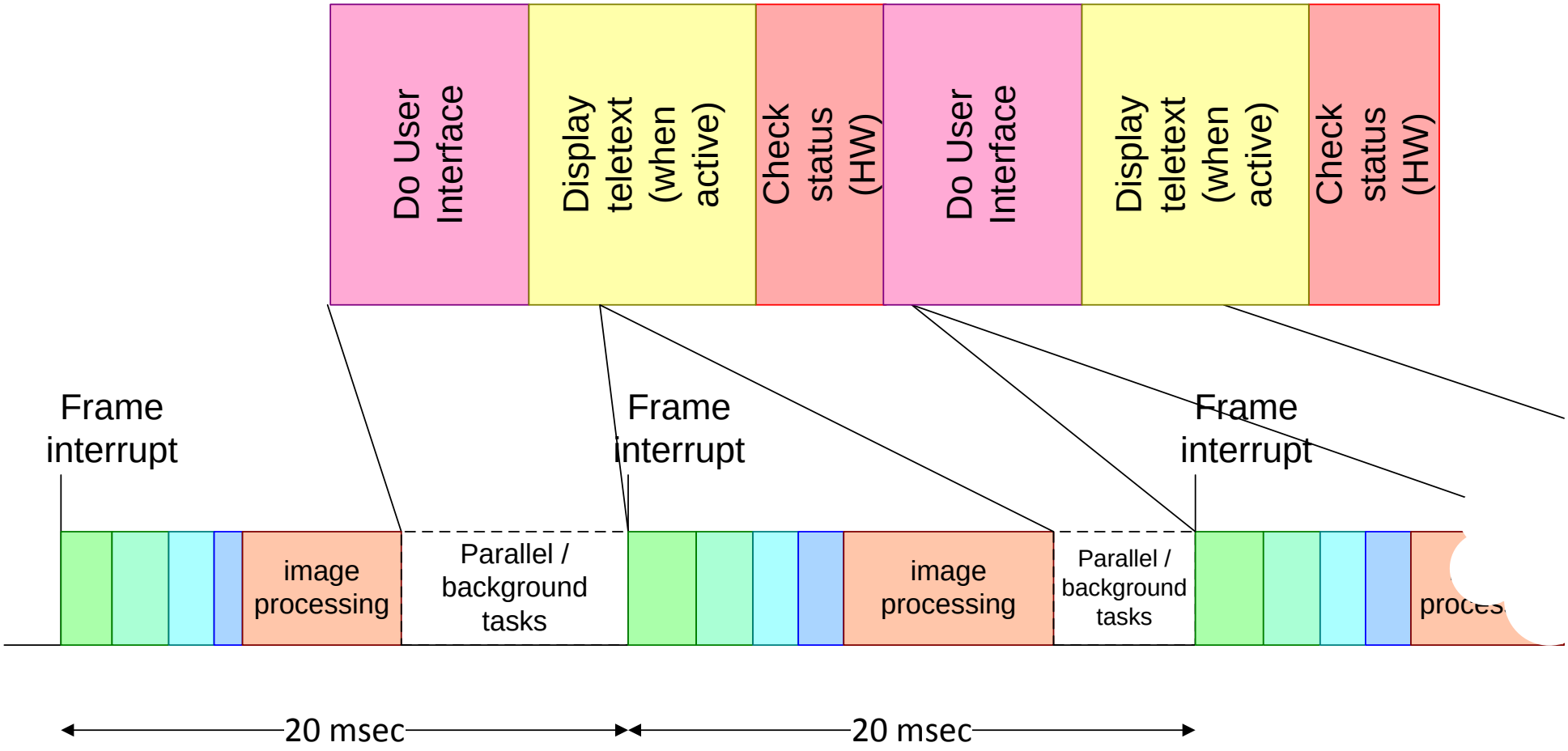
- Assuming that all processing and acquisition is done in HW
- Graphics rendering (user interface + teletext display) is done in SW

Where do you expect variation?

How feasible and how reliable is this design?

Low Priority Work in the Background

Design with multiple parallel tasks



Synchronous or Asynchronous?

