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**Real-Time Architectures
2003/2004**

A real-time architecture for
multimedia consumer terminals
(MCTs)

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A real-time architecture for MCTs

- Multimedia Consumer Terminals (MCTs):
 - Trends;
 - Characteristics.
- Media processing in software:
 - A Digital Video Platform;
 - Scalable Video Applications;
 - Challenges & approaches.
- A co-operative QoS approach:
 - Multi-disciplinary team;
 - System.
- A retrospect on real-time issues

2

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Multimedia Consumer Terminals

The diagram illustrates a central television set connected to various external components. On the left, there is a satellite dish labeled 'DVB Tuner' and a tower labeled 'RF Tuner'. Below the TV, there is a 'VGA' monitor and a 'DVD CDx front end'. On the right, there is a 'Cable modem', an 'IEEE 1394 interface', a 'CVBS interface', and a 'YC interface'. A red text box on the right side of the diagram contains the following text:

Focus:
Receivers in
broad-cast
environments
High-quality
video
applications

3

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Trends

- Digitization and compression:
 - DVD, DTV
- Featurization:
 - Software services:
 - TXT, OSD, menus, habit learning.
 - Processing:
 - Sharpness enhancement, 100 Hz, PIP, dual screen.
- Convergence of services:
 - Delayed viewing (TV + VR/DVD-recorder);
 - Games (TV + game-console);
 - TV-commerce and interaction (TV + internet).
- Upgrading:
 - New standards for D-STB via satellite.

4

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Characteristics

- High quality:
 - Including timeliness of audio and video.
 - Example: video enhancement.

Input stream: movie

Original (24 Hz)

Up-scaled (60 Hz)

Rendered stream: TV screen

QoS trade-off:
 Lesser picture quality often better than temporal incorrectness.

5

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Characteristics

- High dependability:
 - Must work, immediately, and at all times.
- High Volume Electronics:
 - Global market with multiple standards;
 - Short product development cycles;
 - Product families.
- Low power:
 - No fan in a TV set ...
- High pressure on price:
 - DVD recorder from \$2000 to \$200 in 2 years.

6

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Traditional High-End TV Architecture

Traditional TVs, Set-Top Boxes:

- Fixed algorithms for fixed HW architectures
- Upgrade for new services/applications is problematic
- Systems are not flexible

7

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Media processing in software

- Based on programmable platforms
- Advantages:
 - Upgrading;
 - Fast time-to-market of new features;
 - Scalable video applications → product families.
- Boundary conditions:
 - Cost-effectiveness;
 - Preserve existing qualities.

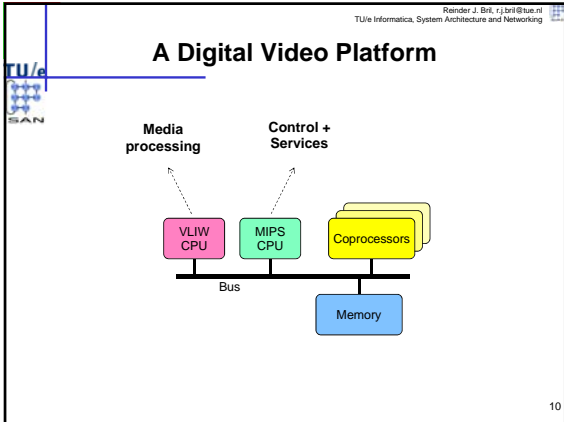
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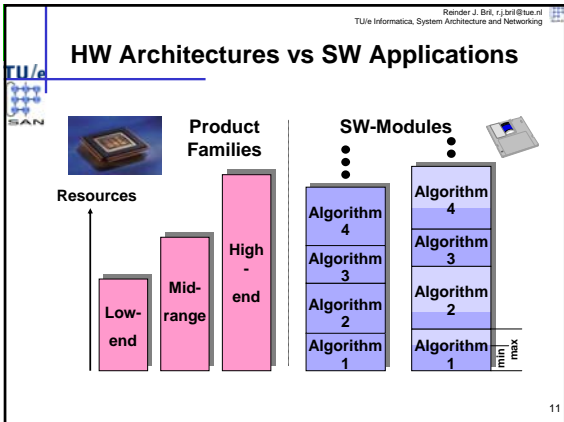
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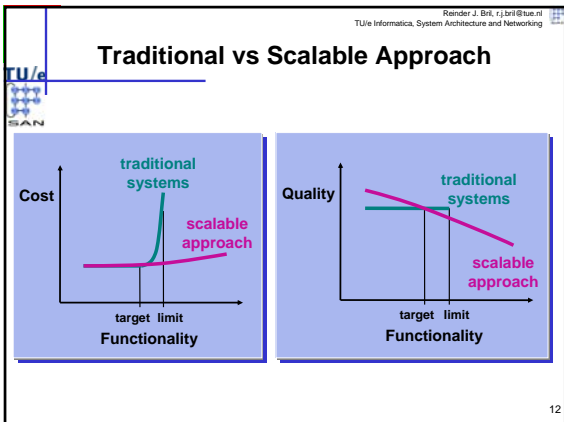
Media processing in software

