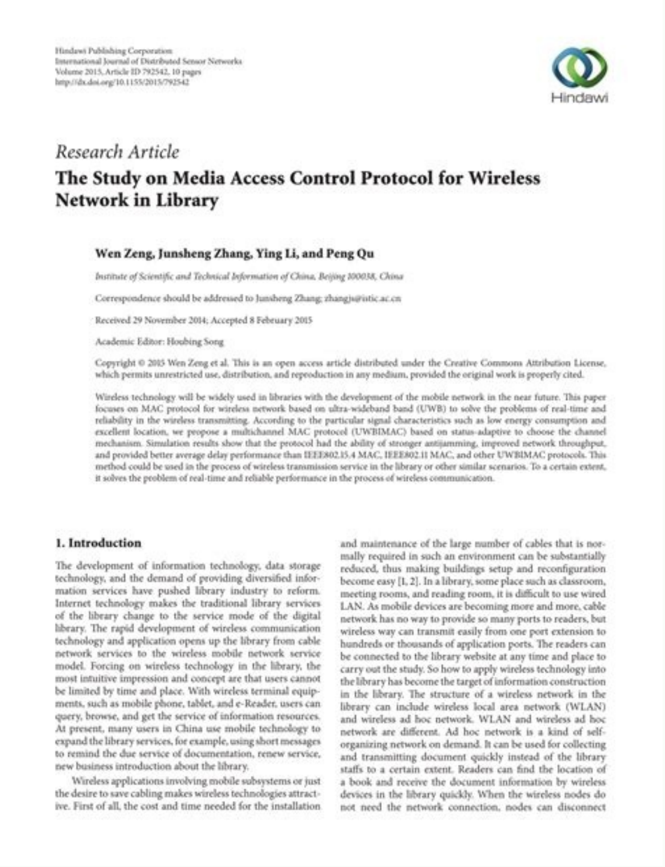
Medium access control protocol pdf



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Research Article

The Study on Media Access Control Protocol for Wireless Network in Library

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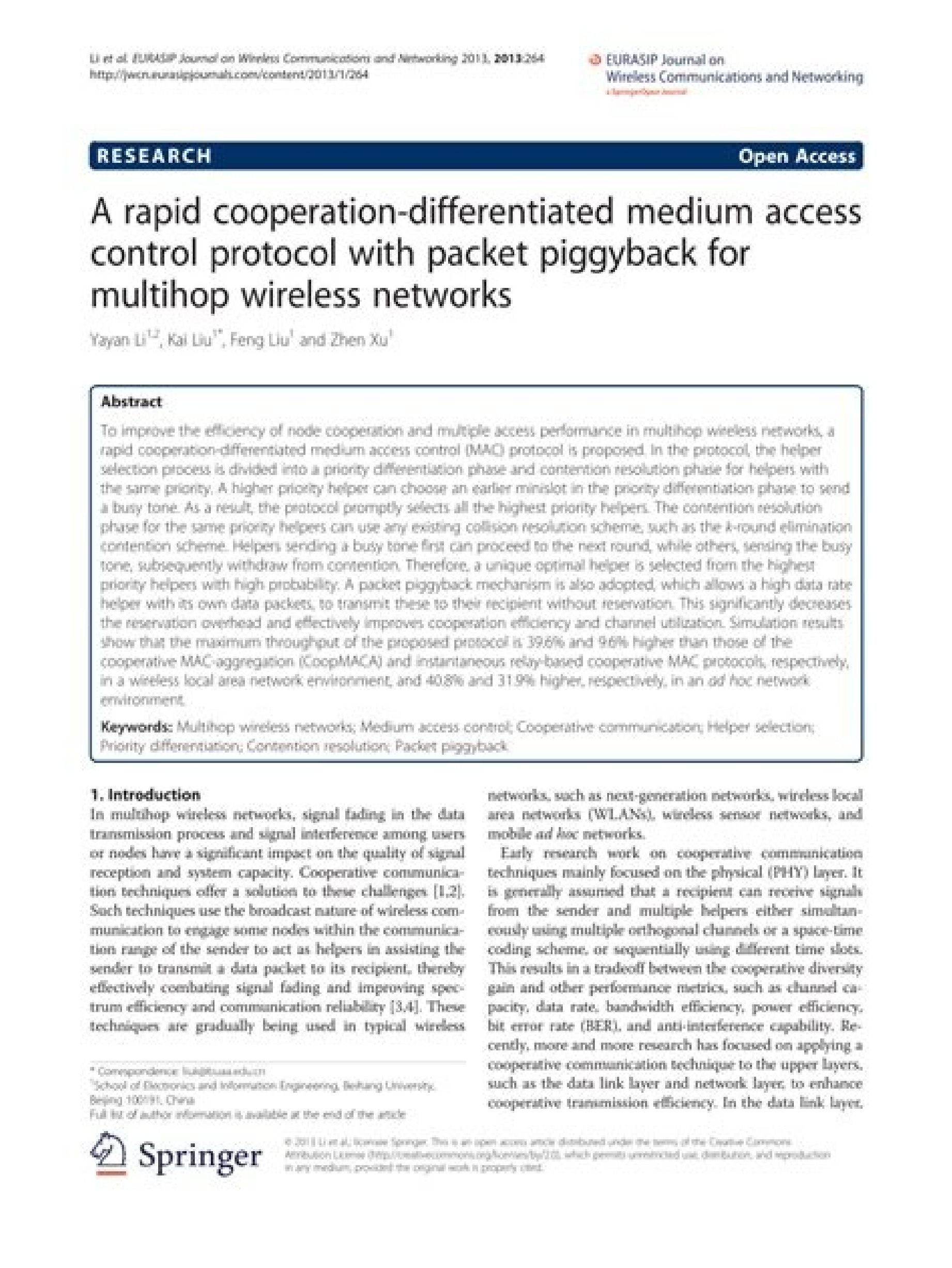
Wireless technology will be widely used in libraries with the development of the mobile network in the near future. This paper focuses on MAC protocol for wireless network based on ultra-wideband band (UWB) to solve the problems of real-time and reliability in the wireless transmitting. According to the particular signal characteristics such as low energy consumption and excellent location, we propose a multichannel MAC protocol (UWBIMAC) based on status-adaptive to choose the channel mechanism. Simulation results show that the protocol had the ability of stronger antijamming, improved network throughput, and provided better average delay performance than IEEE802.15.4 MAC, IEEE802.11 MAC, and other UWBIMAC protocols. This method could be used in the process of wireless transmission service in the library or other similar scenarios. To a certain extent, it solves the problem of real-time and reliable performance in the process of wireless communication.

