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Wireless Technology in Educational System

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Abstract. Wireless networks will play an important role in education. The infrastructure of wireless networks mostly focuses on wireless ad-hoc networks. They will provide freedom from place restrictions, flexibility, dynamic interaction, scalable multicast services and adaptive architecture. One of their most appealing services is group communication. New educational models and wireless architectures have been proposed to enhance collaborative training. Wireless ad-hoc networks are multihop wireless networks and can provide a dynamic educational environment. However, the lack of fixed infrastructure in ad-hoc wireless networks generates new research problems. This paper examines the different ways wireless technology work and the required prerequisites to integrate it into the educational area. It also describes educational opportunities and challenges of teaching in a real time wireless classroom environment. Since ad-hoc networks do not need fixed infrastructure, the developed protocols must be self-configuring. Additionally, this paper refers to the constraints and barriers, which prevent wireless networks from being accepted. It provides educational models and techniques in order to easier the transition from traditional computerized training systems to wireless training systems. Different approaches for multicast services propose the utilization of several routing protocols or hybrid adaptive mechanisms for joining/leaving groups. Lastly, the paper compares models and architectures in educational wireless networks, taking into consideration the shortages of the educational systems, and predicts future trends and perspectives of integrated educational environments.

Keywords: wireless ad-hoc networks, multicast services, wireless educational environment, models

1 Introduction

Last decades a new technology has been arising providing a number of affordable wireless network solutions independent of time, place restrictions and installations of wires. Wireless networking refers to the utilization of cross-vendor industry standards, such as IEEE 802.11, where nodes (computers) communicate without needing to be wired. The infrastructure of this network predefines the existence of standard protocols that must be adaptable or oriented according to the demands such as the components that affects the network capacity and quality of services (QoS). The continuous growth of wireless technology has supplement the area of business and school, where the exchange of data was unattainable or unadvisable with wiring networks, as well as sophisticated applications where network wiring is impossible, such as in wireless banking, warehousing or point-of-sale handheld equipment with many facilities through additional characteristics and models of communication. The infrastructure models of wireless technology especially in educational systems can be focused on two categories of networking. Ad-hoc networks and wireless networks that use an access point or base station to communicate with a wired network.

The advantages by communicating wirelessly are obvious in school educational systems. Students, faculty and staff increasingly want boundlessly network access from general-purpose classrooms, meeting rooms, auditoriums, and even the hallways of campus buildings. There is interest in creating mobile computing labs utilizing laptop computers equipped with wireless Ethernet cards. Recently, industry has made significant progress in resolving some constraints that have affected the widespread adoption of wireless technologies. Some of the constraints have included disparate standards, low bandwidth, and high infrastructure and service cost.

Both types of wireless technologies can support the institutional mission and provide cost-effective solutions. Wireless is being adopted for many new applications: to connect computers, to allow remote monitoring and data acquisition, to provide access control and security, and to supply a solution for environments where wires may not be the best implementation. New technologies rapidly find acceptance in the university environment. To determine the appropriate application of wireless communication, the campus community will be fully engaged to ensure that this developing technology will be used to enhance the teaching, learning, and research environment. Moreover, these networks can function efficiently in multicasting transmissions where the participants are dispread in a specific area.

It is worth to mention that technology trends simulate wireless environments for travellers in order to be educated for cultures of the place they visit, to learn languages and to be informed for accommodations and entertainment places. These efforts are also focusing to enhance educational system by providing time-tested methods in conjunction with pedagogical techniques.

This paper presents an overview of existing wireless technologies in educational system and an assessment of issues and recommendations for future deployment of wireless technologies.

2 Wireless ad-hoc networks

Our researches are concentrated on the advantages of ad-hoc wireless networks that seem to be more valuable considering the time and place restrictions, in an educational system. An ad-hoc wireless network is a collection of nodes participating in a covered area of transmission and cooperating to exchange data wirelessly. The topology depends on the movement of the nodes and the gain of bandwidth of the routing protocol and the type of communication. A major component that predefined the type of transmission concerns whether the transfer of data is designate unicast, multicast or broadcast communication. In each case the routing protocol defers according to rules and objectives of a successful communication and minimum allocation of bandwidth and power restrictions of wireless nodes. Ad-hoc wireless networks facilitate a dynamic educational system where participants enter or leave a training session without notifying a centralized manager of the network. The lack of infrastructure gives a model of communication nodes that are adaptive in continuous changes. Factors such as power expended, variable wireless link quality, and topological changes, become relevant issues during the survey of the shortest path from source to destination.

Models and implementation of an ad-hoc wireless network can solve different necessities in an educational environment where the challenges are increasing. These networks provide flexibility, collaborative training, dynamic interaction, and adaptive architecture for group communication. In an ad-hoc or multihop network each computer is equipped with a wireless networking interface card covering a transmission area where each computer (node) which interferes in this area can constitute the bridge to the rest of the network operating either as a destination or a relay. Another model of multihop networks concerns the interaction of a group of nodes with a wireless access point using one node as the bridge which is determined to communicate through this point with the wired network of the campus or the educational institute. In this case the topology and the range of the wireless network are dependent also on the range and the transmission rate of the access point.

