Efficient Multimedia Streaming for Power Aware Devices: A survey

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Outline

- Introduction
- Categorization of Solutions
- Category 1: DVS Techniques
- Category 2: Network level optimizations
- Category 3: Content Adaptation
- Category 4: Architecture Changes
- Conclusion

Introduction

- What are Power Aware Devices? What are their characteristics?
  - Running on battery power – energy consumption is crucial
    - Laptops, handhelds, mobile phones
  - Usually have Power Saving Features:
    - Power saving modes
    - Ability to switch off certain components (eg. Caches, memory banks)

Frequency, Voltage and Relative power of mobile AMD Athlon 4 CPU

Frequency	300	500	600	700	800	1000
Voltage	1.2	1.2	1.25	1.3	1.35	1.4
Relative Power (%)	22.04	36.73	47.83	60.35	74.39	100

Introduction

- Characteristics of Multimedia tasks
  - High consumption of CPU
  - High consumption of Networking resources (streaming)
  - High consumption of display resources (video)
  - Real time characteristics
  - Demands for resources varies a lot – depends on content and media application
  - Low spatial locality in media data (poor caching behaviour)

- Research challenge to optimize energy consumption!

Introduction: MPEG basics

- MPEG video content -> sequence of images or "frames"
- 3 types of frames: I, P, B
- I frame -> Intra frame (medium compression)
  - I frame is independently coded
- P frame -> Predicted frame (higher compression)
  - P frame differentially coded with respect to a previous I frame or a P frame
- B frame -> Bidirectional frame (high compression)
  - B frame differentially coded with respect to a I/P frame ahead and I/P frame behind

Introduction: MPEG basics

- General Characteristics of various MPEG frames
  - Decoding expense : I > B > P
  - Decoding expense for 2 frames of the same type is usually similar in the short term
  - In the long term there can be high variability in the decoding times for a particular frame type

Power consumption of video decoding:

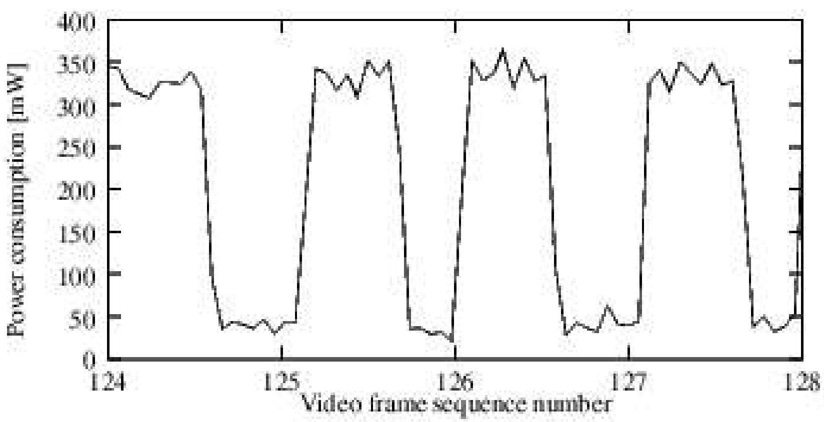


Figure 1: Power consumption of video decoding (15 fps).

Categorization of solutions

- Main source of energy consumption
  - CPU/memory + additional circuit boards (~1-3 W)
  - Network hardware (1.4 W)
  - Display (~1W)

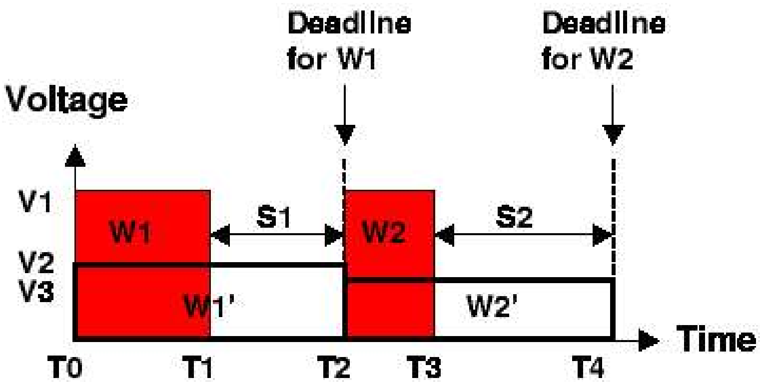
- Solutions mainly target these specific sources.

