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Effective Multimedia Communication Over Wireless Sensor Networks an Coalesce Of FPGA and Network Simulator

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Abstract*: Wireless Multimedia Sensor Networks has constraints when huge data has to be delivered. This system proposes architecture to reduce the packet error rate and retransmission of image. In addition it proposes a queue strategy to reduce packet error rate. In addition, it allows only one node to transmit at-a-time. Thus reducing collision and retransmissions.*

I. Introduction

In Wireless Multimedia Sensor Networks (WMSN), with the large volume of the multimedia data generated by the sensor nodes, both processing and transmission of data leads to higher levels of energy consumption than in any other types of wireless sensor networks (WSN). This requires the development of energy aware multimedia processing algorithms and energy efficient communication in order to maximize network lifetime while meeting the QoS constraints [1].

II. UDP And Matlab

UDP uses a simple connectionless transmission model with a minimum of protocol mechanism. It has no handshaking dialogues, and thus exposes the user's program to any unreliability of the underlying network protocol. There is no guarantee of delivery, ordering, or duplicate protection. UDP provides checksums for data integrity, and port numbers for addressing different functions at the source and destination of the datagram. With UDP, computer applications can send messages, in this case referred to as datagram's, to other hosts on an Internet Protocol (IP) to communications to set up special transmission channels or data paths. UDP is suitable for purposes where error checking and correction is either not necessary or is performed in the application, avoiding the overhead of such processing at the network interface level.

Initially image is converted into binary using matlab coding. This image is further packetized and sent to nodes. The image conversion in matlab is shown below:

Fig.1. Black and white image compression and UDP transmission.

UDP is suitable for purposes where error checking the protocol implemented here is UDP (User Defined Protocol) for transmission and NS-2 software is used.

III. AODV And Matlab

The AODV is a reactive protocol; routes are created only when a node wants to communicate with another node. The primary objectives of AODV are to discover the path, to identify the destination and to transfer the encrypted packets between the source and destination. There are four types of control packets RREQ, REER, HELLO and RREP. The first three are sent by broad cast, while RREP is sent by unicast. It discovers the route based on local routing table. The algorithm enables dynamic, self starting, and multi-hop routing between the participating mobile sensor nodes. The existing algorithm is implemented in software and requires more power consumption. It consumes longer processing time for execution of algorithm. The existing algorithm is insecure and it is prone to network routing attacks.

AODV routing protocol. Initially, the node is in ideal state. When an originator needs to communicate with another node, namely the destination, the source of the originator broadcasts the RREQ message. Once the destination is reached, it generates RREP message which is unicast to the source. It is known that a node can be a source, an intermediate node and a destination.

When a node in an active route gets lost, a route error message (RERR) is generated to notify the other nodes on both sides of the link of the loss of the link. Route discovery is initiated by broadcasting a RREQ message. The route is established when a RREP message is received. A source node receives multiply RREP messages with different routes. It then updates its routing entries if and only if the RREP has a greater sequence number, i.e. fresh information. Reverse path setup is established while transmitting RREQ messages through the network each node notes the reverse path to the source.

When the destination is found the RREP message will travel along this path, so no more broadcasts will be needed. When a broadcast RREQ packet arrives at a node having a route to the destination, the reverse path will be used for sending a RREP message.

While transmitting this RREP message the forward path is set up. As soon as the forward path is built the data transmission can be started. Data packets waiting to be transmitted are buffered locally and transmitted in a FIFO- Queue when a route is set up. After a RREP was forwarded by a node, it can receive another RREP.

The image to be transmitted is reduce in packet size by reducing background and extracting object using Median filtering and DWT respectively.

This image is packetized and ready to be transmitted in the nodes through NS2 software. Since it is energy efficient we go for reliable protocol AODV (Ad-hoc On-Demand Distance Vector routing)

A. Object Extraction

In the field of computer vision object recognition describes the task of finding and identifying objects in an image or video sequence. Humans recognize a multitude of objects in images with little effort, despite the fact that the image of the objects may vary somewhat in different viewpoints, in many different sizes and scales or even when they are translated or rotated. Objects can even be recognized when they are partially obstructed from view. This task is still a challenge for computer vision systems. Many approaches to the task have been implemented over multiple decades.

Object extraction is an algorithm for extracting foreground objects from color images and videos with very little user interaction. It has been implemented as "foreground selection". Although the algorithm was originally designed for videos, virtually all implementations use primarily for still image segmentation. In fact, it is often said to be the current de facto standard for this task in the open-source world. Initially, a free hand selection tool is used to specify the region of interest. It must contain all foreground objects to extract and as few background as possible. The pixels outside the region of interest from the sure background while the inner region defines a superset of the foreground, i.e. the unknown region.