- A Digital Video Platform
- Scalable video applications
- Challenges & approaches

9







Example: One High-Quality Application



13

HQ Video-Conference, Reduced Background Quality

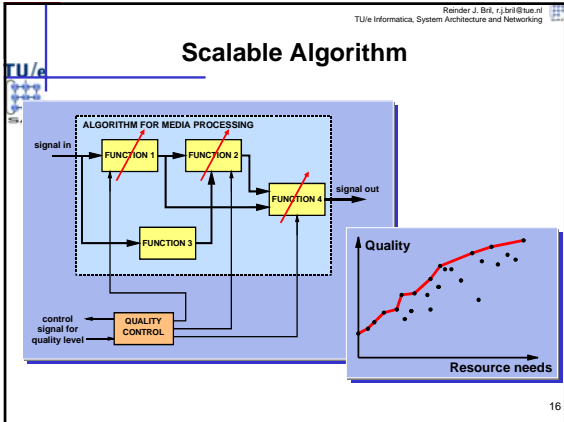


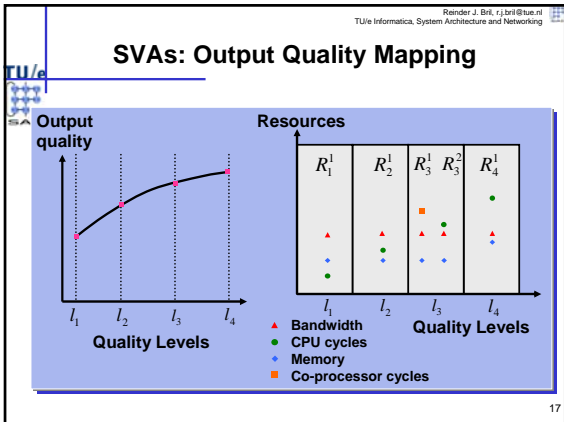
14

Quality Levels in Algorithms



15



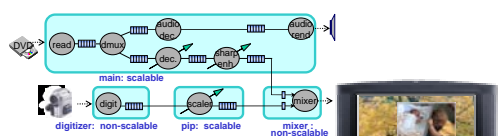


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- ## Challenges & approaches
- Maximize system utility, given available resources:
 - Elements (semantically neutral):
 - Utility of individual applications;
 - Resource usage;
 - Relative importance.
 - Approach:
 - static: [Lee et al 99].
 - dynamic:
 - Applications: local quality control;
 - System: global system utility control.
 - Resource sharing:
 - Interference between applications
 - Predictability;
 - System robustness
 - Approach: resource reservation.
- 18

Challenges & approaches

- Mode changes:
 - Examples:
 - System:
 - Start of new application: main → main + pip;
 - Change of user focus: main → pip;
 - Exchange of main and pip.
 - Application:
 - movie (24 Hz film) to commercial (50 Hz camera);
 - Channel switching.
 - Smooth transitions required
 - Approach: mode-change protocol(s).

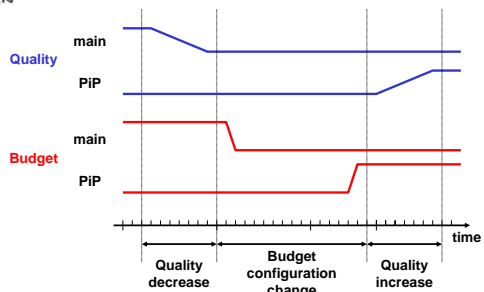
Example: Main → Main + PiP



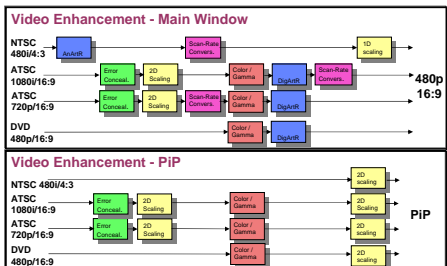
- (1) Initial: Main
- (2) Intermediate: reduce quality
- (3) Intermediate: start PiP
- (4) Final: Main + PiP