Categorization of Solutions

- Solutions categorized into following
  - DVS Techniques
    - DVS guided by CPU utilization prediction
  - Network level optimizations
    - Network device aware delivery optimizations
  - Content adaptation
    - Adapting media content to decrease processing
  - Architecture changes
    - Reconfiguration of hardware units (Simulated)

Category 1: DVS Techniques

- What is DVS?
  - Most mobile processors have Dynamic Voltage Scaling (DVS) support.
  - What is DVS?
    - Power = C * f * V^2
    - C = Circuit capacitance
    - F = Frequency of Processo
    - V = Supply voltage
    - Reducing voltage greatly reduces power
    - Concern: Reducing Voltage also reduces f.
    - Ensure deadline can be met under this low frequency



  - Spread “slack time” by reducing frequency of processor

DVS Techniques

- General technique:
  - Try to predict CPU requirement for decoding a media unit
  - Switch CPU frequency to appropriate level so media unit can be decoded.
- Pouwelse et al
- Insight: Strong correlation between frame size and decoding time

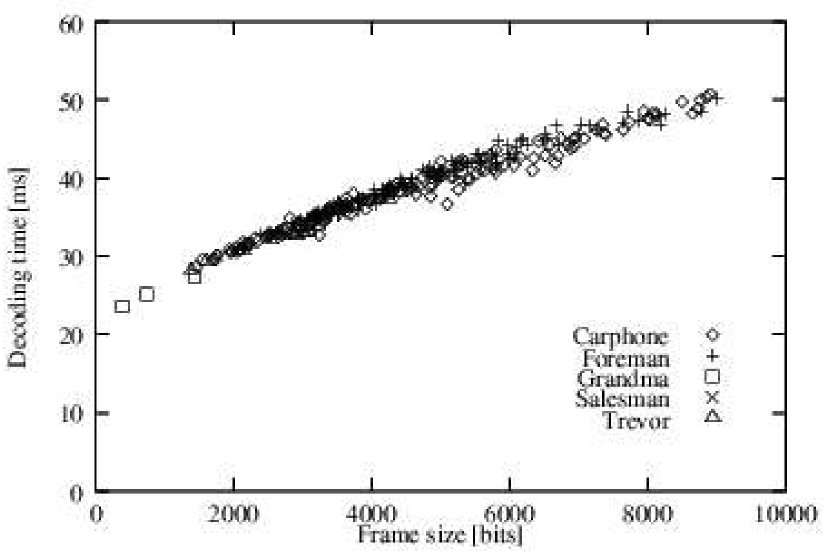
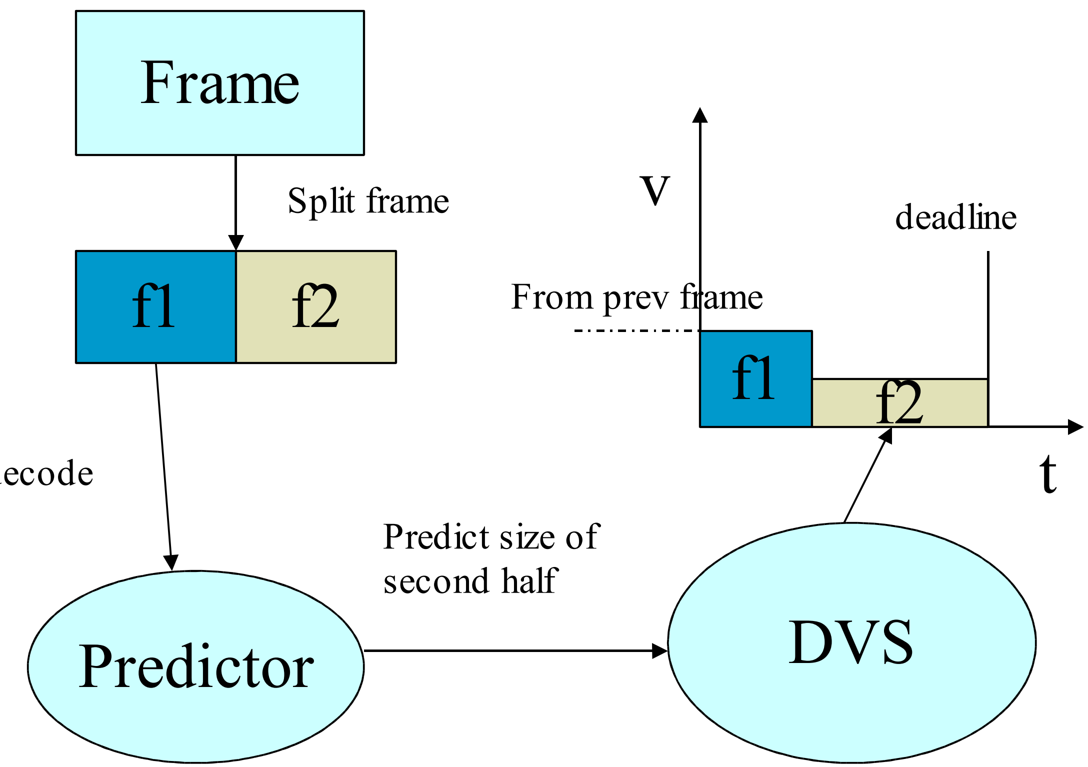


Figure 3: Decoding times for P frames @ 236 MHz.

