P2P Link Buffering Control with Fault-recovery on Digital Yarn

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Abstract

A wearable computing has been proposed as an alternative of the best mobile computing interfaces and devices. A digital garment acts as a key element of wearable computing. We will apply digital yarn link as material of data communications on purpose to take advantage of a digital garment. This paper proposes the link buffering architecture and the transmission processes for peer-to-peer (P2P) communications using a digital yarn. Then it proposes the link buffering control and data frame transmission methods for efficient link buffering as well as frame buffering process for fault-recovery.

Keywords: *Link layer, P2P communication, buffering, data framing, and digital yarn*

1. Introduction

With an advent of the ubiquitous computing technology in recent years, computing appliances become gradually closer to human, and the time of using information devices has been increased. As for ubiquitous computing, a wearable computing has been proposed as an alternative of the best computing interfaces and devices [1-3].

Digital garment is considered as the principal component of wearable computing. We will apply digital yarn as material of data communications on purpose to take advantage of a digital garment [4]. This micro-thin digital yarn can be applied on a regular garment knitting process as a super-lightweight weaving textile unlike the existing communication lines. The digital fiber has already been developed but is still incomplete to be used as a communication standard configuration and transport platforms [4-5].

To improve the performance and feasibility of wearable computing, the P2P communication system is required for the distributed computing. We first present the P2P communication logic, and then describe the techniques of communication performance and safety enhancements.

The P2P system can be typically regarded as a special case of distributed systems. Therefore, it realizes the high availability of the system through information distributed processing, or it can improve the system reliability through redundant computing procedures. This paper proposes the multiple links to improve the performance and safety of peer-to-peer (P2P) communications using a digital yarn [4-5].

This paper proposes a communication buffering interface and specification for peer-to-peer (P2P) using a digital yarn [4-5].

A *buffer* is a temporary storage area for data while the data is being transferred. It overcomes the gap of transfer speed between sender (or Input port) and receiver (or Output port). A buffer can be often used for supporting a recovery of loss data frames. There have the problems that if the buffer size were too large, it makes the efficient use of memory resources worse and otherwise, if it has the smaller buffer capacity, it makes the available channel bandwidth inefficient due to a waste of the network failure of digital yarn. Therefore, it is necessary to set up the optimal size of the buffer capacity [6-8].

Typically, a buffer consists of FIFO (First In First Out) structure. The buffer model presented in this paper is the send-receive buffer of Ethernet, which is widely used in LAN (2^{nd} Data Link Layer in OSI specification) communication systems. We will try to transmit the signal data on P2P connection (1:1 relationship) on LAN.

This paper consists of overview and related works of wearable P2P buffer communication system in Section 2. Section 3 describes the wearable P2P link buffering processes. Section 4 presents the experimental environments and analyzes the system performance. Finally, Section 5 concludes this paper.

2. Wearable P2P Buffer Communication System

Wearable P2P communication system supports the exchange of infrastructure of information to build the wearable embedded computing services for the user. In order to build these systems, two or more information sharing nodes (MSS) have been configured and the wired and wireless communication channels should be organized for the information exchange. More particularly, this study focuses on the wear-embedded wired communication system based on digital yarn.

The wearable P2P communication is a transferring process sending the information initiated by the sender-peer to the receiver-peer. The P2P transmission system considers the link propagation delay and multiplexing method as a factor that influences on the transmission performance and the channel efficiency.

Conventional P2P communication systems mainly provide the external P2P transmission among peer to peer users [9-12]. But we want to propose the internal P2P transmission system that provides the data transmission between one peer node and another peer node embedded on a digital garment.

Figure 1 shows the P2P computing system based on P2P communication channels. Any one of the peer terminals becomes an initiator, and the other peer terminal turns to be a correspondent.

The P2P link communication has the LAN compatible architecture and uses CSMA/CD access protocol as access control method. If the P2P communication data are failed on the link layer, it can be retried until it is successful or it reaches the limited retry count.

The wearable P2P link can support bidirectional communication between front-peer and rear-peer embedded on a garment. To improve the communication performance, we consider propagation delay of the P2P link. We also will consider the frame fault-ratio of the P2P links to improve the communication safety.

