Sustainable Computing: Informatics and Systems 18 (2018) 34–44

Contents lists available at ScienceDirect

Sustainable Computing: Informatics and Systems

journal homepage: www.elsevier.com/locate/suscom

Video sensor node energy preservation through dynamic adaptive video encoding parameters' values selection

Othmane Alaoui-Fdili [a,d,*], François-Xavier Coudoux [b], Youssef Fakhri [c], Patrick Corlay [b], Driss Aboutajdine [d]

[a] LAPSSII, Ecole Supérieure de Technologie de Safi, Université Cadi Ayyad, Safi, Morocco
[b] Univ. Valenciennes, CNRS, Univ. Lille, YNCREA, Centrale Lille, UMR 8520 – IEMN, DOAE, 59313 Valenciennes, France
[c] LARIT équipe réseaux et Télécommunications, Ibn Tofail University, Kénitra, Morocco
[d] LRIT-CNRST URAC29, Faculty of Sciences, Mohammed V University in Rabat, Morocco

ARTICLE INFO

Article history:
Received 31 March 2017
Received in revised form 23 October 2017
Accepted 15 February 2018
Available online 23 February 2018

Keywords:
Energy consumption
Adaptive video encoding
H.264/AVC
Intra coding
Lifetime extension
Wireless videos sensor networks

ABSTRACT

Wireless video sensor networks (WVSN) are energy constrained systems where deployed video nodes are capable of capturing the visual scene, performing local processing such as video compression, then routing the results toward the destination. In this paper, we consider the problem of minimizing the energy consumed by the video sensor node to encode and transmit the video stream under a defined video quality constraint. In the present work, Intra-Only H.264/AVC is considered as video compression scheme. Particularly, we propose to control at run-time both the energies consumed for video encoding and transmitting, in addition to the video encoding distortion. Thus, we begin our study by profiling the evolution of these quantities according to two coding parameters, namely the frame rate (FR) and the quantization parameter (QP). Following an analysis of the obtained measurements, we propose empirical parametric models in line with the observed behaviors, then validate them with different video sequences. Finally, we introduce the Dynamic Adaptive Encoding Parameters' values Selection (DAEPS) procedure which relies on these models to solve the problem under consideration. Simulations show the advantage of considering such an approach, which is capable, on the one hand, of extending the lifetime of the video sensor node up to 2.3 times, when compared with state-of-the-art approaches, and on the other hand, of complying with the defined end-to-end video quality constraint.

© 2018 Elsevier Inc. All rights reserved.

1. Introduction

Wireless sensor networks (WSN) are offering a new solution for monitoring indoor and outdoor environments [1,2]. They consist of a large number of interconnected sensor nodes, and can collect data, process, then route them towards the destination using multi-hops short range transmissions. Sensor nodes are battery powered units and replacing this component is in general difficult, and in some cases, impossible. Therefore, all possible efforts have been made to propose energy-efficient communication algorithms and schemes in order to extend node lifetime as much as possible [3,4]. The recent advances in CMOS image and video processing technologies have allowed the sensor nodes to capture and process visual information. Networks of such interconnected devices are called Wireless Video Sensor Networks (WVSN)s [5,6]. Recently, the research in WVSNs gained high interest due to the multitude of applications that are envisioned and could be developed [7].

In a WVSN, the collected visual information needs to be compressed prior to transmission. Hence, new challenges have been introduced to the WSN researchers community because of the particular features of this kind of data. Specifically, processing energy was so far neglected in WSNs since it was considered a very simple operation [2]. However, the energy consumed for video data processing has to be taken into account [8]. According to the experiments presented in [9], conducted on Stargate/Telos video sensor nodes, the computational energy depletion constitutes the major portion (more than 90%) of the total energy consumption compared to the bit transmission energy. Therefore, energy-efficient compression schemes are needed since a large amount of energy is drained during this phase.

The particularity of the context of the WVSN suggests designing more adaptive solutions, that consider at every stage the various indicators reflecting the current state of the node and its neighbor-

* Corresponding author at: LAPSSII, Ecole Supérieure de Technologie de Safi, Université Cadi Ayyad, Safi, Morocco.
E-mail address: othmane.alaoui.fdili@gmail.com (O. Alaoui-Fdili).

https://doi.org/10.1016/j.suscom.2018.02.006
2210-5379/© 2018 Elsevier Inc. All rights reserved.

hood. In this paper, the considered indicators are the remaining energy (RE) of the video source node as well as the perceived transmission distortion. The key idea of the paper is to propose an energy-efficient and adaptive video encoding scheme that, given a user's end-to-end desired video quality, an estimated transmission distortion and a current remaining energy budget, selects the appropriate configuration in terms of the quantization parameter (QP) and frame rate (FR) to preserve from useless energy consumption while meeting the specified desired end-to-end video quality. The considered video encoding standard is the Intra-only H.264/AVC in its Baseline profile [10]. Practically, to reach our objective, we first investigate the behavior of the considered energies and distortion. Then, we propose empirical parametric models, as functions of QP and FR, in line with the observed behaviors. Third, the proposed models are validated using a different set of video sequences. Finally, we introduce the dynamic adaptive encoding parameters' values selection (DAEPS) procedure, which relies on these to perform energy saving while meeting the required end-to-end video quality.