A so-called foreground brush is then used to mark representative foreground regions. The algorithm outputs a selection mask. The selection can be refined by either adding further foreground markings or by adding background markings using the background brush.

B. Background Subtraction

Background subtraction, also known as Foreground Detection, is a technique in the fields of image processing and computer vision wherein an image's foreground is extracted for further processing (object recognition etc.).

Generally an image's regions of interest are objects (humans, cars, text etc.) in its foreground. After the stage of image preprocessing (which may include image denoising, post processing like morphology etc.) object localization is required which may make use of this technique. Background subtraction is a widely used approach for detecting moving objects in videos from static cameras. The rationale in the approach is that of detecting the moving objects from the difference between the current frame and a reference frame, often called “background image”, or “background model”.

Background subtraction is mostly done if the image in question is a part of a video stream. Background subtraction provides important cues for numerous applications in computer vision, for example surveillance tracking or human poses estimation. However, background subtraction is generally based on a static background hypothesis which is often not applicable in real environments. With indoor scenes, reflections or animated images on screens lead to background changes. In a same way, due to wind, rain or illumination changes brought by weather, static backgrounds methods have difficulties with outdoor scenes.

Median filtering is very widely used in digital image processing because, under certain conditions, it preserves edges while removing noise. In signal processing, it is often desirable to be able to perform some kind of noise reduction on an image or signal.

IV. Transmission Strategy Using FPGA

Network part is responsible for data transmission path setup which is referring to communication between nodes to the end node which is done via hardware wireless transceiver module (Xbee OEM RF Module). Here the OS will play the role in order to establish the flooding protocol used in the network. There are two data processing mechanisms in network part which are transmitting data mechanism and receiving data mechanism.

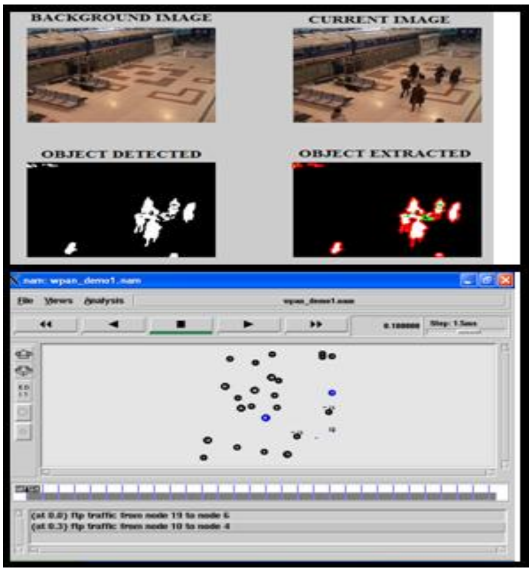

Fig 2.Image compression and AODV transmission

Transmitting data start with collecting data from application part and send the data to the wireless transceiver. Once a packet of data reaches at the Network part, it will be processed by appending the data packet with network protocol data unit (network PDU). Receiving data mechanism is started when the transceiver of a node receives the data.

The data it will be sent to MCU through USART. The MAC destination address of the packet will be examined in order to verify whether the address is the same as the address of the node. If the MAC destination address differs, then the packet will be dropped.

However, if it is the same, then the packet will be examined again by duplicate checker mechanism to ensure that the packet never reaches at the node yet. If it does, then the packet will be dropped.

After duplicate checker, the network destination address of the packet will be verified. If it is correct then the packet will be passed to application part. However, if the wrong network destination address is received, then the packet will be rebroadcasted. Fig. 4 shows the flow chart of the receiving data mechanism.

Table I. Application Layer Control Messages

Message	Structure			
Image packet	0xAAAA	Packet ID (2-bytes)	Image data (N-bytes)	CRC-8 (1-byte)
Camera setup	0xAA00	Camera parameters (4-bytes)		
Image Query	0xAA01			
Image Size	0xAA02	Image size (2-bytes)		
ACK	0xAA03	Packet ID (2-bytes)		
NACK	0xAA04	Packet ID (2-bytes)		
START-OF-TRANSMISSION	0xAA05	Packet size (1-byte)		
END-OF-TRANSMISSION	0xAA06			

Software was developed to run the background subtraction and object extraction functions on an ATmega328p micro- controller based WSN node. In the active mode, the power consumption of the

ATmega328p node at 16MHz, 3.3V, 25OC is about 11mW, while that of the proposed architecture on XC3s1000 FPGA at 50MHz is 21.96mW (from Table IV). However, the ATmega328p system requires more than 2 seconds to complete the image processing task, while the proposed system completes the same task in only 49.15ms, i.e. more than 40 times faster.

