Integrated Power Optimization with Battery Friendly Algorithm in Wireless Capsule Endoscopy

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Abstract
The recently continuous enhancement and development in the biomedical side for the betterment of human life. The Wireless Body Area Networks is a significant tool for the current researcher to design and transfer data with greater data rates among the sensors and sensor nodes for biomedical applications. The core area for research in WBANs is power efficiency, battery-driven devices for health and medical, the Charging limitation is a major and serious problem for the WBANs.this research work is proposed to find out the optimal solution for battery-friendly technology. In this research we have addressed the solution to increasing the battery lifetime with variable data transmission rates from medical equipment as Wireless Endoscopy Capsules, this device will analyze a patient's inner body gastrointestinal tract by capturing images and visualization at the workstation. The second major issue is that the Wireless Endoscopy Capsule based systems are currently not used for clinical applications due to their low data rate as well as low resolution and limited battery lifetime, in case of these devices are more enhanced in these cases it will be the best solution for the medical applications. The main objective of this research is to power optimization by reducing the power consumption of the battery in the Wireless Endoscopy Capsule to make it battery-friendly. To overcome the problem we have proposed the algorithm for "Battery Friendly Algorithm" and we have compared the different frame rates of buffer sizes for Transmissions. The proposed Battery Friendly Algorithm is to send the images on average frame rate instead of transmitting the images on maximum or minimum frame rates. The proposed algorithm extends the battery lifetime in comparison with the previous baseline proposed algorithm as well as increased the battery lifetime of the capsule.
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Key words:
Wireless Body Area Network; Battery Friendly Algorithm; Wireless Capsule Endoscopy

1. Introduction

The ENDOSCOPY is a combination of two words one is Endo means "Inside" and "scope" means "view". It is the best way to views images of the human body inside. Wireless Capsule Endoscopy or capsule is swallowed by a human into the inner body, it starts traveling in the gastrointestinal tract of human, during its travel, and it transmits the images of the gastrointestinal tract to a receiver which is connected with the waist of the patient. If the framework comprises of the gadgets which devour high force and thus running for restricted time because of capturing high-resolution images with the good transmission rate of images creates a tradeoff between high-quality images and lifetime of battery [1]. Remote Body Zone Organization is a useful apparatus for the analysis of maladies identified with the gastrointestinal plot of the human body. These are challenging issues with existing Wireless Capsule Endoscopic Technology is the limited battery life of the capsule which is because of the high-resolution images and high transmission data rate of captured frames of images [1].

The wireless capsule endoscopy recognizes the entire (Gastrointestinal) plot and relates the determination innovation. Wireless capsule endoscopy captures images and sends them to the receiver by its antennas that have transmitter and receiver wirelessly, and data is recorded into a data recorder from the patient's gastrointestinal tract. Food and drug administration in 2001 approved the first model of wireless-capsule endoscopy.

Fig. 1 Wireless Capsule endoscope system.

After numerous years this innovation has been acclaimed and gives the high goal and great battery lifetime and different capacities to examine the gastrointestinal lot by catching great goal pictures and analyze gastrointestinal lot [2, 3, and 31].
Wireless Sensor network includes a considerable number of easy use of sensors, cost-effective and optimized power which relatively smallish in size can easily use for diagnosis. In wireless networking, the latest advancement shows embedded technologies and Micro-Electro-Mechanical Systems makes Wireless Sensors Networks magical power to attract for the solution of many potential applications like in health care, intelligent transportation, ecological monitoring, and home automation [4].