Major time delay element of wearable communication is the transmission buffer memory than the physical transmission link. The performance of frame buffering is affected by buffer count and frame size. The buffers are classified as sender buffer and receiver buffer. Data received from the upper layer are transferred to the frame buffer in the link layer, and then they are relayed to the digital yarn link on the physical layer. Data arrived to the receiver are relayed to the frame buffer on the link layer. Finally, they are transferred to receiver on the upper layer.

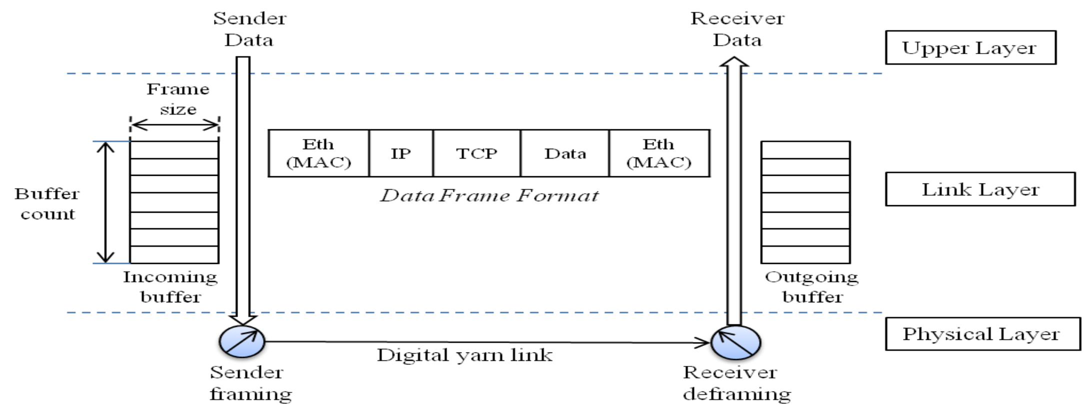

Figure 1. P2P Link Buffering and Access Control on Digital Yarn

3. Wearable P2P Link Buffering Process

The wearable P2P communication process supports the data transfer between two terminals that are built-in digital garment. Wearable P2P communication buffering process assumes that it multicasts all information occurring between terminals. This process is done by separating the normal buffering process mode and faulty buffering process mode. The normal buffering process is a buffered data transfer mode that routinely occurs when acquiring the sensing data and the sensing module control. Under the assumption with link defects, faulty process is the buffered transmission mode that collects the sensing data or transmits the control message to control the sensing module. These two modes should maintain the buffers for the purpose of multicasting the same data. The buffers are a set of current transmission data as resource information for process recovery or synchronization.

The communication process events are classified into real-time and non-real-time data. First, the real-time data means the continuous information as streaming the sensing signals. It can be received from the correspondent and saved to storage devices instantly for accurate data management. Second, the non-real-time data means the discrete information as general intermediate messages. It can be received from the correspondent and saved to storage devices occasionally for emergency data management.

Normal buffering process

Sender buffering process as an initiator peer()

Start and initiate the frame buffering within the data link between the starter's ID and the correspondent's ID;
Check a new input frame event in a sending buffer;
Send the data frame in the sending buffer through data link;
Receive the confirm message from Receiver;
If (the confirm message = *NAK*) then resend;
Otherwise wait for next frame event;

Receiver buffering process as a correspondent peer()

Start and Initialize its receiving buffer for the data link between its ID and the correspondent's ID;
Receive data frame from the data link;
Check a new frame event;
Reply the confirm message with Sync information including frame sequence to Sender;

Figure 2. Link Buffering in Normal Process

As shown in the Figure 2, the normal transfer process, the sender and receiver generate memory buffer and store data frames and then should pass the confirmation message including sync information to other peers to support the data frame sequencing and fault-recovery on each sending event and receiving event, respectively.

The sender transmits data frames on the data link from its buffer. The receiver accepts the data frames from the transfer link and then save them to its buffer.