Synchronous => Map on Highest frequency Constraints: - Processing frequency must be a whole (integer) multiple of the lower frequencies - Each process must be completed within the period of the highest frequency, together with the high-frequency process
A-Synchronous => Concurrent processes

Multiple Periods in a Simple TV

Input signal	50 Hz
Processing	100 Hz
User Interface	20 Hz
Power and Housekeeping	0.5 Hz
Output	50, 100 Hz

Summary Case Simple Analog TV

Simple Analog TV

Performance model requires:

- identification of processing steps
- their relation
- critical parameters and values

Synchronous design sufficient for periodic applications with one dominant frequency

Multiple views on system:

- HW diagram
- SW construction diagram
- Functional flow
- Time-line

Case Digital Television

From Analog TV to Digital TV

Adding more input formats and output devices

Multiple heterogenous periods: asynchronous design with concurrent tasks.

Digital Television

Input	Many frequencies
	Video & Audio variable timing
Output	Many frequencies
Processing	Variable

Many video variants (see table)
Many audio variants (quality, number of speakers, ...)

Simple Video Processing Pipeline

multi task design complex TV

In modern television the format of the image can change (e.g. widescreen)

The user can set the refresh rate to higher values (e.g. 100Hz anti-flicker)

Different displays (CRT, LCD, Plasma) can be attached
that need the image in different formats
(interlaced, non-interlaced, different refresh rates)

Non interlaced images need special filtering of the image
to prevent ragged images

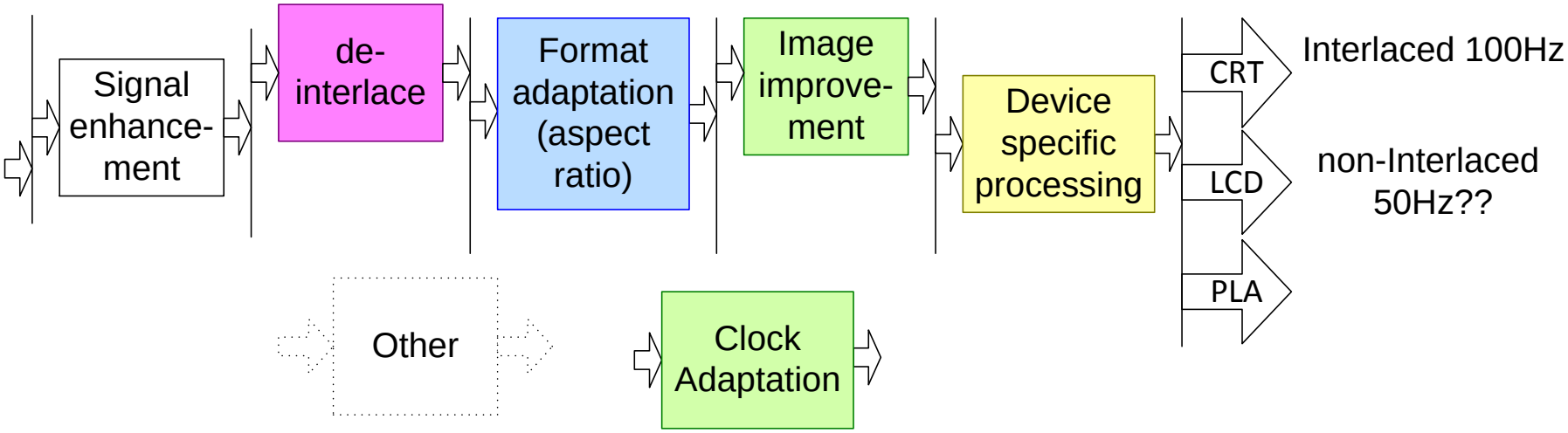
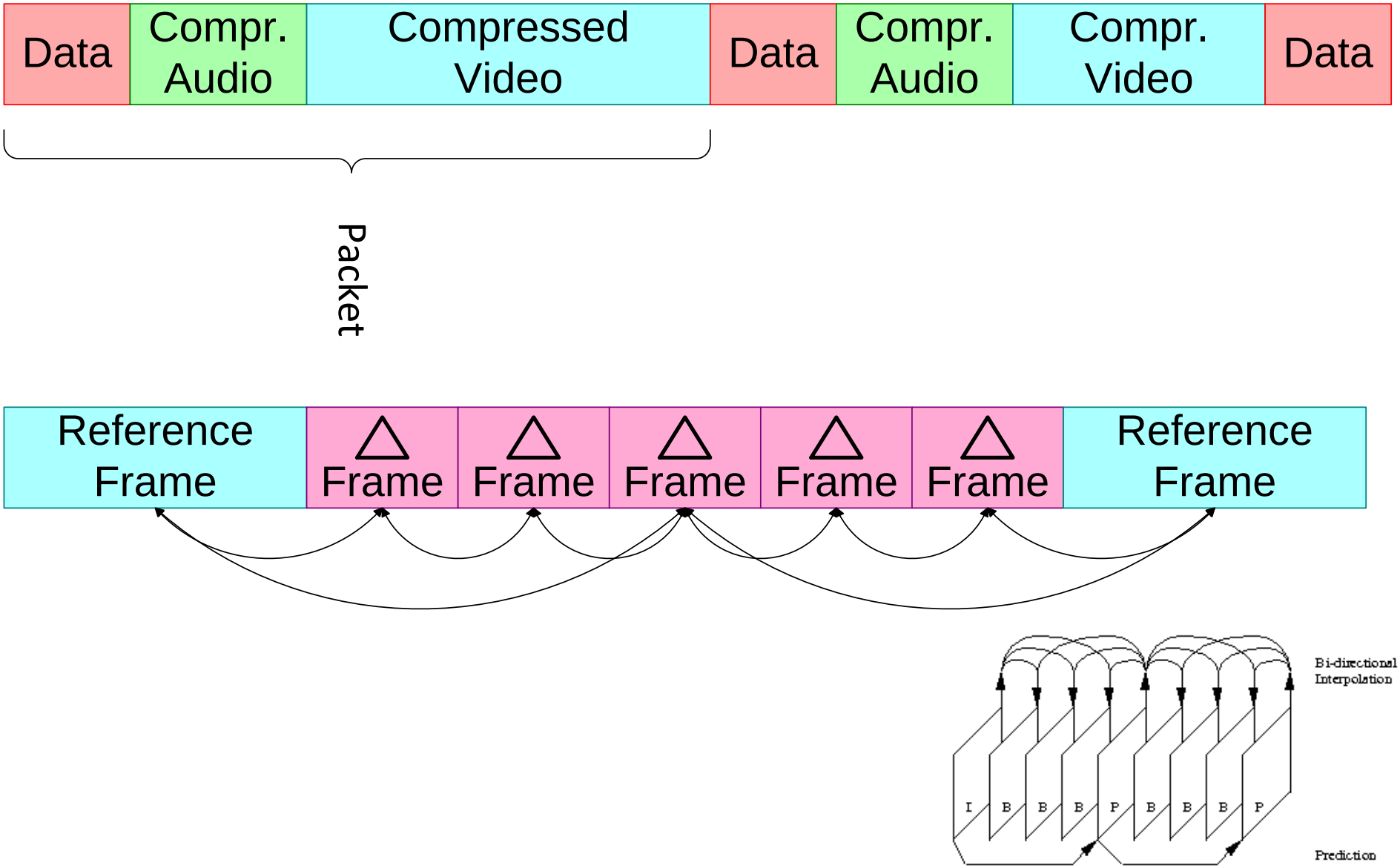