1. Introduction

The development of information technology, data storage technology, and the demand of providing diversified information services have pushed library industry to reform. Internet technology makes the traditional library services of the library change to the service mode of the digital library. The rapid development of wireless communication technology and application opens up the library from cable network services to the wireless mobile network service model. Forcing on wireless technology in the library, the most intuitive impression and concept are that users cannot be limited by time and place. With wireless terminal equipments, such as mobile phone, tablet, and e-Reader, users can query, browse, and get the service of information resources. At present, many users in China use mobile technology to expand the library services, for example, using short messages to remind the due service of documentation, renew service, new business introduction about the library.

Wireless applications involving mobile subsystems or just the desire to save cabling makes wireless technologies attractive. First of all, the cost and time needed for the installation and maintenance of the large number of cables that is normally required in such an environment can be substantially reduced, thus making buildings setup and reconfiguration become easy [1, 2]. In a library, some place such as classroom, meeting rooms, and reading room, it is difficult to use wired LAN. As mobile devices are becoming more and more, cable network has no way to provide so many ports to readers, but wireless way can transmit easily from one port extension to hundreds or thousands of application ports. The readers can be connected to the library website at any time and place to carry out the study. So how to apply wireless technology into the library has become the target of information construction in the library. The structure of a wireless network in the library can include wireless local area network (WLAN) and wireless ad hoc network. WLAN and wireless ad hoc network are different. Ad hoc network is a kind of self-organizing network on demand. It can be used for collecting and transmitting document quickly instead of the library staffs to a certain extent. Readers can find the location of a book and receive the document information by wireless devices in the library quickly. When the wireless nodes do not need the network connection, nodes can disconnect



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A rapid cooperation-differentiated medium access control protocol with packet piggyback for multihop wireless networks

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Abstract

To improve the efficiency of node cooperation and multiple access performance in multihop wireless networks, a rapid cooperation-differentiated medium access control (MAC) protocol is proposed. In the protocol, the helper selection process is divided into a priority differentiation phase and contention resolution phase for helpers with the same priority. A higher priority helper can choose an earlier minislot in the priority differentiation phase to send a busy tone. As a result, the protocol promptly selects all the highest priority helpers. The contention resolution phase for the same priority helpers can use any existing collision resolution scheme, such as the *k*-round elimination contention scheme. Helpers sending a busy tone first can proceed to the next round, while others, sensing the busy tone, subsequently withdraw from contention. Therefore, a unique optimal helper is selected from the highest priority helpers with high probability. A packet piggyback mechanism is also adopted, which allows a high data rate helper with its own data packets, to transmit these to their recipient without reservation. This significantly decreases the reservation overhead and effectively improves cooperation efficiency and channel utilization. Simulation results show that the maximum throughput of the proposed protocol is 39.6% and 9.6% higher than those of the cooperative MAC-aggregation (CoopMACA) and instantaneous relay-based cooperative MAC protocols, respectively, in a wireless local area network environment, and 40.8% and 31.9% higher, respectively, in an *ad hoc* network environment.