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Wireless Sensors Networks sensor nodes consist of bounded energy budget and power operated battery, while in unreachable circumstances it is not easy for drained sensor to replace with a new battery or to recharge it. It is inoperable and incommoding. In education, it can be observed that to have strong battery backup power there is a need for greater charge capacity for a network. As Wireless Sensors Networks deal with micro-level technology and effective battery backup, therefore, it should be relatively tiny and light. The digital integration technology hard to contribute in it to continue this pace for further assistance [5, 28] In resultant it becomes a challenging issue for the designer to overcome this battery hunger packet transmission problem, various approaches already presented for strong battery backup [6-9]. For instance, the authors [9] give their point of view regarding the sensor's optimal planning, for boosting network lifetime and decreasing power dissipation in the cluster-based network. The author reveals his point of view about the energy-efficient algorithm (i.e., Lazy Packet Scheme) in which he discusses this strategy how to improve the duration of transmission through minimizing the transmission energy over the wireless medium. Taking the view of electrochemical properties meanwhile boosting the battery life is not considered by lowering the energy consumption of a battery [10], we may outstretch that according to the battery characteristics if we design an efficient algorithm it can boost up the lifespan of any storage through injecting assumed relaxation duration between two packets to get improved charge capacity. we are defining some existing work related to that it touches the boundary of our theme work as well, these hold on MAC schemes, an algorithm for task scheduling and battery aware routing whereas power optimization, battery properties, and battery models. They are all sure to minimize the power of the battery until the workload finishes. The stochastic model is developed with the burst discharge process to track out charge recovery discussed in [11].

The storage nonlinearity for task scheduling are proposed in algorithms related to loading current profile and shaping [12]. The authors seeing the nodes in the system and faceoff the complexity of the channel through the proposed novel battery-aware MAC scheduling scheme [13]. Compensating the latency of some network components of interlinked systems a scheduling scheme is presented, so that the decaying factor is improved and remains battery-friendly [14]. The author [15], [16] gives light on routing algorithm for battery aware; through utilizing rate limit impact and battery recuperation impact that improves the battery life expectancy.

2. Endoscopy detection body parameters

The below parameters are investigated from the Food and drug administration approved wireless-capsule systems and specifications for the human and medical applications [6].

Table 1: Endoscopy Detection Parameters [6].

CAPSULE ENDOSCOPY	Field of View	Images /sec	Battery lifetime	Resolution
EndoCapsule	145'	2	8 hours	512*512
PillC am SB2;	156'	2	8 hours	256*256
PillC am SB2EX;	156'	2	12 hours	256*256
MicroCam	170'	3	11 hours	320*320
PillC am ESO2;	169'	18	8 hours	256*256

The world is going toward power optimization where the lifetime of Wireless Capsule and High Battery Charge Consumption is a big problem to be resolved. Higher resolution and frame rate are more battery hungry so keeping in see qualities and usefulness of sensor hubs in Wireless Sensors Networks our research focuses on extension battery lifetime. The problem is of power consumption due to various reasons such that capturing high- resolution images and transmission of images to the receiver and the light-emitting diodes. Table 1 shows the different values of different parameters currently available in markets.

2.1 Endoscopy Systems Configuration

Wireless Capsule Endoscope system works like, it takes images to store those images, it controls the capsule, and it communicates with the work station and so on. The fundamental aspect of this framework contains information recorder and battery, as shown in figure 2 wireless capsule endoscopy system, has to perform tasks like imaging the Gastrointestinal tract of the human body, then it has performed compression to compress the image, and then transmit it to the receiver connected outside on the patient's waist.

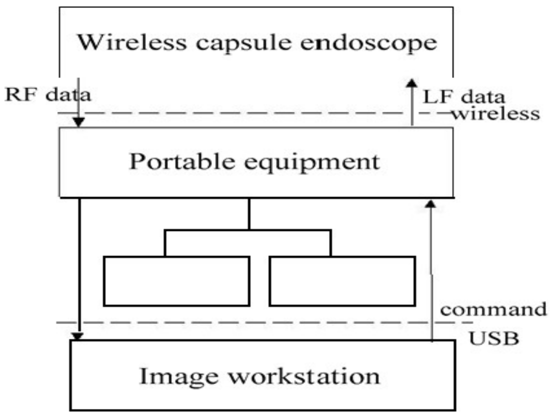

Fig. 2 Wireless capsule Endoscopy System

2.2 Proposed Algorithm

This is the proposed algorithm for the Battery friendly algorithm (BFA) Pseudocode furthermore, these main parameters explain the pseudo-code. Furthermore, explain in the section of the results and discussion portion.