Mode change protocol

User focus change: Main → PiP



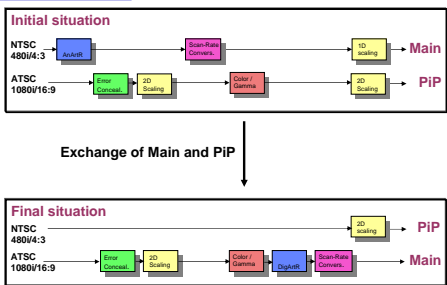
Example: Video enhancement modes



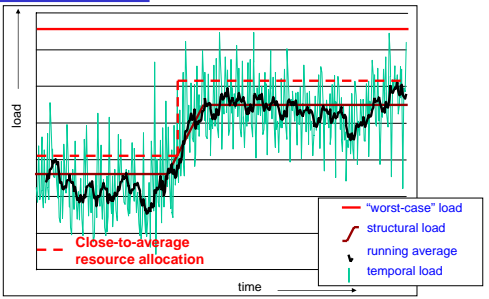
Note: Number and order of algorithms change for Main Window upon input change !



Example: Video enhancement modes



Challenges: dynamic load



MPEG decoding of DVD stream



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A co-operative QoS approach

- Organization (multi-disciplinary):
 - Video domain experts;
 - System software specialists;
 - Mathematicians.
- System:
 - Adaptive applications:
 - Scalable video applications;
 - Local quality control.
 - QoS-based resource management (QRM):
 - Resource reservations;
 - Global system utility control.

25

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Co-operative QoS approach: system

Global system utility control	Optimizes system utility, sets quality levels + allocates resources
Adaptive applications	
Local quality control	Provide quality levels + estimated resource req.
SVAs	
Resource manager	Provides guaranteed resource budgets

26

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QoS approach: local quality control

- Synchronous (3D graphics):
 - Estimate `work' for next frame and set operational quality level according to available resources.
- Asynchronous (high quality video):
 - Through buffering and work-ahead;
 - Progress (i.e. amount of budget [= virtual time] till deadline);
 - Quality selection based on penalties & reward:
 - Deadline miss (-);
 - Quality level fluctuation (-);
 - Quality level (+).

27

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Co-operative QoS approach

- **Shared responsibilities:**
 - QRM: enabling;
 - Applications: executing.
- **Cost-effectiveness:**
 - QRM:
 - resource allocation according to relevance;
 - Low system overhead;
 - Close to average-case resource allocation.
 - Applications: *effective and efficient media processing.*
- **Robustness:**
 - QRM: resource reservations;
 - Applications: "get by" with budget.
- **Seamless switching between modes:**
 - QRM: mode-change protocol;
 - Applications: smooth transitions.

28

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A retrospect on real-time issues

- Real-time is a QoS parameter !
 - Deadline miss: a *penalty* for local quality control.
- Modes of a system:
 - Number of applications (main, pip, disk);
 - Modes of applications (input, output);
 - Quality settings and budgets of applications.
- Hierarchies:
 - Control:
 - Global system utility control;
 - Local quality control (of an RCE).
 - Scheduling:
 - Periodic budgets;
 - Asynchronous tasks (sharing a budget).

29

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References

- [Bril et al 01] R.J. Bril, C. Hentschel, E.F.M. Steffens, M. Gabrani, G.C. van Loo, and J.H.A. Gelissen, *Multimedia QoS in consumer terminals* (invited lecture), In: Proc. IEEE Workshop on Signal Processing Systems (SIPS), pp. 332 – 343, September 2001.
- [Lee et al 99] C. Lee, J. Lehoczky, R. Rajkumar, and D. Siewiorek, *On quality of service optimization with discrete QoS options*, In: proc. 5th IEEE Real-Time Technology and Applications Symposium (RTAS), pp. 276 – 286, 1999.
- [Steffens et al 03] L. Steffens, S. van Loo, and C. Otero Perez, *Trends in Operating Systems – Resource Management for Future CE Systems* (invited lecture), ESTIMEDIA Workshop, <http://www.idt.mdh.se/estimedia/steffens.pdf>, October 2003.
- [Wüst et al 04] C.C. Wüst and W.F.J. Verhaegh, *Quality control for Scalable Media Processing Applications*, Journal of Scheduling, 7(2): 105-117, March 2004.

30