Keywords: Multihop wireless networks; Medium access control; Cooperative communication; Helper selection; Priority differentiation; Contention resolution; Packet piggyback

1. Introduction

In multihop wireless networks, signal fading in the data transmission process and signal interference among users or nodes have a significant impact on the quality of signal reception and system capacity. Cooperative communication techniques offer a solution to these challenges [1,2]. Such techniques use the broadcast nature of wireless communication to engage some nodes within the communication range of the sender to act as helpers in assisting the sender to transmit a data packet to its recipient, thereby effectively combating signal fading and improving spectrum efficiency and communication reliability [3,4]. These techniques are gradually being used in typical wireless networks, such as next-generation networks, wireless local area networks (WLANs), wireless sensor networks, and mobile *ad hoc* networks.

Early research work on cooperative communication techniques mainly focused on the physical (PHY) layer. It is generally assumed that a recipient can receive signals from the sender and multiple helpers either simultaneously using multiple orthogonal channels or a space-time coding scheme, or sequentially using different time slots. This results in a tradeoff between the cooperative diversity gain and other performance metrics, such as channel capacity, data rate, bandwidth efficiency, power efficiency, bit error rate (BER), and anti-interference capability. Recently, more and more research has focused on applying a cooperative communication technique to the upper layers, such as the data link layer and network layer, to enhance cooperative transmission efficiency. In the data link layer,

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Reservation Packet Medium Access Control for Wireless Sensor Networks

Hengguang Li and Paul D Mitchell

Abstract **- This paper introduces the Reservation Packet Medium Access Control (RP-MAC) protocol for Wireless Sensor Networks (WSNs). The protocol incorporates a periodic listen/sleep schedule to conserve energy and employs a novel channel reservation mechanism to enhance the rate at which packets can be transferred over multiple hops, thereby improving throughput and reducing end-to-end delay. To evaluate the performance of RP-MAC, it is compared with the established S-MAC protocol through simulation. Results show that RP-MAC can support much higher traffic loads as a direct result of its higher throughput capability along with reduced end-to-end delay for packet transmissions across a multi-hop link. These benefits come at the expense of higher energy consumption, but this is maintained at an acceptable level.**

Index Terms **— Wireless sensor network, medium access control, energy-efficiency, MAC, S-MAC, RP-MAC**

I. Introduction

A Wireless Sensor Network (WSN) consists of a potentially large number of nodes deployed in an ad-hoc fashion, capable of monitoring environmental conditions and reporting them back to a central location. A wide range of applications is foreseen for WSNs, ranging from environmental monitoring and disaster prevention to military and tracking applications [1-2]. In many cases, sensor nodes will be deployed in remote or inaccessible places where they will be required to take periodic measurements or detect and report on events for a long period of time without external intervention and with no access to a fixed power source. To maximise network lifetime, energy-efficient operation is important, with traditional performance measures taking very much a secondary role. It is well understood that communication in a sensor network generally consumes more energy than computation, and so a lot of effort has been devoted to energy-efficient Medium Access Control (MAC) protocol design. MAC protocols determine the means by which nodes access the radio communications medium and transfer information through the network, and have a major impact on overall energy consumption.

It is worth remembering that the capacity of ad hoc networks is severely constrained and they have been shown not to scale well [3]. Developing more energy-efficient protocols at the expense of throughput and delay performance may not be the best approach. Improving the rate at which packets can be transferred through a network will alleviate capacity bottlenecks (such as those where traffic converges around a sink node) and enable the network to support a much higher rate of monitoring and/or event reporting. Associated reductions in end-to-end delay will permit delay sensitive applications to be supported.

This paper proposes the Reservation Packet Medium Access Control (RP-MAC) protocol, which incorporates a traditional listen/sleep schedule to improve energy efficiency. This is combined with a novel reservation mechanism to provide more efficient transfer of data over multiple hops, enabling it to support higher traffic loads and provide lower end-to-end delay compared with existing approaches. In the following section, some recently proposed and pertinent MAC protocols for WSNs are introduced. Then in section III, the RP-MAC protocol is described in detail, including the reservation mechanism. In section IV, the simulation scenario is presented, followed by a comparative performance evaluation of RP-MAC with S-MAC in section V. Finally, the advantages of RP-MAC are summarised in the conclusions in section VI.