Inputs: r, VF, $L_{vf,}$ buffer, t_{B}, t_{D}.
Outputs: Energy saving, Battery Charge saving, Average Transmission Schedule of VBR video.

$$For$$
$$T = 0\ to\ VF - 1$$
$$Do$$
$$begin$$
$$If$$
$$Favg\ (VF) \leq r(t)$$
$$begin$$
$$F_{max} \sum_{t=1}^{VF} \frac{D(t) + Buffer}{t_D}$$
$$if$$
$$F_{avg}(VF) > r(t)$$
$$begin$$
$$F_{max} \sum_{t=1}^{VF} \frac{D(t) + Buffer}{t_D}$$
$$if\ F_{imn} \leq F_{avg}(VF) \leq F_{max}$$
$$begin\ F_{avg}(VF) = \frac{F_{max} + F_{min}}{2}$$
$$end\ end\ end$$

2.3 The Proposed Algorithm Parameters (BFA)

Table 2 shows the selection parameters for the proposed algorithm for the compression of the Baseline algorithm while in these below terms we have considered the data rate and data transmission, Image transfer quality rate, number of frames for the charge consumption of the sensors, and sensor node while the reliable communication and transferring the data furthermore this algorithm also focused the optimized the consumption path and for the video transmission and its high-quality images for the patient treatments.

Table 2: Simulation Parameters used in BFA

Parameter	Value (KB)	Parameter	Value
Buffer Size	40, 60, 80, 100	Image frame idle time	0.5 min
Image Frame Rate (r(t))	5 per second	Image frame length	4279 Bytes
No. of Tasks (m)	5	Initial buffer size (q_buffer)	0
Initial Current Value (I)	50mA	Voltage (V)	4.95 volt
Image frame arrival time (t_g)	33 m Second	Inter arrival time (Δ)	40 msecond
No. Image frames (I_F)	900	Total charge consumption (α)	35232 mA mints
Image frame total time (t_D)	5 minutes	Data rate	40kbps
Nonlinear battery value (β)	0.81min^-1/2	Image frame average time (avg t)	4.5 mints

3. Results and Discussion

The proposed Simulation-based Algorithm for the Battery Friendly Scheme is quite more efficient as compared to the conversational method (Baseline) for the charge consumptions as shown in Figure 3, as also mentioned both proposed and BFA scheme charge consumption rate concerning the bits the more efficient and reliable source is the BFA algorithm.

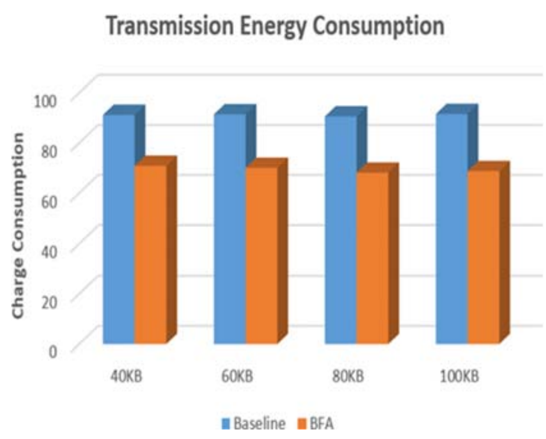

Fig. 3 Transmission Energy consumption.

Figure 4 indicates the transmission energy consumption of battery-friendly algorithm (BFA) and Baseline at different buffer sizes. From these results, it can be seen that at lower load currents battery-friendly algorithms (BFA) consume less energy than Baseline. Transmission time increases because of the lower load currents thereby lowering transmission energy drain.