Fault-recovery buffering process
P2P link sequencing()
Sender and receiver synchronize the process sequences respectively; Remove the messages of mismatched sequences; Remove the orphan data frames; *Fault detection and classification();*
Fault detection and classification()
Buffer overflow is detected by the threshold value of memory size; Loss or orphan of data frame is detected by the value of frame sequence; Data frame error is detected by CRC-check; Receiver sends a sync or fault message to correspondent sender; *Stand by state();*
Stand by state()
Wait for the recovery message from faulty sender peer or from receiver with the overflowed buffer; Skip or block the P2P messages as a *NAK* message;
Recovery state()
Receive the recovery message with recovering frames; *P2P link sequencing();* Send a continuous frame message to the correspondents;

Figure 3. Link Buffering in Fault-Recovery Process

As shown in the Figure 3, fault-recovery based link buffering process performs the transfer frame recovery and frame synchronization procedures as following when the P2P transmission faults are occurred (*P2P link sequencing()*). First, it detects and classifies the frame defects (*Fault detection and classification()*). Second, it should wait until the faulty peer terminal is repaired (*Stand by state()*).Third, the failure terminal backwards to the last location of fault-free frame sequence, and then propagates the synchronization information to the correspondent terminals (*Recovery state()*). Finally, if the sequencing and recovery is complete, the normal transfer buffering process can be retried.

4. Performance Evaluation

4.1. Experimental Environments

The conductive yarn developed by KITECH (Korea Institute of Industrial Technology) is referred to as digital yarn [4]. The digital yarn can transmit the electrical signals having a constant delay on the time between input signal and output signal. The propagation delay of digital yarn depends on the length of digital yarn. The transmission delay time per the unit length of digital yarn can be represented by the following formula.

$$y = 3.05 \times x - 0.04 \qquad (1)$$

Where, x=the length of digital yarn in[m] and y=input-output delay in [ns].

A P2P link communication test of Figure 4 was conducted to check whether communication is enabled through the embedded digital yarn using the same video data. The results showed the good transmission performance with 70Mbps more.

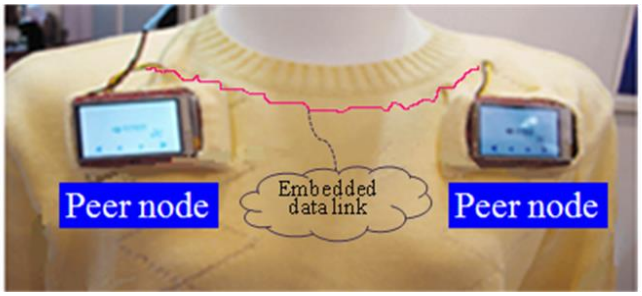

Figure 4. P2P Link Communication System Configuration on Digital Yarn

The P2P transmission test was conducted to analyze the digital yarn' communication performance using digital yarn in a length of between 1m and 5m. The following systems were utilized to calculate the amount of transmission data. The two peers have the same experimental specifications such as Intel Dual Core 2.0GHz, 1GB RAM, 80GB HDD, Ethernet compatible Network Interface, and Intel(R) PRO/1000 MT Mobile Connection (10Mbps).

The wearable P2P system can be divided into static and dynamic configuration depending on the presence or absence of the position changes of the wearable user mobility. The static configuration is a system model to evaluate durability and transmission performance of digital yarn by modeling the user without any movement indoor. The dynamic configuration is a system model to evaluate digital yarn's durability and transmission performance by modeling the users who frequently move in the outdoor environment. These configuration changes have any effect on the performance of the frame data transfer? For example, does a user's movement bring to increase or to decrease the capacity of sensing data? Or, does it affect on frame transmission error? In this paper, we will not describe about the experiments of the wearable P2P configuration changes.

4.2. System Analysis and Evaluations

This section shall perform the analysis and evaluation of a communication system that is based on a P2P link. The performance of P2P communication system depends on the latency of link queue. The transmission performance can be improved depending on the latency of transmission links and the access time of buffering. That is to improve the transmission performance by applying buffering as a way to overcome the problem of transfer performance degradation if the transmission link causes fault.

Digital yarn has resistance because it is a kind of wire. This resistance element is the main cause to attenuate the signal from the transmitter. When apparel production is executed for a man of 180cm height, the required digital yarn with up to the length of 5m and the impendence of 6.6ohm per 1m was applied to digital clothing.