II. Related Work

A large number of MAC protocols have been proposed for sensor networks, with energy-efficiency the primary design criterion. Schedule-based Time Division Multiple Access (TDMA) and contention-based schemes are the most common, since they enable operation on a single frequency channel and provide flexible capacity assignment [4-5].

In schedule-based TDMA schemes, individual terminals are assigned particular time slots to transmit and receive data in a contention-free manner. As nodes only need to switch on their transceivers in their scheduled time slots, this can be a very energy-efficient approach, but scheduling is notoriously difficult to achieve in a distributed fashion. One example designed specifically for WSNs is the Traffic Adaptive Multiple Access (TRAMA) protocol [6], in which nodes announce their intended schedules and determine whether they have priority to transmit in each slot. Disadvantages of this approach include significant signaling overheads and complexity in determining transmission priorities. Tight synchronisation is also required.

Contention-based schemes are a natural solution for distributed networks because individual nodes decide how and when to access the radio medium, but they do suffer from a number of energy waste mechanisms. In addition to packet collisions (when more than one packet arrives at a receiver simultaneously), overhearing is a common problem which corresponds to nodes unnecessarily receiving packets destined to other nodes. Idle listening is another issue, which relates to energy consumed through idle sensing of the channel for possible packet reception.

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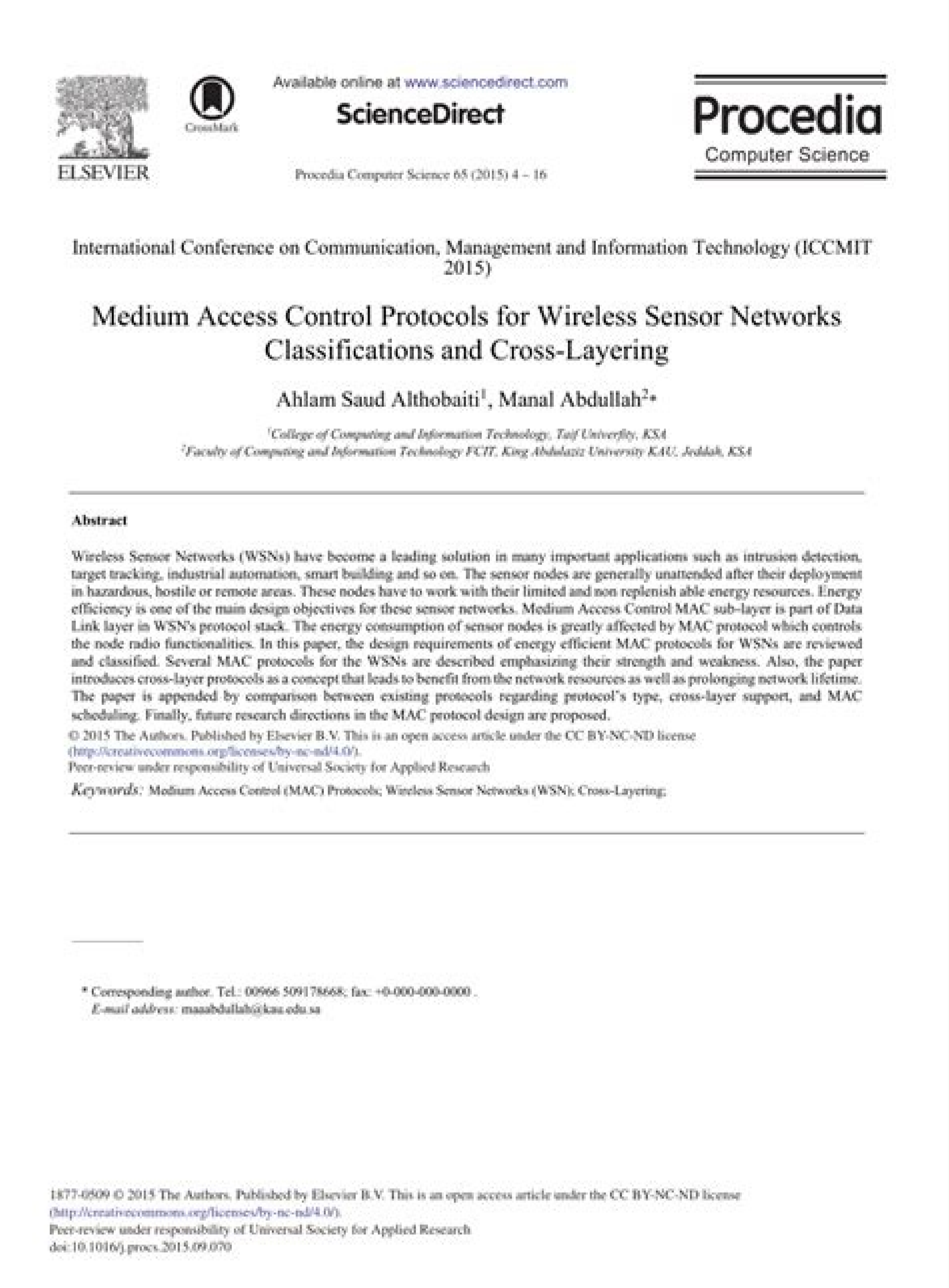

