IQRA NATIONAL UNIVERSITY, PESHAWAR, PAKISTAN

NETWORKS MANAGEMENT

Program: MSCS/PhDCS	**FINAL-TERM EXAM**	**Semester: Spring 2020**
Maximum Marks: 50		**Time Allowed: 6 Hours**

Note : ***Write down the complete statements of Q1 otherwise just answers will lead to zero marks.***

The paper should be submitted in pdf form and plagiarism will be checked; ***2 students with the same plagiarism report and answers will lead to zero marks to both.***

Cc: ***to Vice Chancellor***

Controller of Examination

Head of Department

Q1. Select the correct answer of the given ones. (10)

1) Interactive transmission of data independent of a time sharing system may be best suited to
   (a) simplex lines (b) half-duplex lines (c) full-duplex lines (d) biflex lines
2) The loss in the signal power as of an Electromagnetic signal is called
   (a) attenuation (b) propagation (c) scattering (d) interruption
3) Early detection of packet losses improves _____________ acknowledgment performance.
   (a) odd (b) even (c) positive (d) negative
4) Additional signal introduced in the desired signal in producing hypes is called
   (a) fading (b) noise
   (c) scattering (d) dispersion
5) Token is a _____________________ that rotates around the ring.
6) Ring may have up to _____________ (802.5) or _____________ (IBM) nodes.
7) FDDI can support a maximum of _______________ stations.
8) Error-correcting codes are __________________ enough to handle all errors.
9) ACK is a small ____________________ confirming reception of an earlier frame
10) Electronics are _________________ as compared to optics

Q2: Distinguish between error correction and error detection. Explain any two error detection techniques with mathematical examples other than given in slides, search from internet. (10)

Q3: What is encoding? Write down different types of encoding. Explain characteristics of AM, FM and PM with mathematical equation?

Q4: Compare Ethernet and Token Ring concept of data networking with diagrams. Which one is better in your opinion and why? (10)

Q5. Explain the concept and review of Reliable Transmission with diagram (from a research paper of 2019 or 2020) and its functionality. The name and reference of paper should be given. (10)

Q1. Select the correct answer of the given ones.

1) Interactive transmission of data independent of a time sharing system may be best suited to **half-duplex lines.**
2) The loss in the signal power as of an Electromagnetic signal is called **propagation.**
3) Early detection of packet losses improves **negative** acknowledgment performance.
4) Additional signal introduced in the desired signal in producing hypes is called **noise.**
5) Token is a **frame** that rotates around the ring.
6) Ring may have up to **24bits** (802.5) or ____________ (IBM) nodes.
7) FDDI can support a maximum of **500** stations.
8) Error-correcting codes are **not sufficient** enough to handle all errors.
9) ACK is a small **control frame** confirming reception of an earlier frame.
10) Electronics are ________________ as compared to optics.

Q2: Distinguish between error correction and error detection. Explain any two error detection techniques with mathematical examples other than given in slides, search from internet. (10)

Answer; **Error Correction & Error Detection**

Error correction is to find errors and restore the original data without errors. Error correction is the process of detecting errors in transmitted messages and reconstructing the original data without errors. Error correction ensures that correct and error-free messages are received from the receiver. When data is sent from the sender to the receiver, error correction codes are used to detect and correct errors.

Error Detection; Error detection is the process of detecting errors in the data sent from the transmitter to the receiver in the communication system. In digital communication systems, errors are transferred from one communication system to another along with data. We use some redundant codes to detect these errors and add them to the data when it is transmitted from the source (transmitting side).

Error detection is to find errors caused by noise or other faults in the process from the transmitter to the receiver.

Types of Error detection;

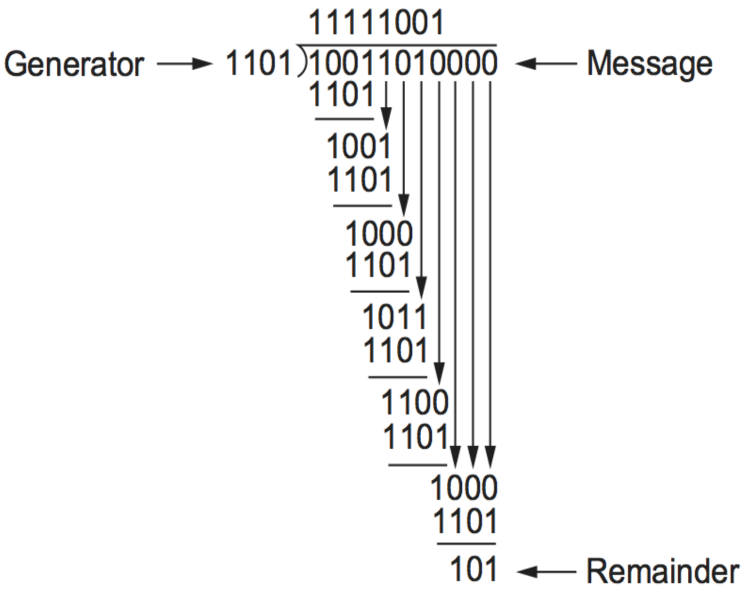
1. Parity Checking

- 1 is added if it has an odd number of 1’s
- 0 is added if it has an even number of 1’s
- The system makes the total number of 1’s even, which is why it is referred to as even parity checking.