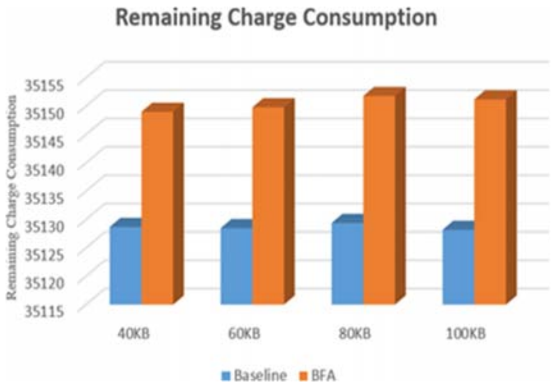

Fig. 4 BFA Consumed / Remaining Charge

As the proposed algorithm is verify these results by applying a different value of buffer size correspondence with different transmission energy consumption in a battery-friendly algorithm (BFA) and Baseline. If we talk about the relationship between buffer size and transmission energy consumption, with the slight increase in buffer memory given in kilobytes (KB) due to less buffer size and image processing constraint for a minute time this memory being used as shown in Figure 3- 4, with the increase in buffer size the transmission energy consumption is decreased because temporary data remain in a buffer memory for more time due to this cache memory is effected while processing another execution task (multi-layer execution). It can be easily analyzed that battery-friendly algorithm (BFA) transmission energy consumption is very much less than the baseline transmission energy consumption.

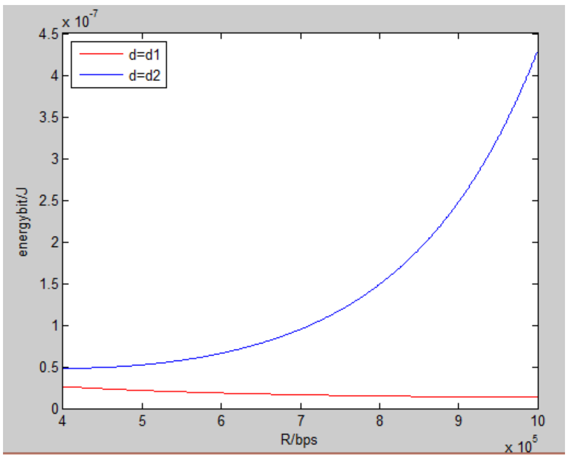

Figure 5. Energy consumption with distance.

While discussing Figure 4, the results which are shown with different buffer size corresponding charge consumption. Besides that, results indicate that increase in buffer size reduces the charge consumption due to confinement of frame with sufficient memory so that overflow situation does not occur, if the buffer size is less may be very next, having no space in the buffer that causes overflow that results in the high peak load current effect. Also, can be related to aliasing in data, so while the increase in buffer memory it reduces this effect up to near to the ground.

Figure 3 and Figure 4, reveal that the remaining battery charge or charge saved by Baseline, lazy packet transmission algorithm (LA), and Battery Friendly Smooth Algorithm (BSA), respectively with a buffer size of 64KB, 128KB, 512KB 2000 KB and 4000 KB. Due to the arrangement of load currents in increasing order less charge is saved by lazy packet transmission algorithm (LA) and Baseline. On the contrary, more battery charge is saved by Battery Friendly Smooth Algorithm (BSA). Since the lazy packet transmission algorithm (LA) has long continuous tasks with relatively low load currents and slightly long transmission time, while a Baseline has short, heavy tasks with high peak load currents and short transmission time. Also, the lazy packet transmission algorithm (LA) arranges tasks with increasing load currents, which is not battery-friendly.

The simulation result reveals that battery-friendly algorithm (BFA) performance is far better than Baseline in sense of battery charge consumption minimization, by using battery-friendly algorithm (BFA) technique lifetime of battery and battery charge consumption is optimized up to 12.73% concerning Charge consumption it is noticed that these results on the basis when buffer size is 40KB.

When discussing the transmission energy consumption it saves up to 0.9%.so it may be said that battery-friendly algorithm (BFA) is far better than Baseline scheme, as per Figure 4 battery friendly algorithm (BFA) consumes less transmission energy consumption than Baseline, and Figures 3 and 4 shows that battery-friendly algorithm (BFA) consumes less charge consumption than Baseline Figure 4 and that show the reaming charge of the battery-friendly algorithm (BFA) is more than Baseline, so battery-friendly algorithm (BFA) is much more efficient in term of energy optimization, Charge consumption, Transmission energy consumption. Battery-friendly algorithm (BFA). As buffer size increases, then battery charge and transmission energy consumption are Increasing slightly which in practice is not suitable for battery lifetime extension, energy-efficient, smooth, longtime, and battery-friendly video transmission in wireless body Sensor networks (WBSNs).