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Medium Access Control Protocols for Wireless Sensor Networks Classifications and Cross-Layering

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Abstract

Wireless Sensor Networks (WSNs) have become a leading solution in many important applications such as intrusion detection, target tracking, industrial automation, smart building and so on. The sensor nodes are generally unattended after their deployment in hazardous, hostile or remote areas. These nodes have to work with their limited and non replenish able energy resources. Energy efficiency is one of the main design objectives for these sensor networks. Medium Access Control MAC sub-layer is part of Data Link layer in WSN's protocol stack. The energy consumption of sensor nodes is greatly affected by MAC protocol which controls the node radio functionalities. In this paper, the design requirements of energy efficient MAC protocols for WSNs are reviewed and classified. Several MAC protocols for the WSNs are described emphasizing their strength and weakness. Also, the paper introduces cross-layer protocols as a concept that leads to benefit from the network resources as well as prolonging network lifetime. The paper is appended by comparison between existing protocols regarding protocol's type, cross-layer support, and MAC scheduling. Finally, future research directions in the MAC protocol design are proposed.

Keywords: Medium Access Control (MAC) Protocols; Wireless Sensor Networks (WSN); Cross-Layering;

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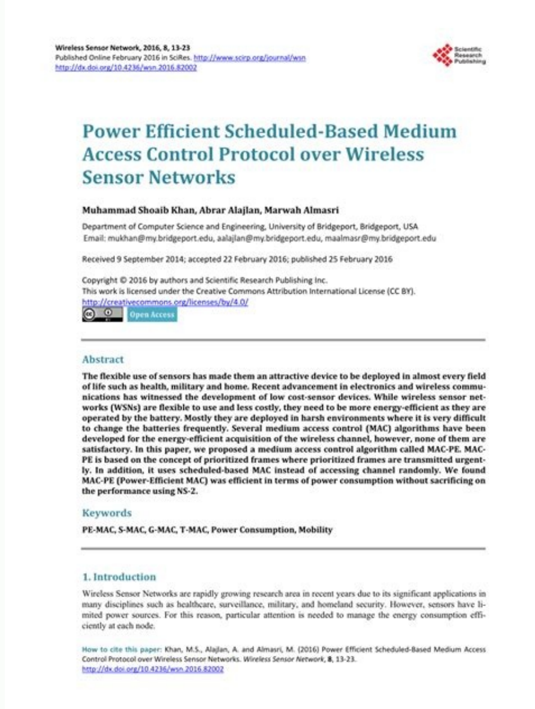

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Power Efficient Scheduled-Based Medium Access Control Protocol over Wireless Sensor Networks

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Abstract

The flexible use of sensors has made them an attractive device to be deployed in almost every field of life such as health, military and home. Recent advancement in electronics and wireless communications has witnessed the development of low cost-sensor devices. While wireless sensor networks (WSNs) are flexible to use and less costly, they need to be more energy-efficient as they are operated by the battery. Mostly they are deployed in harsh environments where it is very difficult to change the batteries frequently. Several medium access control (MAC) algorithms have been developed for the energy-efficient acquisition of the wireless channel, however, none of them are satisfactory. In this paper, we proposed a medium access control algorithm called MAC-PE. MAC-PE is based on the concept of prioritized frames where prioritized frames are transmitted urgently. In addition, it uses scheduled-based MAC instead of accessing channel randomly. We found MAC-PE (Power-Efficient MAC) was efficient in terms of power consumption without sacrificing on the performance using NS-2.

Keywords

PE-MAC, S-MAC, G-MAC, T-MAC, Power Consumption, Mobility

1. Introduction

Wireless Sensor Networks are rapidly growing research area in recent years due to its significant applications in many disciplines such as healthcare, surveillance, military, and homeland security. However, sensors have limited power sources. For this reason, particular attention is needed to manage the energy consumption efficiently at each node.

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Medium access control protocol in mobile computing. Medium access control protocol ppt. Medium access control protocol for broadcast network. Medium access control protocol in iot. Medium access control protocol tutorialspoint. Medium access control protocol in wireless networks. Medium access control protocols for wireless sensor networks. Medium access control protocol javatpoint.