Original Data	Even Parity	Odd Parity
0 0 0 0 0 0 0 0	0	1
0 1 0 1 1 0 1 1	1	0
0 1 0 1 0 1 0 1	0	1
1 1 1 1 1 1 1 1	0	1
1 0 0 0 0 0 0 0	1	0
0 1 0 0 1 0 0 1	1	0

2. Cyclic Redundancy Check (CRC)

In CRC, an arrangement of repetitious bits (referred to as cyclic redundancy check bits) are attached to the end of data unit, so that the emerging data unit becomes accurately divisible by another prearranged binary number.



3. Check Sum

In the checksum error detection system, the data is separated into sections for each bit.
On the sender's end, the sections are added using 1's aggregate arithmetic to get the sum. The sum is then aggregated to get the checksum.
The checksum section is sent along with the standard data sections.

Q3: What is encoding? Write down different types of encoding. Explain characteristics of AM, FM and PM with mathematical equation?

Answer; **Encoding** is the process of converting data into the format required to meet a variety of information processing needs, including:

- Data transmission, storage and compression/decompression.

- Handle application data, such as file conversion.

In a computer, encoding is the process of putting a series of characters (letters, numbers, punctuation marks, and certain symbols) into a special format for efficient transmission or storage.

Encoding is the process of converting data or a given sequence of characters, symbols, letters, etc. into a specified format to safely transmit data. Encoding is the process of converting data from one form to another. Although "encoding" can be used as a verb, it is usually used as a noun, referring to a specific type of encoded data.

Types of encoding;

- **NRZ (non-return to zero)**

Use two different voltage levels (positive and negative) as the signal elements of two binary digits. The high voltage level of the NRZ code is 1, and the low voltage level is 0. The main behavior of the NRZ code is to keep the voltage level constant within the bit interval. If the value of the previous bit is the same as the value of the current bit, it will not indicate the end or start of the bit and will maintain the same voltage state.

- **NRZI (NRZ inverted)**

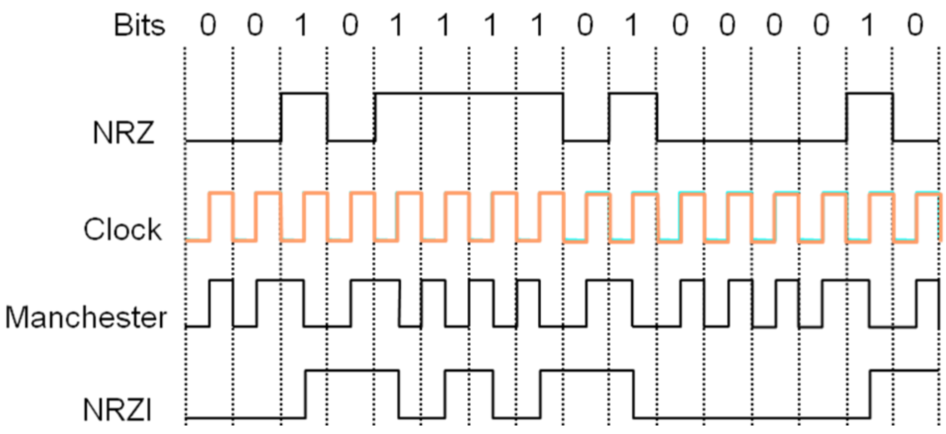
(Non-return to zero inversion) A magnetic recording and data modulation method in which the polarity of a bit is inverted when a bit is encountered. A non-return-to-zero method of transmitting and recording data to keep the sending and receiving clocks synchronized.

- **Manchester**

There will always be an intermediate bit conversion (used as a clock mechanism). The direction of the median conversion represents digital data.

1= low-to-high transition

0= high-to-low transition

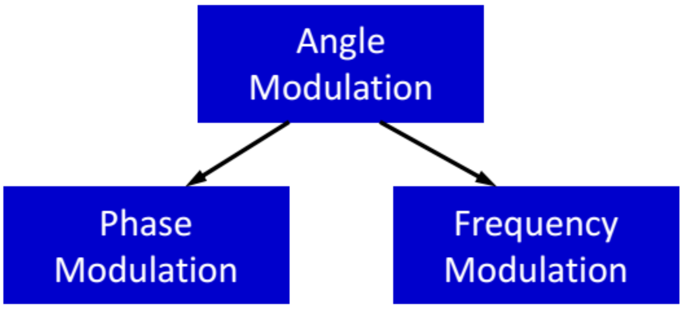


- **4B/5B (8B/10B) in Fast Ethernet**

Every 4 consecutive bits of data are encoded with a 5-bit code (symbol). The selected 5-digit code has no more than one zero at the beginning and no more than two zeros at the end. Therefore, never get more than three consecutive 0s. Use NRZI to transmit the generated 5-digit code.