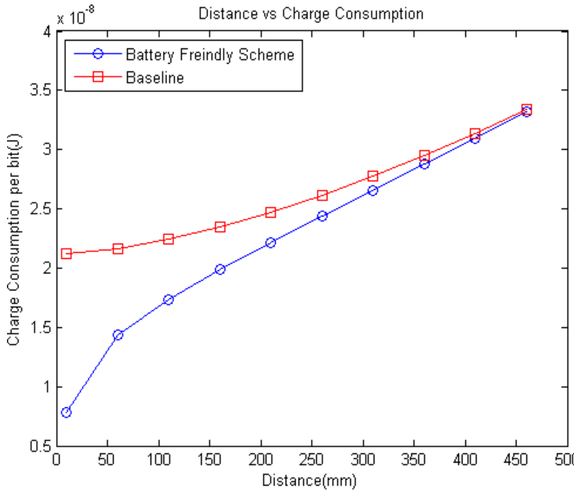

Fig.6 Relationship between Distance and Charge Consumption

Figure 6 shows the relationship of distance and charge consumptions rate between the transmitter and the receiver. The compared results between the charge consumption using a battery-friendly algorithm (BFA) and Baseline. The results show that a battery-friendly algorithm (BFA) performs very well in comparison with baseline techniques. As the BFA scheme achieved minimum charge consumption with increasing distance while the baseline takes more power while the distance is increase as shown.
While Figure 5 show the energy consumption with respect the distance the proposed algorithm was tested in two different inner body distances, where D2 is high so its energy is slightly and regularly increase while the D 1 is short distance so energy remains same.

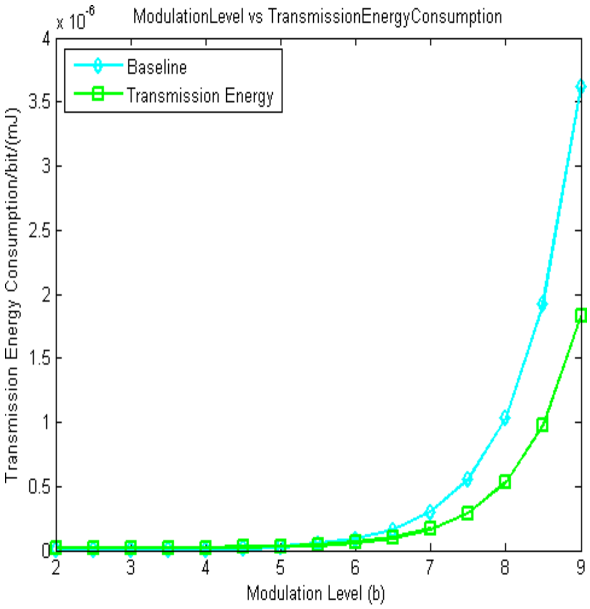

Fig. 6 Modulation level and Transmission

Figure 6 shows the relationship between a modulation level and transmission energy that is consumed during the transmission of video frames. We have used an MPSK modulation scheme, using MPSK allows us to have a good value of baud rate. We have plotted transmission energy consumption for different modulation levels. We have compared transmission energy consumption concerning changing modulation levels with the baseline technique. The results show that the battery-friendly algorithm (BFA) performs much better than the baseline as the transmission energy consumption is less in the battery-friendly algorithm (BFA) than the consumption taking place in the baseline.

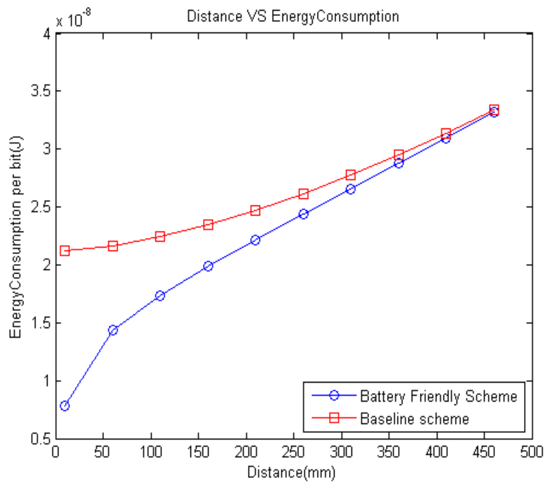

Fig. 7 Proposed Scheme BFA.