The choice of the Intra-only prediction mode is motivated by the results of the experiments presented in [9,11], showing that inter-coding consumes more than 10 times the energy drained by Intra-coding. Hence, choosing Intra-only coding significantly limits the energy consumption of the resource-limited video nodes. It might indeed be expected that the Intra-only coding results in lower compression ratio, but the use of reduced frame rate compensates for this. Furthermore, Intra-only coding avoids error propagation across successive frames, hence preserving video quality. Our motivations behind the choice of QP and FR as controlling parameters in this work are twofold: first, the QP and FR parameters are used in all video encoding standards. Second, they are easy to access on different industrial cameras, such as the LILIN IPD2220ES [12], offering controllable multiple FR and bit rates (i.e., QP). Consequently, the present proposition could be adapted for further standards and easily used by existing cameras or prototyped ones in order to extend their lifetime when used in an energy-constrained system. An extension of this work to the case of ROI-oriented robust transmission, using three video encoding parameters, in addition to an interactive original routing protocol, with node and network levels evaluations, has been recently accepted for publication in [13].

The rest of this paper is organized as follows: Section 2 presents a review of the relevant approaches for sensor node lifetime extension. In Section 3, the main contributions of this paper are explained in detail. Section 4 validates the proposed models then applies the proposed DAEPS procedure. Finally, Section 5 concludes the paper.

2. Related works

Due to the inherent features of the WSNs, which are known as energy-constrained systems, many works have addressed the problem of network lifetime extension under the quality of service constraints. In a typical WSN, with only scalar data, the energy conservation is mainly performed only in the lower layers of the protocol stack, namely the network, MAC and physical layers. For instance, to decrease the energy consumed by idle listening, where a node listens for any possible incoming packets, many works have adopted the technique of duty cycling as a solution [14]. In fact, in [15], the authors introduced the FTA-MAC protocol consisting of rapid adaptation of the receiving nodes wakeup interval according to the source nodes sending rate, which leads to a reduction of the receiving nodes idle listening. Moreover, since the ISM bands are often crowded, the sensor node may decide to wake up upon false detections of surrounding WiFi transmissions. This false wakeup causes significant waste of energy. As a solution, the authors in [16] proposed the Adaptive Energy Detection Protocol, an application-oriented protocol which is able to dynamically adjust a nodes wakeup threshold to improve network reliability and duty cycle. Energy efficiency could also be performed at the PHY layer by optimizing modulation sizes and/or transmission durations in order to minimize the total energy consumption, for example. This particular idea was investigated in [17], which focused on Gaussian channels subject to the delay and peak power constraints, and in [18], which considered fading channels subject to the bit-error-rate (BER) constraints. On the other hand, the authors of [19] adopted the adaptive power allocation idea to achieve network lifetime extension. In fact, instead of transmitting at a fixed power, this last could be adapted with respect to the observed signal to noise ratio (SNR) for more energy saving. Other energy-efficient techniques performed at the MAC and PHY layer, such as unequal protection and retransmission, the distributed beamforming, contention free techniques and the cross-layer design, are listed in surveys [20–22].

Routing is an additional energy consuming phase. To decrease its energy consumption, many solutions could be adopted. One of the most popular is using cluster architecture [23], consisting of subdividing the network into clusters, where each one is managed by a selected node known as the Cluster Head (CH). The CH node is responsible of coordinating the members duty cycles, communications, and performing data aggregation. Thanks to this architecture, the communication and the number of transmissions are reduced, as is the consumed energy. This idea was adopted in several works and proved its ability to decrease the consumed energy over the network [24]. Another way to enhance energy efficiency during the routing process is to consider the remaining energy of the intermediate nodes as a metric in the setup path phase. In fact, the proposed routing protocol in [25] considered this information to establish the next hops candidates scores. The simulation results demonstrated that taking into account the residual energy of the forwarding nodes could notably extend the sensor nodes' lifetime while meeting the quality of service requirements. Other techniques for performing energy-efficient routing are highlighted in [26].

The introduction of visual information in the WSNs has prompted researchers to think of more solutions to realize further energy efficiency. Since the energy consumed during the video/image processing, prior to transmission, is considerable, several works have focused on the introduction of energy efficiency during the video/image compression phase [27,28]. In [29], the authors present a solution based on the correlation characteristics of visual information in the sensor networks. In fact, energy efficiency is achieved using a correlation-aware inter-node differential coding scheme conducted by the H.264/ MVC video coding standard. Using the multiview concept, redundant data of overlapping fields of views are encoded once.

In [30], the authors propose an energy-efficient and adaptive video compression scheme dedicated to the WVSN. The energy efficiency comes from the adoption of two modes, namely the standby and the rush modes, conditioned by a low and high FR respectively. In addition, a simple bit rate adaptation technique, called the frequency selectivity (FS), is applied to the region of interest (ROI) and the background (BKGD) respectively, in order to separately adjust the bit rate of each scene area, hence decreasing the energy consumed during the transmission process. However, the consumed energy during the encoding process was not considered and the selection of the encoding parameters' values -particularly the FR and the QP- was done in a static manner.

Lately, the idea of adapting the video encoding parameters' values at run-time has been gaining more interest in the WVSN context. An adaptive cross-layer framework for video transmission over the WSNs (ACWSN) is presented in [31] and used in [32]. ACWSN adapts the video encoding parameters, namely the group of pictures (GOP) length (i.e., G_L) and the number of B frames (i.e.,

Download English Version:

https://daneshyari.com/en/article/6902995

Download Persian Version:

https://daneshyari.com/article/6902995

Daneshyari.com