Explain characteristics of AM, FM and PM

$$\omega_i(t) = \left.\frac{d\theta(t)}{dt}\right|_{t=t_i} \quad \text{and} \quad \theta(t) = \int_{-\infty}^{t} \omega_i(\alpha)\,d\alpha$$



Amplitude modulation (AM); AM is less used in its basic format, but it provides the basis for many other more advanced modulation types, and modulation must operate on it. A form of modulation commonly referred to as amplitude modulation or AM, used for radio transmission in broadcast and two-way radio communication applications. Although it is the first modulation form used, it is still in use today, mainly for long-wave, medium-wave and short-wave broadcasting and some point-to-point aviation communications.

Frequency modulation (FM); FM is used in many applications from broadcasting to communication, and has many advantages over other modes. Although changing the amplitude of the radio signal is the most obvious modulation method, it is by no means the only method. You can also change the frequency of the signal for frequency modulation or FM. Frequency modulation is widely used at frequencies above 30 MHz, and is particularly well known for its use in VHF FM broadcasting.

But in frequency modulation the instantaneous angular frequency ω_i varies linearly with the modulating signal *m*(*t*),

$$\omega_i = \omega_C + k_f m(t)$$

$$\theta(t) = \int_{-\infty}^{t} (\omega_C + k_f m(\alpha))\,d\alpha = \omega_C t + k_f \int_{-\infty}^{t} m(\alpha)\,d\alpha$$

k_f is frequency-deviation (sensitivity) constant. Units: radians/volt-sec.

Then

$$\varphi_{FM}(t) = A\cos\left(\omega_C t + k_f \int_{-\infty}^{t} m(\alpha)\,d\alpha\right)$$

FM and PM are closely connected.
In PM, the angle is proportional to m(t).
In FM, the angle is proportional to the integral of m(t), ie □mt dt()

Phase modulation (PM); Phase modulation PM can be used for analog and digital data, but it is most commonly used for data input and phase shift. As the name implies, phase modulation, PM uses phase changes to transmit modulation. Phase-modulated PM is sometimes used for analog transmission, but it has become the basis of modulation schemes used to transmit data. Through phase shift input, PSK is widely used for data communication. Phase modulation is also the basis of a form of modulation called quadrature amplitude modulation, where the phase and amplitude change to provide other functions.

$$\theta(t) = \omega_C t + \theta_0 + k_p m(t) \qquad \text{Generally we let } \theta_0 = 0.$$

$$Let\ \theta_0 = 0 \qquad \boxed{\varphi_{PM}(t) = A\cos(\omega_C t + k_p m(t))}$$

The instantaneous angular frequency (in radians/second) is

$$\omega_i(t) = \frac{d\theta(t)}{dt} = \omega_C + k_p \frac{m(t)}{dt} = \omega_C + k_p \dot{m}(t)$$

In phase modulation (PM) the instantaneous angular frequency ω_i varies linearly with the derivative of the message signal m(t) (denoted here by ṁ(t)).

k_p is phase-deviation (sensitivity) constant. Units: radians/volt
[Actually in radians/unit of the parameter *m*(*t*).]

Summary

Definition: Instantaneous frequency is $\omega_i(t) = \frac{d\theta(t)}{dt}$

	Phase Modulation	Frequency Modulation
Angle	$\theta(t) = \omega_C t + k_p m(t)$	$\theta(t) = \omega_C t + k_f \int_{-\infty}^{t} m(\alpha)\, d\alpha$
Frequency	$\omega_i = \omega_C + k_p \frac{dm(t)}{dt}$	$\omega_i = \omega_C + k_f m(t)$

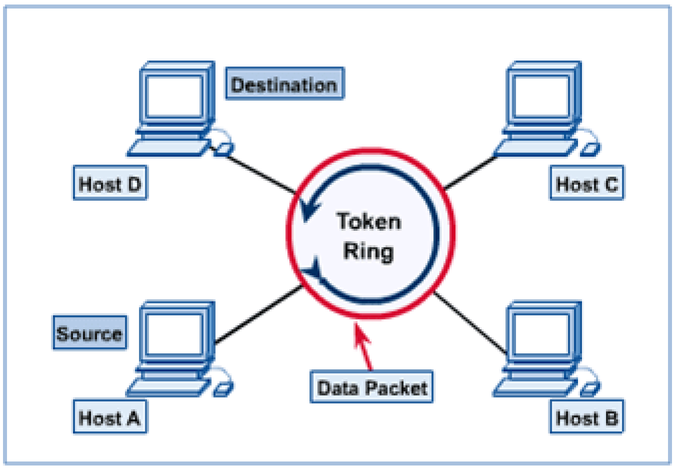
In phase modulation, m(t) causes a phase change θ.

