Power consumption issues for wireless video transmission

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Why is Energy Important Today?

Humanity's Top Ten Problems over Next 50 Years:

1. Energy
2. Water
3. Food
4. Environment
5. Poverty
6. Terrorism and War
7. Disease
8. Education
9. Democracy
10. Population

Figure 1: Photo of Earth.

2003: 6.5 Billion People
2050: 8-10 Billion People

Overview of Energy

Projected World Energy Consumption

- World population now is 6B; in 2050, 10B?

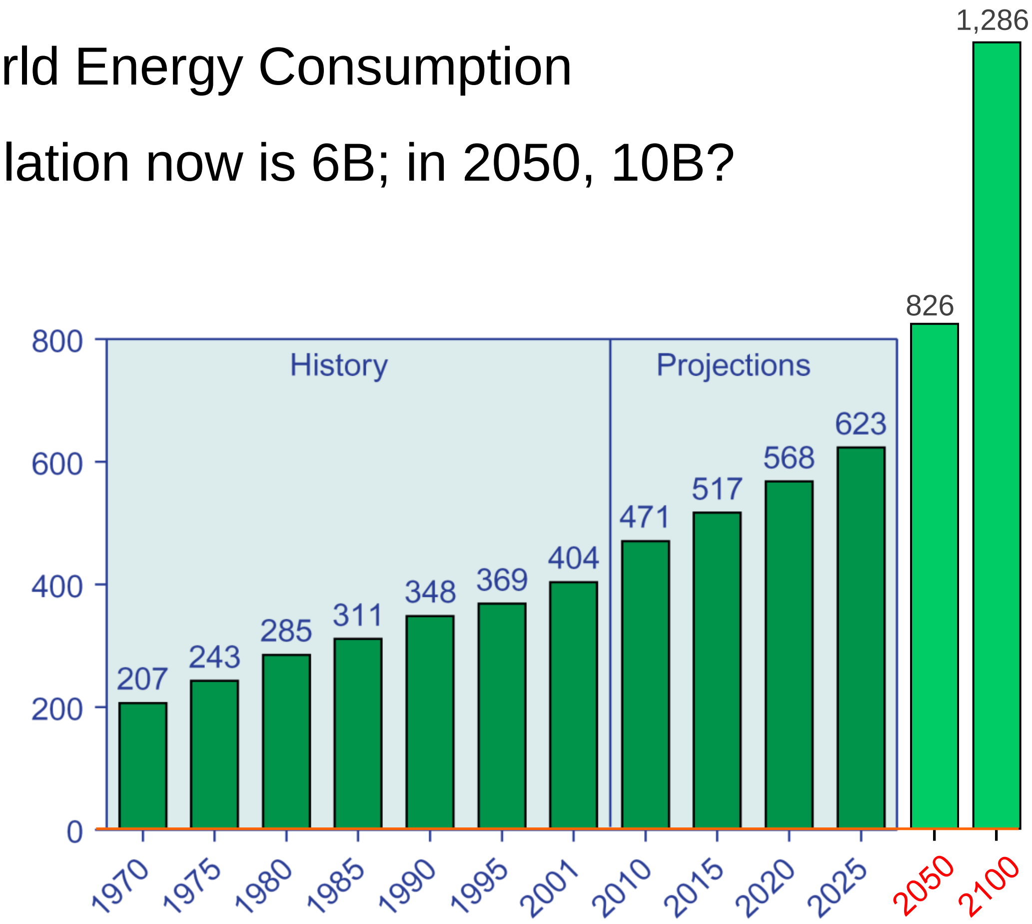
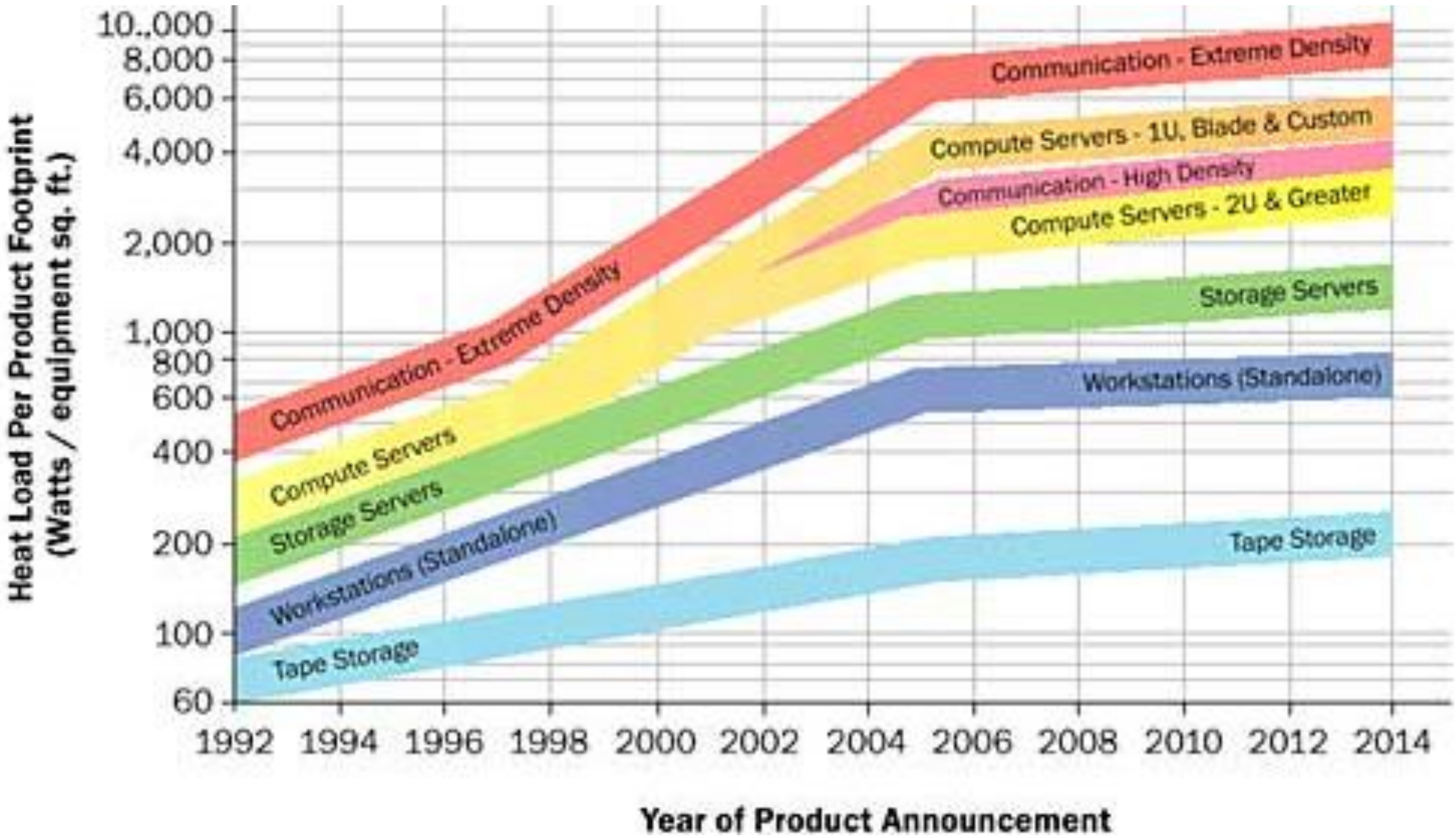