Computer NetworkComputer EngineeringMCA The medium access control (MAC) is a sublayer of the data link layer of the open system interconnections (OSI) reference model for data transmission. It is responsible for flow control and multiplexing for transmission medium. It controls the transmission of data packets via remotely shared channels. It sends data over the network interface card.MAC Layer in the OSI ModelThe Open System Interconnections (OSI) model is a layered networking framework that conceptualizes how communications should be done between heterogeneous systems. The data link layer is the second lowest layer. It is divided into two sublayers −The logical link control (LLC) sublayerThe medium access control (MAC) sublayerThe following diagram depicts the position of the MAC layer −Functions of MAC LayerIt provides an abstraction of the physical layer to the LLC and upper layers of the OSI network.It is responsible for encapsulating frames so that they are suitable for transmission via the physical medium.It resolves the addressing of source station as well as the destination station, or groups of destination stations.It performs multiple access resolutions when more than one data frame is to be transmitted. It determines the channel access methods for transmission.It also performs collision resolution and initiating retransmission in case of collisions.It generates the frame check sequences and thus contributes to protection against transmission errors.MAC AddressesMAC address or media access control address is a unique identifier allotted to a network interface controller (NIC) of a device. It is used as a network address for data transmission within a network segment like Ethernet, Wi-Fi, and Bluetooth.MAC address is assigned to a network adapter at the time of manufacturing. It is hardwired or hard-coded in the network interface card (NIC). A MAC address comprises of six groups of two hexadecimal digits, separated by hyphens, colons, or no separators. An example of a MAC address is 00:0A:89:5B:F0:11. Updated on 30-Jul-2019 22:30:25 Skip to Main Content A media access control is a network data transfer policy that determines how data is transmitted between two computer terminals through a network cable. The media access control policy involves sub-layers of the data link layer 2 in the OSI reference model.The essence of the MAC protocol is to ensure non-collision and eases the transfer of data packets between two computer terminals. A collision takes place when two or more terminals transmit data/information simultaneously. This leads to a breakdown of communication, which can prove costly for organizations that lean heavily on data transmission.This network channel through which data is transmitted between terminal nodes to avoid collision has three various ways of accomplishing this purpose. They include:Carrier sense multiple access with collision avoidance (CSMA/CA)Carrier sense multiple access with collision detection (CSMA/CD)Demand priorityToken passingCarrier sense multiple access with collision avoidance (CSMA/CA) is a media access control policy that regulates how data packets are transmitted between two computer nodes. This method avoids collision by configuring each computer terminal to make a signal before transmission. The signal is carried out by the transmitting computer to avoid a collision.Multiple access implies that many computers are attempting to transmit data. Collision avoidance means that when a computer node transmitting data states its intention, the other waits at a specific length of time before resending the data.CSMA/CA is data traffic regulation is slow and adds cost in having each computer node signal its intention before transmitting data. It used only on Apple networks. Want to learn more about the technicalities? Check out our Academy for lessons on access control. Go to Academy Carrier sense multiple access with collision detection (CSMA/CD) is the opposite of CSMA/CA. Instead of detecting data to transmit signal intention to prevent a collision, it observes the cable to detect the signal before transmitting.Collision detection means that when a collision is detected by the media access control policy, transmitting by the network stations stops at a random length of time before transmitting starts again.It is faster than CSMA/CA as it functions in a network station that involves fewer data frames being transmitted. CSMA/CD is not as efficient as CSMA/CA in preventing network collisions. This is because it only detects huge data traffic in the network cable. Huge data traffic increases the possibility of a collision taking place. It is used on the Ethernet network.The demand priority is an improved version of the Carrier sense multiple access with collision detection (CSMA/CD). This data control policy uses an 'active hub' in regulating how a network is accessed. Demand priority requires that the network terminals obtain authorization from the active hub before data can be transmitted.Another distinct feature of this MAC control policy is that data can be transmitted between the two network terminals at the same time without collision. In the Ethernet media, demand priority directs that data is transmitted directly to the receiving network terminal.This media access control method uses free token passing to prevent a collision. Only a computer that possesses a free token, which is a small data frame, is authorized to transmit. Transmission occurs from a network terminal that has a higher priority than one with a low priority.Token passing flourishes in an environment where a large number of short data frames are transmitted. This media access control policy is highly efficient in avoiding a collision. Possession of the free token is the only key to transmitting data by a network node. Each terminal holds this free token for a specific amount of time if the network with the high priority does not have data to transmit, the token is passed to the adjoining station in the network.Media access control regulates how a network is accessed by computer terminals and transmits from one terminal to the other without collision. This is achieved through CSMA/CD, CSMA/CA, demand priority, or Token passing. Multiple network nodes often share the same medium. For example, several computers might connect to a wireless access point or plug into an Ethernet hub. We need a protocol to decide which one can access the medium if more than one has information to send at the same time. We need a media access protocol (MAC). Some MAC protocols are: CSMA/CA, Carrier Sense Multiple Access/Collision Avoidance: Listen to see if the channel is in use. If it is, back off for a time and retry later. ("Carrier Sense" implies that a node can tell when another device is using the communication medium -- like a telephone busy signal). CSMA/CD, Carrier Sense Multiple Access/Collision Detection: If a collision is detected after transmitting a frame, back off for a time and retransmit it. (Collisions are detected when a node receives a garbled frame). Polling: The network has a master node and two or more slaves. The master node queries each slave in turn to see whether it has some data to transmit. If it does, it transmits the data, if not, the master moves on to the next slave node. Token ring: A token (a pattern of bits) is passed from one node to the next. A node can only transmit when it has the token. This is similar to polling, but the nodes are