The simulation results and found that a battery-friendly algorithm (BFA) performs outstanding based on the given parameters in comparison with the baseline method of reducing power consumption in Wireless Capsule Endoscopy systems. This chapter contains the results obtained after studying different parameters of wireless capsule endoscopy (WCE) systems like modulation level, remaining charge, charge consumption due to threshold distance, transmission energy are discussed and their interdependence is shown in graphs.

3.1 Experimental Results between the BFA Algorithm and Baseline Scheme

Table 3 clearly shows that the permeance compression between the Base Line and the proposed algorithm that the proposed method is more effective and less power charge consumed and explain in the results of the experiment, the overall progress is better and more effective rather than the baseline scheme for the biomedical applications, BFA is less power is taken and more reliable algorithm to transform the video data of inner body of the human for the treatments.

Table 3: Performance Analysis of BFA and Baseline

Buffer Size	Strategies	Transmission Energy Consumption[J]	Charge Consumption[σ]	Remaining Charge[a-σ]
40KB	Baseline	91.2682	7481.6	35128.7
	Battery Friendly Algorithm	70.9197	3022.9	35149.2
60KB	Baseline	91.5039	5001.9	35128.5
	Battery Friendly Algorithm	70.1194	2975.2	35149.8
80KB	Baseline	90.6507	3719.5	35129.4
	Battery Friendly Algorithm	68.79531	2892.1	35151.8
100KB	Baseline	91.6339	3000	35128.2
	Battery Friendly Algorithm	68.79531	2874.7	35151.2

4 Conclusion and Future Work

In this paper, our main purpose is the battery-friendly packet transmission algorithm (BFA). We have compared the different baseline results and battery-friendly algorithm (BFA) results using the analytical battery model. The simulation results and performance of the battery-friendly algorithm (BFA) are authenticated in terms of transmission of frames with energy consumption and the battery charge consumption than saving the charge during the image transmission in the wireless body area network. When we look through the characteristics of the battery to minimize transmission energy consumption during the transmission is not equivalent to enhancing the life of the battery.

Battery lifetime performance is dependent upon the characteristics of the discharging of the battery rather than just transmission energy consumption minimization. For minimization of battery charge consumption need is to understand both the functionalities of charging and discharging. We have designed a very attractive and less complex algorithm method such as battery friendly algorithm (BFA) for friendly frame rate transmission to draw smooth and lower load current for saving transmission of energy and increase the life of battery life and reducing the power consumption with lower load current.

Integrated power optimization endoscopy is a technology that can never be complete because it will develop and develop with time compared to conventional wireless capsule endoscopy. Future challenges for integrated power optimization endoscopy that improve image quality and the visualization of each part in the gastrointestinal (GI) tract. There are possible developments in Integrated power optimization endoscopy in near future by designing algorithms depended upon the best image resolution with highly effective in diagnostic gastrointestinal endoscopy. The rate can of transferring images be increased so images to be shown at the workstation will be more sufficient for the patient to diagnose. A battery-friendly algorithm (BFA) is an algorithm that has less distortion of load current. Battery-friendly smooth algorithm (BSA) performs better than baseline but it has some limitations. The limitation is due to buffering size if the buffer size is increased so transmission energy and battery charge consumption increase slightly so due to this battery drains faster and faces the problem of shorter battery life and no longer transmission. In near future we will improve the battery-friendly algorithm (BFA) and implement those for the online result that results will be observer-independent and very high-definition transmission with high data rates for energy in the wireless body area network (WBAN) with the application of integrated power optimization Endoscopy (WCE). The image quality is not bad but needs to be improved if it is to become a realistic supernumerary for flexible upper and lower gastrointestinal endoscopy. An increase in the frame rate, angle of view, depth of field, image numbers, duration of the procedure, and improvements in illumination seem likely. The quality of the image is not bad but we have to need to improve with realistic supernumerary for flexibility of upper and lower gastrointestinal (GI) wireless capsule endoscopy. The main need is to increase the frame rate, angle of view, depth of field, and the number of images, improve development in the wireless capsule endoscopy (WCE).

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