In frequency modulation, m(t) causes a frequency change f.

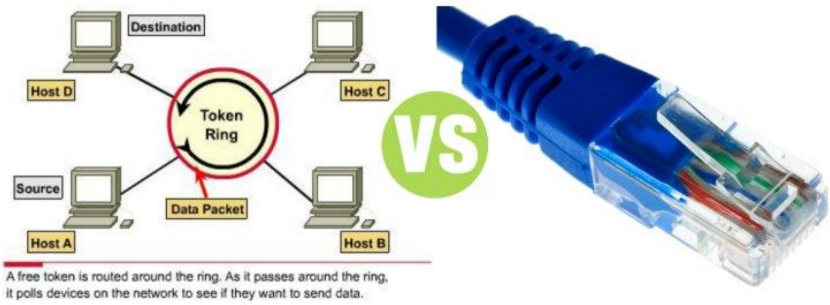
Q4: Compare Ethernet and Token Ring concept of data networking with diagrams. Which one is better in your opinion and why? (10)

Token Ring : In token ring, the token ring passes through the physical ring. The token ring is defined by the IEEE 802.5 standard. In Token Ring there is a workstation and a special framework called token.

A station in token ring can transmit data frame if it contains a token. After the successful transmission of data frame token are pointed(issued). Token ring is a Star shaped topology and handles priority in which some nodes may give priority to the token. The token ring station waits for permission to speak (token), but transmits all the received traffic to the next member of the ring until the token is received. A token ring is defined as a local area network that has the property to send a node only if it has certain coins continuously from other consecutive nodes.



Ethernet : IEEE 802.3 defines the Ethernet. It uses CSMA/CD mechanism. It means that if many stations exist at the same time to talk, all stations will be closed. To resume them, wait for a random time. Unlike token ring it doesn't employ any priorities. And it is less costly than token ring network. Ethernet is defined as a system for connecting various computers to form a local area network, and has different protocols to ensure the smooth transmission of information.



Token Ring	Ethernet
In token ring, a token passing mechanism is used.	Ethernet uses carrier sense multiple access/collision detection (CSMA/CD) mechanism.
The token ring is defined by the IEEE 802.5 standard.	Ethernet is defined by the IEEE 802.3 standard.
Token ring is deterministic.	It is not deterministic.
Token ring is a star topology.	Ethernet is a bus-shaped topology.

The token ring handles priority in which some nodes may give priority to the token.	While Ethernet does not employ priority.
Token ring costs more than Ethernet.	The cost of Ethernet is 70% lower than Token Ring.
The token ring contains routing information.	While Ethernet does not contain routing information.

Q5. Explain the concept and review of Reliable Transmission with diagram (from a research paper of 2019 or 2020) and its functionality. The name and reference of paper should be given.

(10)

Abstract

Standard protocols for reliable data transmission on unreliable channels are based on various ARQ (Automatic Repeat Request) schemes, so that the sending node receives information from the receiver and forwards the lost data. We discussed this issue in the case of unidirectional data transmission on a simple wireless channel with many detection and monitoring application characteristics. Taking a specific project as an example, we show how the constraints of low-cost integrated wireless systems hinder a feasible solution that does not use the popular model of window-based and periodic confirmation.

We have also provided an effective solution to this problem and demonstrated its advantages over traditional protocols.

1. Introduction

Many wireless sensing devices can operate comfortably in one direction, that is, assuming that accidental loss is acceptable, send their samples at certain intervals without the need for feedback from the receiving end. However, in some inspection applications, all samples are considered important. In the systems they involve, the sample represents a specific process to be analyzed at the receptor level, and the accuracy of this analysis is critical. Many areas of medical surveillance, especially those related to the tracking and diagnosis of cardiac activity, fall into this category. Although it can be argued that the occasional gaps in the sampled data can be filled by interpolation or other "riddles", the health professional community does not accept such arguments. In addition to being understandably obsessed with the highest quality data that forms the basis of life diagnosis, medical procedures are often affected by public criticism and litigation (often uninformed). To prevent this, the vocabulary of terms that characterize the accuracy of medical diagnostic procedures must exclude sentences such as "almost all data" and "approximate records".

From an engineering perspective, we hope to produce a practical device at the lowest cost. Here, "utility" refers to a device that can work and meet user expectations. Even if these requirements are very high, very large equipment will inevitably cost more than equipment that meets these requirements with minimal resources (memory, processor power, or RF bandwidth). In particular, the amount of RF bandwidth required by the device affects far more than the monetary cost of the project. The RF spectrum is inevitably polluted everywhere, especially in places such as medical institutions, where a large number of wireless sensors will have to compete for bandwidth to deliver all samples to their collection equipment. Therefore, we cannot simply say that money is not an object of the type of reliability requirements inherent in medical applications, for example, random over-design of bandwidth. Instead, our goal should be to find the correct algorithm and protocol set to achieve the reliability goal with minimum bandwidth. In addition to reducing the total cost of equipment, this method will also translate into an "eco-friendly" design, and, if only for our immediate benefit, it will enable us to deploy more equipment in a given circumference .