Actually, a digital yarn can transfer digital electrical signals and has a constant delay time between input and output port. A buffer can be organized of sending and receiving buffers for digital yarn link communication. The access time of each memory buffer (D_b) is about 10ns. The buffered transmission delay per the unit length of a digital yarn can be represented by the following Figure 5 and formula.

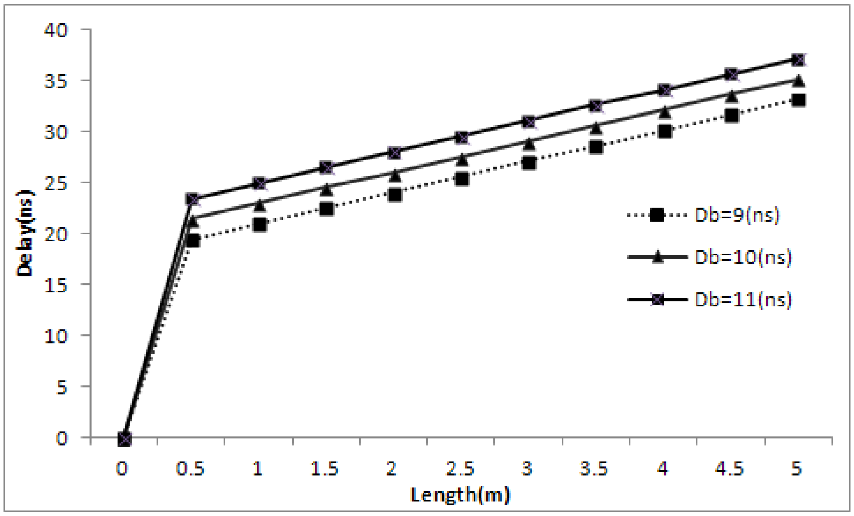

Figure 5. Buffer-based Propagation Delay of Digital Yarn

$y_b=(2\times D_b) + 3.05x-0.04$ (where, D_b is buffering delay; x=Length in[m]; y_b=Buffered input-output delay in[ns]).

When the access time of buffer memory is 9ns, 10ns, and 11ns, Figure 5 shows the data propagation delay in each case according to the length of digital yarn. The access time of buffer memory typically appears at the random time about near to 10ns.

Due to the transmission errors of digital yarn in a physical layer, the minimum buffer space is needed for both overcoming the loss of a transmission frame and maximizing data transfer efficiency. The buffer size of digital yarn (*Buff_size*) depends on the propagation delay (D_p) and signal bit rate (*Bit_rate*) as the following formula.

$$Buff\_size = D_p * 2 * Bit\_rate.$$

The following examples are transfer experiments based on a digital yarn of 3m and 5m for computing the size of the buffer requirement.

First example is a case of the length 3m and a bit rate of 10Mbps. Buffer size = 9.11ns*2*10Mbps=9.11*0.000000001*2*10000000= 0.1822 bit.

Second example is a case of the length 5m and a bit rate of 100Mbps. Buffer size = 15.21ns*2*100Mbps=15.21*0.000000001*2*100000000 = 3.042 bit.

In the example above, because signal losses occur in units of the transmission frame, a buffer with the minimum frame size consisting of bit streams is needed. The minimum Ethernet frame size used in the experiment is 64 bytes and the maximum Ethernet frame size is 1522 bytes.

First, as shown in Figure 6, this experiment evaluated the buffer-based transmission time delay of each length unit of digital yarn according to the amount of transferring data. It is assumed that the normal process with synchronization is performed in P2P data communication when it is fault-free on unidirectional link. The buffer-based transmission time delay of 1m digital yarn is taken less than that of 3m and 5m. In addition, if the transmission data size becomes larger, the performance gap significantly emerges. Therefore, we can find the fact that the standard specification of digital yarn is important, but the adaptive link set-up and operational techniques are selectively required according to the different physical length of the digital yarn.