Table with ATSC Video Formats

spec	Horizontal pixels	Vertical pixels	Aspect ratio	Monitor interface	Format name	Frames per sec	Fields per sec	Transmitted interlaced
					1080i60	30	60	yes
	1920	1080	16:09	1080i	1080p30	30	30	no
					1080p24	24	24	no
					720p60	60	60	no
	1280	720	16:09	720p	720p30	30	30	no
					720p24	24	24	no
				480p	480p60	60	60	no
	704	480	16:09		480i60	30	60	yes
				480i	480p30	30	30	no
ATSC					480p24	24	24	no
				480p	480p60	60	60	no
	704	480	04:03		480i60	30	60	yes
				480i	480p30	30	30	no
					480p24	24	24	no
				480p	480p60	60	60	no
	640	480	04:03		480i60	30	60	yes
	640			480i	480p30	30	30	no
					480p24	24	24	no
NTSC	»640	483	04:03	Note 1	Note 1	30	60	yes
Note 1: Some people refer to NTSC as 480i.								

Source: http://www.hdtvprimer.com/ISSUES/what_is_ATSC.html

Data Packets in Digital TV



Summary Case Digital Television

From Analog TV to Digital TV

Real-life applications rapidly introduce all kinds of variations

Concurrent tasks cope with different periods

Colofon

The ASP™ course is partially derived from the EXARCH course developed at *Philips CTT* by *Ton Kostelijk* and *Gerrit Muller*.

Extensions and additional slides have been developed at *ESI* by *Teun Hendriks*, *Roland Mathijssen* and *Gerrit Muller*.