equal peers. There is no master node. RTS/CTS, Request to Send/Clear to Send: After the base station gives A permission to transmit, it tells B to hold off for a short time. View Discussion Improve Article Save Article Like Article The Data Link Layer is responsible for transmission of data between two nodes. Its main functions are- Data Link ControlMultiple Access ControlData Link control – The data link control is responsible for reliable transmission of message over transmission channel by using techniques like framing, error control and flow control. For Data link control refer to – Stop and Wait ARQ Multiple Access Control – If there is a dedicated link between the sender and the receiver then data link control layer is sufficient, however if there is no dedicated link present then multiple stations can access the channel simultaneously. Hence multiple access protocols are required to decrease collision and avoid crosstalk. For example, in a classroom full of students, when a teacher asks a question and all the students (or stations) start answering simultaneously (send data at same time) then a lot of chaos is created(data overlap or data lost) then it is the job of the teacher (multiple access protocols) to manage the students and make them answer one at a time. Thus, protocols are required for sharing data on non dedicated channels. Multiple access protocols can be subdivided further as – 1. Random Access Protocol: In this, all stations have same superiority that is no station has more priority than another station. Any station can send data depending on medium's state(idle or busy). It has two features: There is no fixed time for sending dataThere is no fixed sequence of stations sending dataThe Random access protocols are further subdivided as: (a) ALOHA – It was designed for wireless LAN but is also applicable for shared medium. In this, multiple stations can transmit data at the same time and can hence lead to collision and data being garbled. Pure Aloha: When a station sends data it waits for an acknowledgement. If the acknowledgement doesn't come within the allotted time then the station waits for a random amount of time called back-off time (Tb) and re-sends the data. Since different stations wait for different amount of time, the probability of further collision decreases. Vulnerable Time = 2* Frame transmission time Throughput = G exp{-2*G} Maximum throughput = 0.184 for G=0.5Slotted Aloha: It is similar to pure aloha, except that we divide time into slots and sending of data is allowed only at the beginning of these slots. If a station misses out the allowed time, it must wait for the next slot. This reduces the probability of collision. Vulnerable Time = Frame transmission time Throughput = G exp{-*G} Maximum throughput = 0.368 for G=1For more information on ALOHA refer – LAN Technologies (b) CSMA – Carrier Sense Multiple Access ensures fewer collisions as the station is required to first sense the medium (for idle or busy) before transmitting data. If it is idle then it sends data, otherwise it waits till the channel becomes idle. However there is still chance of collision in CSMA due to propagation delay. For example, if station A wants to send data, it will first sense the medium.If it finds the channel idle, it will start sending data. However, by the time the first bit of data is transmitted (delayed due to propagation delay) from station A, if station B requests to send data and senses the medium it will also find it idle and will also send data. This will result in collision of data from station A and B. CSMA access modes- 1-persistent: The node senses the channel, if idle it sends the data, otherwise it continuously keeps on checking the medium for being idle and transmits unconditionally(with 1 probability) as soon as the channel gets idle.Non-Persistent: The node senses the channel, if idle it sends the data, otherwise it checks the medium after a random amount of time (not continuously) and transmits when found idle. P-persistent: The node senses the medium, if idle it sends the data with p probability. If the data is not transmitted ((1-p) probability) then it waits for some time and checks the medium again, now if it is found idle then it send with p probability. This repeat continues until the frame is sent. It is used in Wifi and packet radio systems. O-persistent: Superiority of nodes is decided beforehand and transmission occurs in that order. If the medium is idle, node waits for its time slot to send data. (c) CSMA/CD – Carrier sense multiple access with collision detection. Stations can terminate transmission of data if collision is detected. For more details refer – Efficiency of CSMA/CD (d) CSMA/CA – Carrier sense multiple access with collision avoidance. The process of collisions detection involves sender receiving acknowledgement signals. If there is just one signal(its own) then the data is successfully sent but if there are two signals(its own and the one with which it has collided) then it means a collision has occurred. To distinguish between these two cases, collision must have a lot of impact on received signal. However it is not so in wired networks, so CSMA/CA is used in this case. CSMA/CA avoids collision by: Interframe space – Station waits for medium to become idle and if found idle it does not immediately send data (to avoid collision due to propagation delay) rather it waits for a period of time called Interframe space or IFS. After this time it again checks the medium for being idle. The IFS duration depends on the priority of station.Contention Window – It is the amount of time divided into slots. If the sender is ready to send data, it chooses a random number of slots as wait time which doubles every time medium is not found idle. If the medium is found busy it does not restart the entire process, rather it restarts the timer when the channel is found idle again.Acknowledgement – The sender re-transmits the data if acknowledgement is not received before time-out.2. Controlled Access: In this, the data is sent by that station which is approved by all other stations. For further details refer – Controlled Access Protocols 3. Channelization: In this, the available bandwidth of the link is shared in time, frequency and code to multiple stations to access channel simultaneously. Frequency Division Multiple Access (FDMA) – The available bandwidth is divided into equal bands so that each station can be allocated its own band. Guard bands are also added so that no two bands overlap to avoid crosstalk and noise. Time Division Multiple Access (TDMA) – In this, the bandwidth is shared between multiple stations. To avoid collision time is divided into slots and stations are allotted these slots to transmit data. However there is a overhead of synchronization as each station needs to know its time slot. This is resolved by adding synchronization bits to each slot. Another issue with TDMA is propagation delay which is resolved by addition of guard bands. For more details refer – Circuit Switching Code Division Multiple Access (CDMA) – One channel carries all transmissions simultaneously. There is neither division of bandwidth nor division of time. For example, if there are many people in a room all speaking at the same time, then also perfect reception of data is possible if only two person speak the same language. Similarly, data from different stations can be transmitted simultaneously in different code languages.