The problem solved in this article emerged during the design of a wireless detection device for cardiac monitoring based on cardiography (BCG [1,2]). The main function of the device (later called HDL (for cardiac data recorder)) is to collect data samples from a set of sensors, store them temporarily in local flash memory, and then connect from reliable (almost real-time) to the wireless channel Workstation (we call it PPC). (For collection and processing points.) For cost considerations, plus RF bandwidth limitations and requirements for extended battery life, we base our wireless links on RF devices. Cheap and low power consumption controlled by a microcontroller.

The most difficult element in the design is the protocol for transferring the sampled data to the PPC. Even if the loss is ignored, the amount of bandwidth required to transmit samples in real time is close to the physical capacity of the RF module. The system implementation based on a two-way ARQ scheme with acknowledgement and periodic (sparse) retransmission windows [3] yields the system. Regardless of the selectivity of the confirmation, the fact that the sender must expect and leave room for feedback in the outgoing data stream makes its operation extremely inefficient. As a result, we designed and studied alternatives to these obvious popular models, and proposed solutions that met our goals.

In addition to solving specific problems, our article also proves that the field of small integrated wireless systems also involves a unique set of constraints, which often force us to seek solutions outside the box. Unfortunately, advanced methods of transport and application layer protocols have penetrated into most academic research.

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2. The System

2.1. General Outline

Cardiac shock wave tracing [1, 2] is a method of collecting and interpreting data about the action of the heart by measuring the acceleration of the body around the heart area. The acceleration is detected and measured by sensors connected to the human body and converted into digital data samples, which are then analyzed and visualized by DSP software. In our design, the accelerometer (via wire) is connected to the HDL device, which is responsible for analog-to-digital conversion, intermediate storage of data, and transmission to CPP for analysis and visualization.

The device is equipped with a small amount of flash memory, which can play a dual role. From the perspective of sample transmission from BCG to CPP, it acts as a buffer, compensates for the jitter of the transmitter and allows the node to retransmit the lost samples. It can also be used as a simple database to store the latest sample stream collected by the subject, which can be retrospectively transmitted according to CPP requirements.

2.2. Hardware and Software

The basic hardware components of HDL are MSP430F1611 microcontroller [10] and CC1100 RF module [11] (both from Texas Instruments). Radio frequency band limitations prevent us from using Bluetooth for radio links (in fact the 916 MHz band is the only option), although HDL variants using Bluetooth modules have been built and tested. Another reason for rejecting Bluetooth is that the cost of hardware is greatly increased, and the energy demand is also greatly increased. In addition, it turns out that the mysterious rules of device pairing and the ensuing and uncertain delays caused by the connection of HDL to its PPC (especially with other Bluetooth devices present in the area) proved to be very troublesome .

The microcontroller is programmed according to PicOS [8, 12-14], it is a practical and very efficient operating system, suitable for devices with a small footprint, and can be limited by the small RAM available for low microcontrollers Within the structured multi-threaded processing. range. In fact, the MSP430F1611 is the largest representative of the MSP430 series, with 10 KB of RAM, which proved to be more than necessary. Our main concern is to provide a RAM buffer to accommodate the sample before storing it in flash memory to account for occasional icing due to various special conditions, for example, the need to erase before writing the limit value. A non-empty block. In order to maximize the life of the flash memory, we avoided unnecessary erase operations and balanced the use of all its segments. Therefore, the process of writing data to the flash memory (system call) may hang while waiting for the segment to be written to enter an appropriate state. Enter the number of bits of data per second. This rate is the standard required for the digital representation of the diagnostic quality of the BCG signal. To avoid confusion, from now on, each sample means that a set of 8 values is collected every 1/500 second, and the complete set of samples sent on PPC for processing is called ``collection''. In other words, the shooting represents the complete measurement result, which is processed and displayed on the CPP for evaluation or diagnosis. According to the requirements of the PPC, the ADC converter and sample collection process will be activated. Such a request specifies the duration of the capture in seconds, and HDL converts it to a corresponding number of samples. These samples are then collected and stored in flash memory. They can be transmitted in parallel with their collection, or they can simply be collected and stored locally for later transmission. The device uses a simple differential compression scheme at the stage of repackaging