Figure 2: World energy consumption (Quads).

Energy Consumption in Telecom Centers(1)

– Trends in energy consumption in Telecom are well known as per the chart below published by the Uptime Institute



Energy Consumption in Telecom Centers(2)

- 1.5%-3.0% of energy produced in industrialized countries consumed by telecom and datacom centers. But, magnitude of indirect energy savings attributable to Information and Communications Technology (ICT) unknown.

- Data center energy consumption to double within 5 years on current trajectory due to video on demand, on-line gaming, etc. Telecom & datacom centers already 40X as energy intensive as conventional office buildings.

Video traffic forecast, %

Information from Cisco[1]: by 2013 the amount of video traffic will reach 64% of all transmitted date

Traffic	2008	2009	2010	2011	2012	2013
Audio	10,9	9,4	8,2	7,4	6,9	7,1
Video	**39,5**	**45,5**	**51,9**	**57,1**	**60,4**	**63,7**
P2P	20,3	18,6	16,3	14,5	12,5	10,1
Data	29,3	26,5	23,6	21,2	20,2	19,1

[1] www.cisco.com

Saving energy by compression

Motivation

- $Energy_{send}$ > 1000 nJ
- $Energy_{add}$ < 1 nJ

Can we use compression to save energy?

Concrete Objective

Can we use up to 1000 "adds" to eliminate a bit?

Challenges

- Memory access consumes a lot of energy
- Best compression ratio ≠ Energy savings

- ➢ Most video coders exhibit a very high computational burden
- ➢ The use of such a powerful encoder in a wireless networks application may be objectionable, in that it is possible that the energy saved by transmitting less data does not compensate for the energy required to compress the video data
- ➢ The trade-off between communication and computation is a crucial aspect that need to be investigated

The main goal

Current research focuses on:

- Measuring power
- Evaluating results
- Building model of power consumption of compression and transmission over wireless networks (WiFi, 3G, WSN)
- Model verification
- Efficient power saving strategy proposal

Model 1

Based on Shannon's model

$$C = W\log_2(1+\frac{E}{WN})$$

where *C* is the channel capacity in bits per second,
W is the bandwidth of the channel in hertz,
E is the total transmitter power over the bandwidth measured in watt,
N/2 is the variance of AWGN noise;

Model 2

Simple linear model of transmitter power consumption [1,2]:

$$P_{transmitter}(R) = ((P_{\max} - P_0)/R_{\max}) \cdot R + P_0 + P_{encoder}$$

where $P_{transmitter}(R)$ is transmitter power consumption,

P_0 is transmitter power consumption in sleep mode (no transmission),

$P_{encoder}$ is compression power consumption,

$P_{\max}$ is transmitter power consumption in full transmission mode (without sleeping),

R is average bit rate of transmitted information.

[1] A. Belogolovy, E. Belyaev, A. Sergeev and A. Turlikov, Video Compression for Wireless Transmission: Reducing the Power Consumption of the WPAN Hi-speed Systems, *The 9th International Conference on Next Generation Wired/Wireless Advanced Networking*, 2009.
[2] Wei Pu; Yan Lu; Feng Wu; Joint Power-Distortion Optimization on Devices with MPEG-4 AVC/H.264 Codec, IEEE International Conference on Communication (ICC), June 2006

Model 3

Another linear model [1]:

$$Energy = m \times size + b$$

where m represents the incremental cost

b represents fixed costs

$size$ is the number of bytes transferred

[1] Feeney, L.M.; Nilsson, M.; Investigating the Energy Consumption of a Wireless Network Interface in an Ad Hoc Networking Environment.INFOCOM 2001. IEEE Proceedings of Twentieth Annual Joint Conference of the IEEE Computer and Communications Societies.

Model 4

P - power normalized by the maximum encoder power P_{max} :