07/10/2019 · Short for carrier sense multiple access/collision detection, CSMA/CD is a MAC (media access control) protocol. ... The medium is often used by multiple data nodes, so each data node receives transmissions from each of the other nodes on the medium. There are several CSMA access modes: 1-persistent, P-persistent, and O-persistent. 1-persistent ... 21/09/2020 · Multiple access protocols are a set of protocols operating in the Medium Access Control sublayer (MAC sublayer) of the Open Systems Interconnection (OSI) model. These protocols allow a number of nodes or users to access a shared network channel. Several data streams originating from several nodes are transferred through the multi-point ... 15/06/2019 · -2 - force use of protocol version 2-4 - force use of IPv4-T - disable pty allocation-N - don't start a shell/command (SSH-2 only)-C - enable compression-R - forward remote port to local address. In our case, we will connect to port 12345 and will be forward to 3389; Important: The user is the user for the SSH connection, not for the RDP ! 29/01/2019 · Similar to the Allow-control-allow-origin plugin, it adds the more open Access-Control-Allow-Origin: * header to the response. It works like this. Say your frontend is trying to make a GET request to: Our access control software is a future-proof access management system for medium-sized to large-sized applications. It is easy to use, operate and expand. In addition, it is extremely stable, offering best-in-class reliability, security and several features found only in ... 02/07/2021 · Multiple Access Control ... Random Access Protocol: In this, all stations have same superiority that is no station has more priority than another station. Any station can send data depending on medium's state(idle or busy). ... If the medium is idle, node waits for its time slot to send data. (c) CSMA/CD – Carrier sense multiple access ... The CSMA/CD protocol works with a medium access control layer. Therefore, it first senses the shared channel before broadcasting the frames, and if the channel is idle, it transmits a frame to check whether the transmission was successful. ... It is a protocol that works with a medium access control layer. When a data frame is sent to a channel ... The Internet Control Message Protocol (ICMP) is a network layer protocol used by network devices to communicate. ... Easily secure workplace tools, granularly control user access, and protect sensitive data. Area 1 (Email Security) ... For small and medium businesses that need more than the basic security and peformance features. Cloudflare's ... 08/11/2021 · Internet Control Message Protocol (ICMP) Hot Standby Router Protocol (HSRP) Open Shortest Path First (OSPF) Protocol fundamentals ... Internet Message Access Protocol (IMAP) 11, Jan 21. Difference between Serial Line Internet Protocol (SLIP) and Point-to-Point Protocol (PPP) ... 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