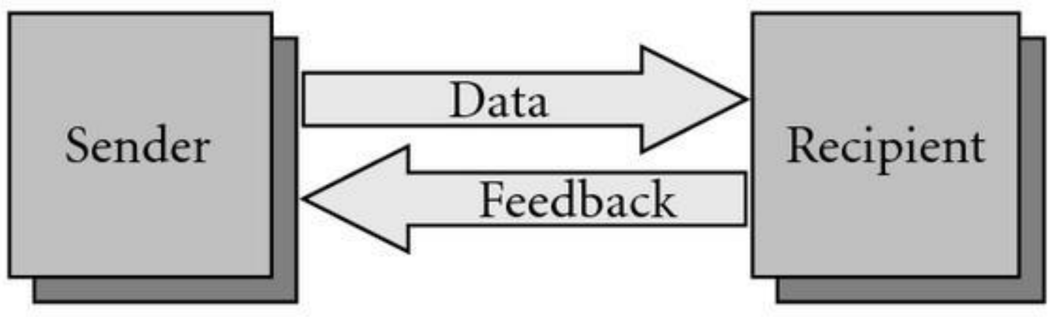
12-bit ADC samples into 48-byte blocks (that is, storage/transmission units). Due to the nature of BCG data, compression schemes can provide very consistent average savings of 45%, almost never falling below 42%. This means that a typical 48-byte block can contain more than 7 samples. As with all lossless compression techniques, in theory, this model can spontaneously increase the data size to 29% (although it is unthinkable in practice).

The available data transmission rate range of CC1100 can be adjusted within a certain interval, the original limit is about 200 kbps, which should consider coding (Manchester), the interval between framing and data packets is reduced to about 50 kbps of the effective bit rate (assuming back-to-back).

3. Data Communication

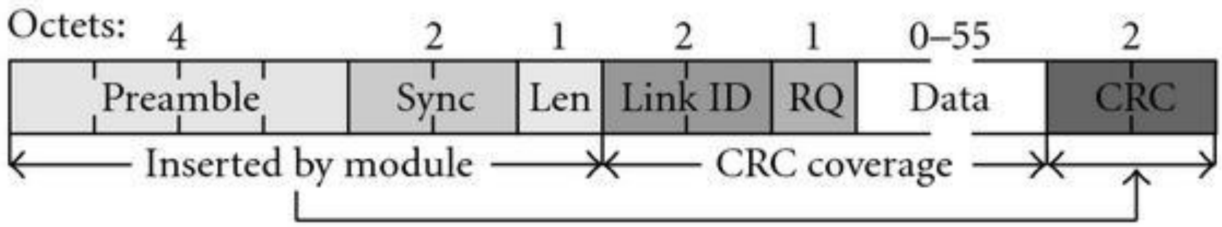
3.1. The Problem and Its Classical Solutions

In addition to transferring sockets from HDL to CPP, the amount of bandwidth required to maintain the connection between HDL and its CPP is negligible. Therefore, we will focus on this very asymmetric communication situation, in which a large amount of data is basically transmitted in one direction. The classic problem of reliable data transmission on an unreliable link is composed of two parties, one of which is the sender (S) and the other is the receiver (R), as shown in Figure 1. This configuration assumes two separate entities (possibly logical channels). Through the reverse channel, the receiver can send a return to the sender, for example, to request retransmission of a lost (corrupted) data packet.