Consequently, the total energy consumption of the ATmega328p node is 22.8mJ which is ∼20 times higher than that of the proposed system. The results on processing time and energy consumption are summarized in Table V. These results show that the proposed WMSN processing system is highly energy efficient and much faster than COTS processor based systems. In addition, the proposed system works effectively in detecting any updating objects in the camera view.

A. Comparing Udp And Aodv

AODV uses multi-hop mechanism but UDP uses hop-by-hop mechanism. As the name states the hop by hop mechanism is slower when compared to multi-hop.This is because instead of requesting only one neighbor at a time,multi-hop method requests surrounding neighbors out of which node gives back RREP is connected for transmission. As stated earlier error detection is difficult in UDP when compared to AODV.More over traffic factors here are not reliable to be used at real time as in AODV.Keeps track of next node whereas in UDP it is not possible because of hop by hop mechanism. Also the security and segment number realization is difficult here.

UDP transmission is used only in few areas of WSN .In contrast; most of the WSN application tends to use AODV for the performance. The transmitted image is Black and White image since there are only two values for transmission. Thus in order to transmit easier and reducing packet size we go for converting color image to black and white. Background subtracted image will have the same size in pixels but reduced in pixel depth. Hence we go for object extraction where object is separated through DWT thus size is reduced which intern reduces packet size.

Reducing packet size makes transmission to speed up more over energy is efficiently used while doing so.

B.Throughput Analysis

Using PicoScope, we measured the total power consumed by the FPGA board over a period of time, as shown in Fig. 5. When idle, the standby power consumed by the entire FPGA board is ∼54mW. The total power consumption rises to ∼82mW during transmission of an image frame. The difference of ∼28 mW is the power required for transmission of the image frame. Measurements have also shown that only 10mW of power is consumed for object extraction and DWT processing (@50MHz) for a background image of 640x480 pixels. Clearly the power consumption for image processing (∼10mW) is much less than the power consumption for data communication (∼28mW).

Nonetheless, the proposed object extraction scheme has significantly reduced the energy required for image transmission. Experiments have confirmed that the total power used to process an image and to transmit an updated (i.e. extracted) object of size 160x100 is ∼20 times less than the power required to only transmit the orig- inal image of size 640x480. More importantly, the proposed application layer protocol has contributed significantly to the reduction of the energy cost of image communication. This is achieved due to the combination of queue control strategy, which reduces the packet error rates, and the strategy to allow only one node to transmit at a time, thereby reducing the possibility of collision and congestion.

The transmitted image is Black and White image since there are only two amplitudes possible for transmission.Thus in order to transmit easier and reducing packet size we go for converting colour image to black and white in case of sample UDP transmission.

Only background subtracted image will have the same size in pixels but reduced in pixel depth.Hence we go for object extreaction where object is separated through DWT thus size is reduced which inturn reduces packet size.Reducing packet size makes transmission to speed up more over energy is efficiently used while doing so.

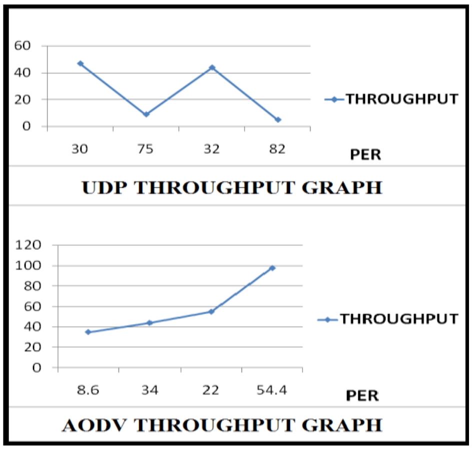

Fig 4.UDP Image Transmission Throughput And AODV Image Transmission Throughput Graphical Comparison.

V. Conclusion

The object extraction architecture coupled with the DWT processor helps significantly reduce the energy cost of image transmission. The application layer protocol proposed in this paper incorporates an effective queue control strategy to reduce packet error rate. In addition, the protocol employs a strategy to allow only one node to transmit at a time, thereby reducing collision and congestion, and consequently the number of retransmissions. The practical results presented in the paper clearly demonstrate the effectiveness of the proposed techniques, namely significant reduction in energy cost of image communication. In contrast with the predictions made in available literature, the proposed strategies make image communication over wireless sensor networks feasible.

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