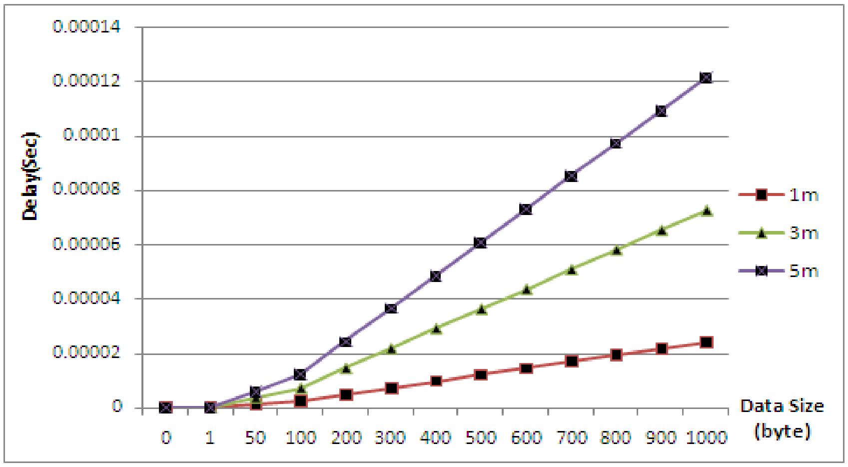

Figure 6. The Buffer-based Propagation Delay Depending on the Length Unit of Digital Yarn

Next, it is assumed that the buffer-based failure-recovery process is performed in P2P data communication when the transmission fault occurs on unidirectional links. Figure 7 shows the results of transmission time delay when the transfer failure-recovery buffering technique is applied according to the channel status of each link with 10^{-1} failure rate. Single station data communication case is a general previous system model in a wearable computing. The analysis result shows that the low fault-ratio of links take smaller transmission time delay for the same transmission data size because the lower the fault-ratio becomes, the better recovery performance is. Here it is assumed that the size of one data frame is 1024 byte and the re-access ratio of memory buffer is 0.1 due to link errors. And, the applied length of the digital yarn link is 3m and 5m.

As a result, we show that the recovery link communication techniques and frame fault recovery methods are required in order to build a high-performance and high safety P2P communication system.

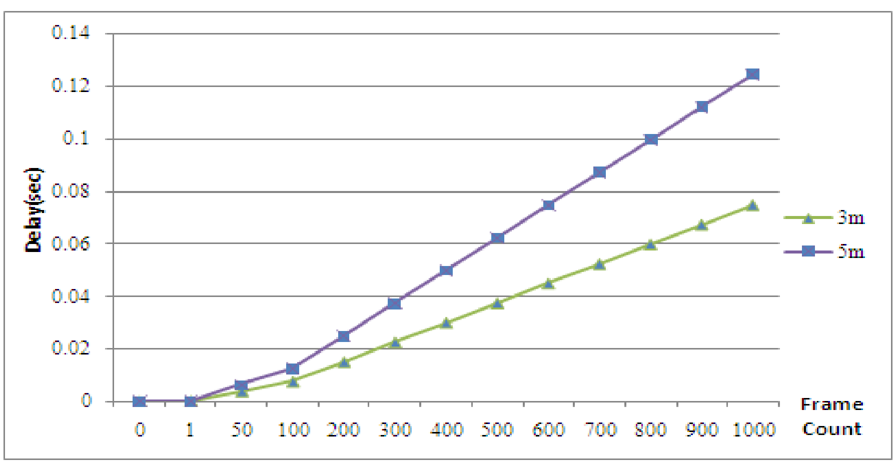

Figure 7. The buffer-based Propagation Delay According to Fault Ratio

5. Conclusions

This work has presented the need of buffering enhancement for the effective transfer in digital yarn. Then the buffering process has required the minimum buffer space of a transmission frame size to overcome the physical environment errors as shown in the experimental analysis results of Chapter 4. Therefore, we conclude that the minimum buffer size is 64 bytes and the maximum buffer size to 1522 bytes. Updated buffering method to overcome the gap of transfer speed between sender (or input port) and receiver (or output port) on wearable P2P link communication.

Also, this work has presented the P2P communication buffering logic in the wearable computing fields using digital yarn. And it has proposed the fault-recovery buffering process as a method to improve the performance and feasibility of the P2P communication system. The experimental results have shown the needs of advanced buffering process and the effectiveness of failure-recovery process simultaneously.

Finally, our future research will be applied to the specific application areas by extending the results of this study, and will build a wearable P2P computing platform.

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