DVS Techniques

- Pouwelse et al



Between 17% - 75% reduction

DVS Techniques

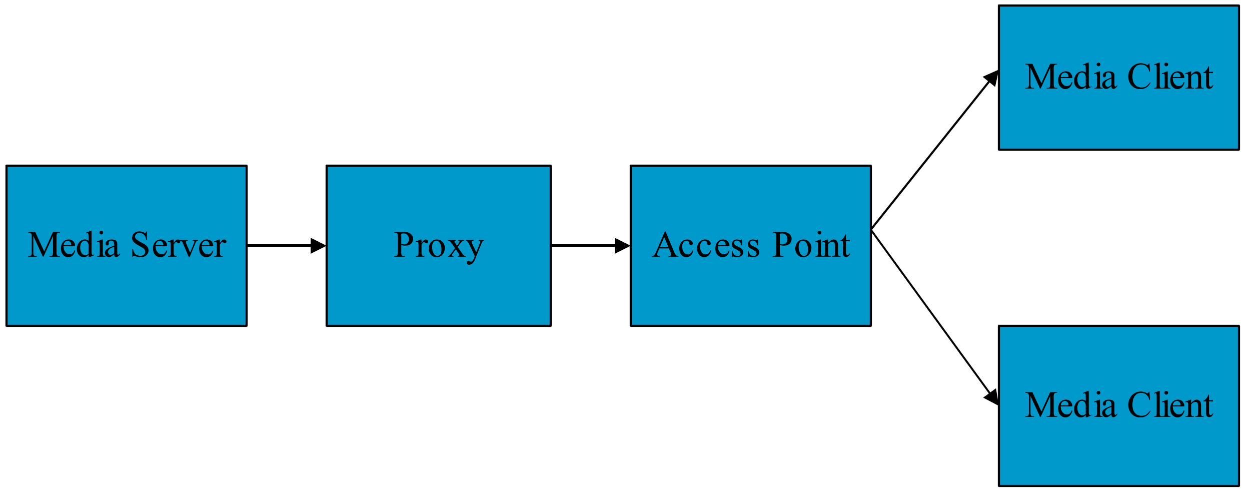
- Bavier et al.
- Average decoding time for previous frame of same frame type recorded
- Weighted adjustment depending on previous prediction success applied to get prediction value.
- Result:
  - Upto 80% improvement in power requirement
  - About 10-20% deadline misses

Network Level Optimizations

- Network cards have various power consumption characteristics
  - Cisco Aironet 350 series
    - Transmit (1.68 W)
    - Receive (1.435 W)
    - Idle (1.34 W)
    - Sleep (0.184W)
- Main idea:
  - Put card in sleep mode as often as possible

Network Level Optimizations

- Instead of sending data all the time, a Proxy sends data in bursts (Chandra et al)



- Burst send schedule is communicated with clients at scheduled times by proxy
- Clients receive data during scheduled times and sleep otherwise
- Result: Over 75% energy saved

Content Adaptation

- Work by Cornea et al.

- Key insight:
  - Media can be transcoded with different parameters (frame rate, bit rate, resolution) without noticeable change to human perception
- Concern: Relationship between media encoding parameters and CPU requirement at client is not clear
  - Use empirical methods to correlate parameter values to power consumption on client

Content Adaptation: Cornea et al.