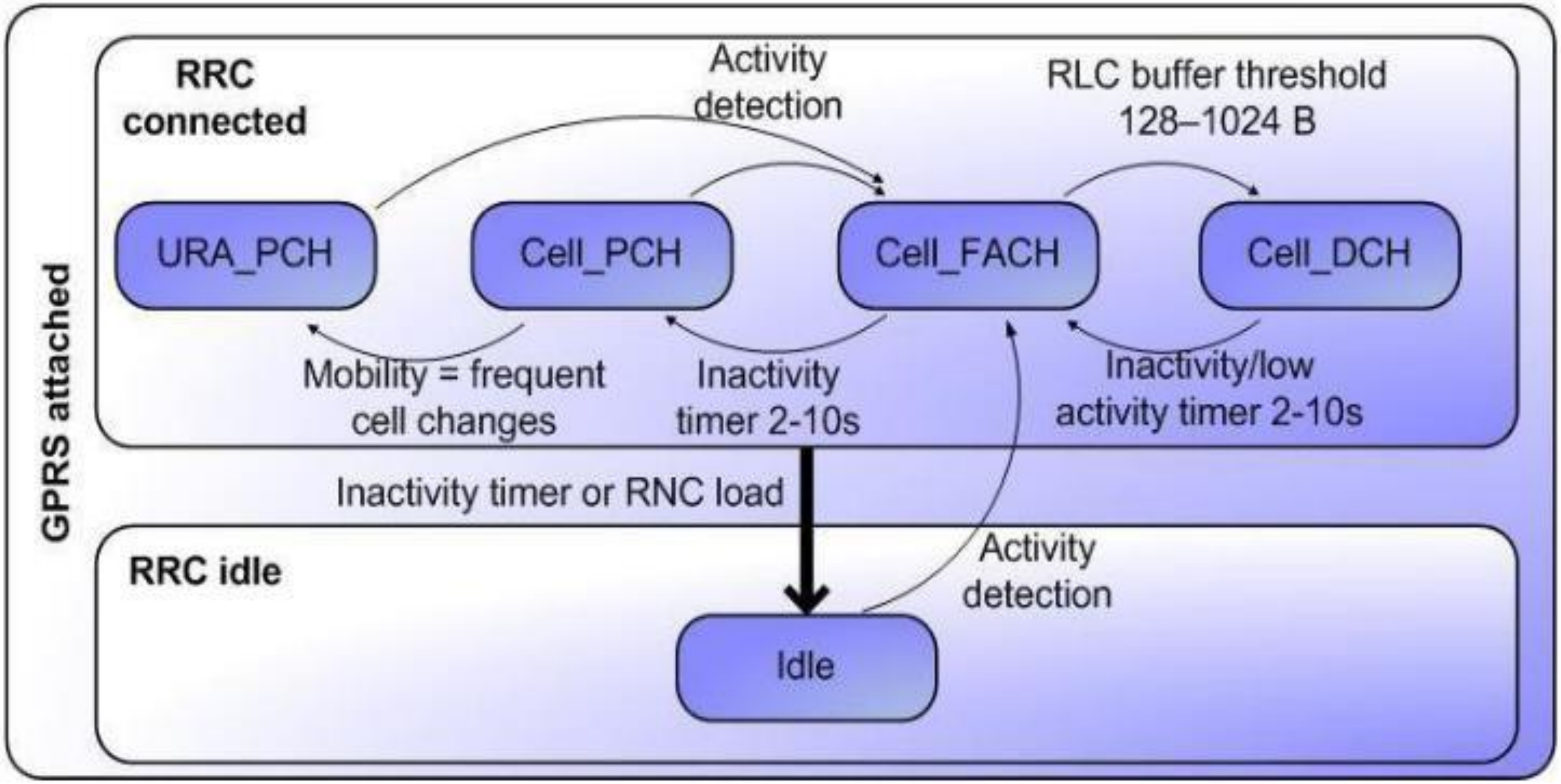
$$P = \frac{\log \frac{D}{\sigma^2}}{(-\lambda \times R)^{\gamma}}, \text{where}$$

σ^2 – the variance of encoded picture. If it is a motion predicted video frame, σ^2 is the variance of the different picture after motion compensation

λ – P-R-D model parameter which characterizes the resource (bits and energy) utilization efficiency of the video encoder

γ – typically $1 \leq \gamma \leq 3$

Four states power consumption



Transmitter state machine

R is data rate (kbps), **C** as transmission rate (kbps), **T** is waiting time (sec), **Buffer_RLC** is number of bits in transmitter buffer, **B_tr** is buffer threshold, **C_tr** transmission rate threshold.

State 1. Cell_PCH
Transmission state: No transmission
Power consumption: 30 mW
If Activity detection then go to **State 2**
Else Go to **State 1**

State 2. Cell_FACH
Transmission state: C2 = f_c2(packet_size,interval) <16 kbps (100ms*100B)
Power consumption: 400 mW + f_p2(packet_size,interval)
If Buffer_RLC>B_tr then go to **State 3**
Else if Inactivity time more than **T sec** go to **State 1**
Else Go to **State 2**

State 3. Cell_DCH
Transmission state: transmission with rate C3=f_c3(packet_size,interval)
Power consumption: 800 mW+f_p3(packet_size,interval)
If R < C_tr holds more than T sec go to **State 2**
Else go to **State 3**

Future work

- Make measurements for N900 (cooperation with HUT, Finland)
- Propose power consumption model
- Propose power consumption strategy in 3G

Papers

[1] E. Belyaev, T. Koski, J. Paavola, A. Turlikov and A. Ukhanova. Adaptive power saving on the receiver side in digital video broadcasting systems based on progressive video codecs // *The 11th International Symposium on Wireless Personal Multimedia Communications*, Lapland, Finland, 2008

[2] E. Belyaev, V. Grinko and A. Ukhanova, Power saving control for the mobile DVB-H receivers based on H.264/SVC standard // *8-th Wireless Telecommunication Symposium*, Czech Republic, 2009

[3] A.Ukhanova, E.Belyaev, Soren Forchhammer, Encoder power consumption comparison of Distributed Video Codec and H.264/AVC in low-complexity mode // *The 18th International Conference on Software, Telecommunications and Computer Networks* , Croatia, 2010

Thank you