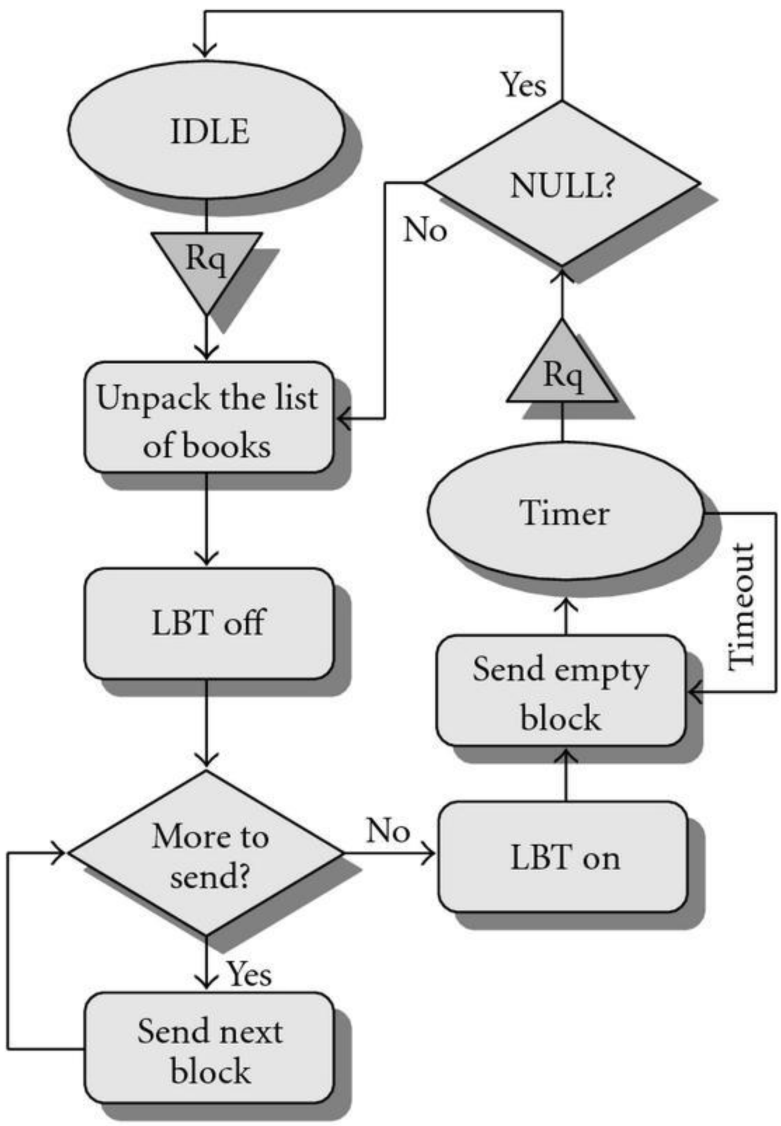


Data Formats

The data exchanged between HDL and its CPP consists of framed data packets, as shown in Figure 2. This configuration, including the maximum length of the payload (data), has been enhanced by the physical characteristics of CC1100. Although in theory, using some tricks, it is possible to have a payload of any length, but in view of the reliability of the reception, the maximum 55 bytes of the data part is already too large a packet. (The CC1100 uses a 64-byte internal FIFO to store output/input frames. When the total length of the data packet exceeds the FIFO size, the data packet must be sent and received in batches, which is not very practical.)



The Workable Scheme



The end of the CPP protocol is shown below.

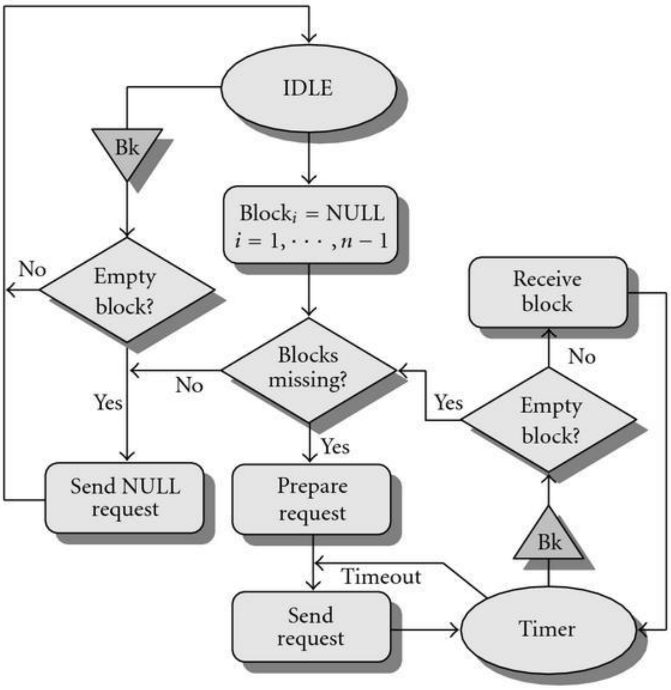
(1) Initialize by marking all the blocks to be received as absent. Then continue to 2.

(2) Find the blocks that are still missing. If not, send a NULL request and enter IDLE state. Otherwise, prepare an application package that covers as many missing blocks as possible, and then go to step 3.

(3) Continue to send request packets at reasonable intervals until a data block packet arrives from HDL. Then proceed to 4.

(4) Continue to receive and store blocks until you see the window packet (an empty block). Then continue to 2.

Figure 6 shows the above flowchart. The triangle Bk represents the packet packet received from the other party. For instant transmission requests during sampling, the first request sent by CPP will ask HDL to start the sampling process and implicitly trigger the first "total" window consisting of all blocks that are helpful for capture.



Conclusions

We have proposed and analyzed a simple protocol for reliably transferring file-like data blocks between low-cost wireless devices. Based on the limitations of applications specifically designed for the protocol, our goal is to maximize the bandwidth available for this type of transmission. The main factor that causes this problem to be different from its conventional formula is the simplicity of the wireless channel, whose original capacity closely matches the transmission bandwidth required by the application. By identifying and understanding the limitations of the platform, we are able to achieve our goals and make full use of its small (though sufficient) resources. Despite being stimulated by very specific applications, the problem seems to be widespread. Our solution can be used to reliably transfer all file type objects.

As a side effect of the presentation, we demonstrated how to use a holistic approach to solve the problem, so as to find a good solution in the integrated world. Our data transmission scheme is the overall derivation of RF modules, flash memory, limited amount of RAM, and some special attributes required by the application. On the one hand, people may be disappointed by such interference with seemingly unrelated "features" and things that should correctly belong to a given, independent "layer". On the other hand, it is reassuring to see such huge creative potential in other conventional projects. This potential makes the field of embedded systems very attractive.

References

B. M. Baker, "ECG: a predictor of coronary heart disease", "Circulation", Volume 1. No. 37, page 1 January 1-3, 1968.

See: Google Scholar

O. Tel, J. Muchlsteff, R. Pinter et al., "Advances in Medical Technology: Shaping the Future of Medicine", G. Spekowius and T. Wendler, editor flying. . 6. Sections 436–488, Springer, Berlin, Germany, 2006.