- Discrete levels of video quality in terms of parameters

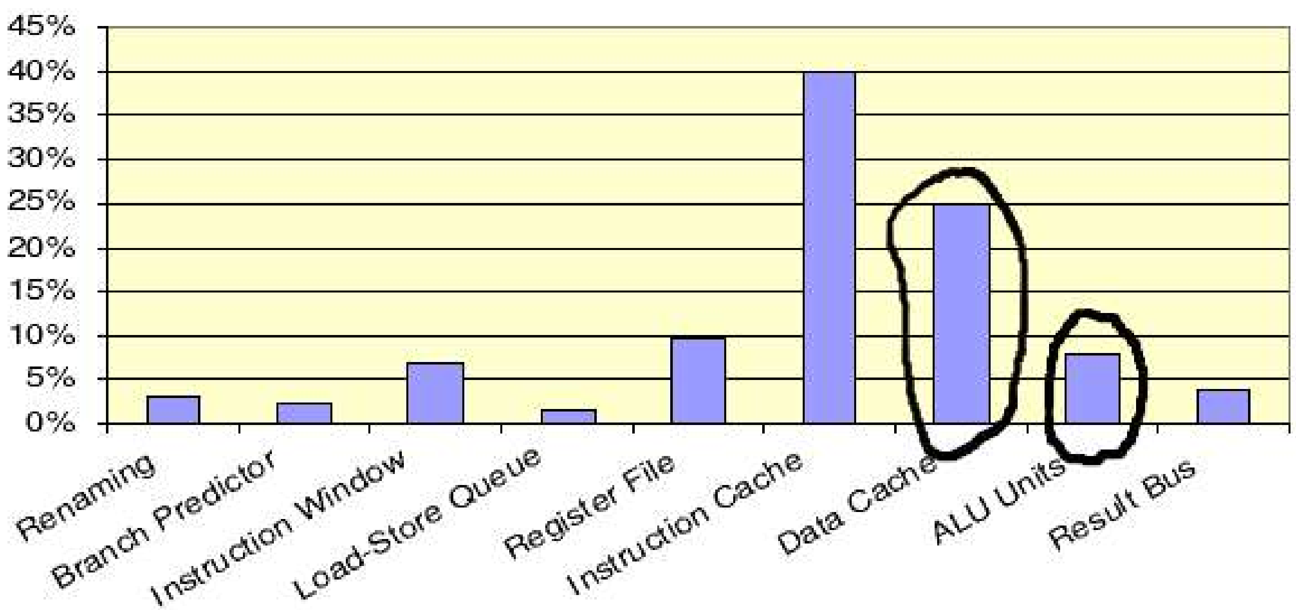
Quality	Transformation Parameters	Avg. Power (Windows CE)	Avg. Power (Linux)
Like Original (No improvement required)	SIF, 30fps, 650Kbps	4.42 W	6.07 W
Excellent	SIF, 25fps, 450Kbps	4.37 W	5.99 W
Very Good	SIF, 25fps, 350Kbps	4.31 W	5.86 W
Good	HSIF, 24fps, 350Kbps	4.24 W	5.81 W
Fair	HSIF, 24fps, 200Kbps	4.15 W	5.73 W
Poor	HSIF, 24fps, 150Kbps	4.06 W	5.63 W
Bad	QSIF, 20fps, 150Kbps	3.95 W	5.5 W
Terrible (poorer quality not acceptable)	QSIF, 20fps,100kbps	3.88 W	5.38 W

- Given energy level at client, maintain best possible video quality for duration of stream
- Proxy transcodes media according to parameter values

Architecture Changes

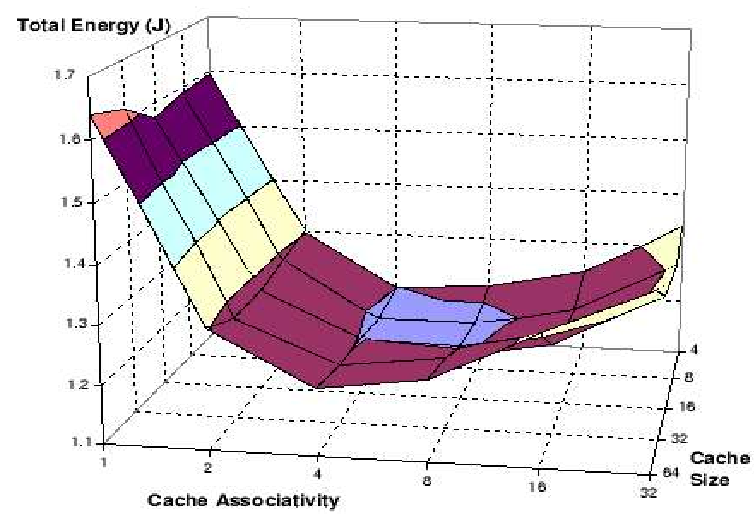
- General Idea
  - Assume architectural units are configurable
  - Switch off units if not required

Fig: CPU internal power distribution



Architecture Changes: Cache Reconfiguration

- Change data cache size and associativity [Cornea et. Al.]
  - Decreasing cache size -> lower cache power consumption
  - Concern:MPEG decoding exhibits poor locality -> greater cache-memory traffic.
  - Use extensive simulations to record "sweet spot" for a video quality level
  - Switch to optimal cache configuration for that video quality
  - 10-20% improvement



Cache Energy Variation on Size and Associativity

Summary

- Multiple ways of supporting power aware multimedia applications
- 4 categories of solutions:
  - DVS Techniques (widely studied)
  - Network level optimizations
  - Content adaptation (relatively new and recently applied to the power domain)
  - Architecture adaptation (completely done through simulations, requires very specific hardware support)