See also: publisher's website | Google Scholar

S. Lin, D. J. Costello, Jr. and M. Miller, "Automatic Repeat Request Error Control System", IEEE Communications Magazine, Volume 1. No. 22, page 12, May 17, 1984.

See also: publisher's website | Google Scholar

R. van Renesse, "Covering the overhead of protocol layering," in the minutes of the ACM SIGCOMM conference on applications, technologies, architecture, and computer communication protocols, volume 1. Page 26 August 1996, Palo Alto, California, USA 96-104.

See also: publisher's website | Google Scholar

L. Song and D. Hatzinakos, "Multilayer Architecture of Wireless Sensor Networks for Target Tracking", IEEE/ACM Transactions No. 15, p. 145-158, 2007.

See also: publisher's website | Google Scholar

R. Jurdak, "Wireless Self-Organization and Sensor Networks: A Cross-Layer Design Perspective", Springer, Berlin, Germany, 2007.

M. B. Abbott and L. L. Peterson, "Improving network throughput by integrating protocol layers", IEEE / ACM Transactions on Networking, Volume 1. No. 1, No. 600-610, 1993.

See also: publisher's website | Google Scholar

P. Gburzynski and W. Olesinski, "Practical methods for low-cost ad hoc wireless networks", "Journal of Telecommunications and Information Technology", Volume 1. In 2008, no. 1 page February 29-42, 2008.

See: Google Scholar
Q. Liu, S. Zhou and G. B. Giannakis, "Multilayer Combination of Adaptive Modulation and Coding and Truncated ARQ on Wireless Links", IEEE Transactions in Wireless Communications No. 5, No. 1746-1755, 2004.
See also: publisher's website | Google Scholar
C. Nagy, "Using TI MSP430 Series for Embedded System Design", Elsevier, Amsterdam, Netherlands, 2003.
Texas Instruments, "CC1100 single-chip low-cost, low-power RF transceiver", 2006, http://focus.ti.com/lit/ds/symlink/cc1100.pdf.
See: Google Scholar
E. Akhmetshina, P. Gburzynski and F. Vizeacoumar, "PicOS: a small operating system for very small embedded platforms", in the minutes of the International Embedded Systems and Applications Conference (ESA '03), pp. 116-122, Las Vegas, Nevada, USA, June 2003.
See: Google Scholar
W. Dobosiewicz and P. Gburzynski, "From Simulation to Execution: On a Programming Paradigm of Reaction Systems", in the minutes of the First International Conference on Computer and Information Technology (FIMCSIT' 06), 561- 568, Wisla, Poland, November 2006.
See: Google Scholar
P. Gburzynski, B. Kaminska and W. Olesinski, "Miniature and efficient wireless ad hoc protocol for low-cost sensor networks", Proceedings of the Design, Automation and Test Conference in Europe (DATE '07), No. 1557-1562, Nice, France, April 2007.
See also: publisher's website | Google Scholar
W. Lynch, "Computer Systems: Reliable Full-Duplex File Transfer over Half-Duplex Telephone Lines," ACM Communications, Volume 1. No. 6, No. 407-410, 1968.
See also: publisher's website | Google Scholar
K. A. Bartlett, R.A. Scantlebury and P.T. Wilkinson, "Notes on Reliable Full-Duplex Transmission over Half-Duplex Links," ACM Communications, Volume 1. No. 5, No. 260-261, 1969.
See also: publisher's website | Google Scholar
C. Barakat, E. Altman and W. Dabbous, "About TCP Performance in Heterogeneous Networks: A Survey", IEEE Communications Magazine, Volume 1. No. 38, 1 page 40-46, 2000.
See also: publisher's website | Google Scholar
H. O. Burton and D. D. Sullivan, "Errors and Error Control," IEEE Conference Proceedings, Volume 1. 60, 11 pages 1293–1301, 1972.

See also: publisher's website | Google Scholar

H. Liu, H. Ma, M. El Zarki and S. Gupta, "Network Error Control Schemes: An Overview", Mobile Networks and Applications, Volume 1. 2, no 2, 167–182, 1997.

See also: publisher's website | Google Scholar

D. Chkliaev, J. Hooman and E. de Vink, "Verification and Improvement of the Sliding Window Protocol", in the Proceedings of the 9th International Conference on System Construction and Analysis Tools and Algorithms (TACAS 03), flying. "Lectures on Computer Science" page 2619. 113-127, Springer, Warsaw, Poland, April 2003.

See: Google Scholar

B. P. Crow, I. Widjaja, L. G. Kim and P. T. Sakai, "IEEE 802.11 Wireless Local Area Network", IEEE Communications Magazine, Volume 1. 35, No. 9, 116-126, 1997.

See also: publisher's website | Google Scholar

X. Ling, LX Cai, JW Mark and X. Shen, "Performance Analysis of IEEE 802.11 DCF with Heterogeneous Tra