Ad-hoc networks do not have a specific infrastructure and predefined locations where they can exchange information with stable rates. Each node in ad-hoc network is functioning simultaneously as server and as source – destination of the message that is transmitted through the network. Ad-hoc wireless networks could be defined as a subcategory of a cellular system as the behaviour of the nodes and the range of transmission simulate a cellular form. Of course it is risky to say that they will work at the same way when decentralized. Differences are increased when there is mobility and entering or leaving of a node from the range of transmission or there isn't any node to behave as a relay for the destination node. Additionally, the behaviour of the routing protocol is changing dynamically and according to factors that do not exist in a cellular system. The key difference between ad-hoc networks and cellular networks is the absence of base stations, which results in every node in the network getting an equal share of the network management functions. For example, every node is a router and every node must be capable of locating other nodes and tracking them as they move. The main interest in multihop wireless networks is focused on the self-configuration of the network especially during movements or dynamic changes in nodes.

2.1 Requirements for Wireless Communication

The mobile wireless communication network must be a seamless and flexible part of the infrastructure. To achieve this, we assume that it should meet the following objectives (J. Broch 1998).

- The node in an ad-hoc wireless network must be able to communicate with other nodes, and with any host in the Internet through an access point,
- There should be means to uniquely identify a node both in fixed and in mobile network.
- In any effort of communication nodes should be able to exchange data at different ways and according to network topology,
- Wireless network must support congestion controls, different architectures, hardware technologies, network or transport protocols and multiple mobility management protocols,

- The existing hosts in the fixed network should be capable of using the mobile access with no requirements for change,
- Network architecture should facilitate the transportation of a message where the nodes' resources are limited,
- Protocols should be able to realize the condition of the network such as transactions failure, increase or decrease of mobile nodes and shortest paths from source to destination with minimum consumption of resources,
- The architecture of a group communication should be reasonably secure.

2.2 Routing protocols and Services

The wireless communication can be categorized according to the applications, the systems as well as the region that it can cover (C. Tschudin 2000), (Tony Larson & Nicklas Hedman 1998).

1. The applications include:	• voice, • access in the Internet, • web browsing, • paging and short messaging, • subscriber information services, • transport of files and video - conferences.
2. The systems include:	• cellular systems • wireless phones • wireless local networks • wide region wireless systems of data • paging systems and • satellite systems
3. The range of cover can be:	• very small (in a working place, a room) • small (in a building, one building square) • of bigger scale (a city or in world scope)

Table 1. Categorization of Wireless Communication

The problems that are incurred in the growth of wireless ad-hoc networks are:

- The determination of requirements in:
  - Speed,
  - Reliability and
  - Guarantee of requirements in quality of services (QoS). Because of the limited and shareware bandwidth of network, and the lack of central controller of these resources, the nodes are compelled to negotiate with regard to the management of resources that is required for the benefit of quality of services at length of path,
- The bandwidth of transmission via the wireless connections. The management of transmission bandwidth is another component that should be recorded at the behaviour of a protocol as it is known that the bandwidth is consumed not only for the parcels of "clean information" that we want to transmit but also for the transmission of parcels of routing,
- The study of various forms of wireless networks and infrastructures and the search of hybrid form of network that it will serve individually,
- The consumption of energy as the participating nodes spend their energy in signals among them and installation of paths of most optimal way in a dynamic wireless network,
- The need of implementation of such networks or hybrid forms,
- The consumption of energy caused by the supply of one node which is related more with the frequency of emission of messages of notifying and more generally emissions that concern activities of maintenances,
- The function of protocol should be distributed and no assembled and this because the centralized protocol is susceptible in congestion,
- The exploration of existing problems of routing in the ad-hoc networks as these are presented at the transmission of such forms of communication,
- The automatic redefinition of wireless ad-hoc network from a failed transmission and feed in of one node,

- Guarantee of the path that will not lead to repeated loop,
- The possibility of adaptability in the topology and typology of movement of network and naturally this adaptability will be supposed to become with as much as possible smaller functional cost (overhead),
- End – to – end delay. The time that a parcel is maintained in the buffer before being decided its reject because of not discovery the path to be promoted,
- The capacity that governs the nodes who participate in the wireless ad-hoc network, as well as the redefinition of provision of nodes according to the mobility and capacity of their location,
- The start of transmission “Bring - Up” after a pause or inactivity of node,
- The determination of the advantages as well as the disadvantages of algorithms of routing of shorter way, of most optimal routing, as well as algorithms of deviation of flow.
- The real performance from end – to – end throughput,
- The search of optimal way,

3 Multicast wireless networks

Multicasting has naturally been considered the ideal technique to be used with multimedia communications, mainly because its inherent nature is to minimize the network resources needed to support this type of transmission (Tony Larson & Nicklas Hedman 1998). Multicast in ad-hoc networks is based in structure of tree. One node initiates the group and becomes the group master of the network. It works as the base node in a multicast tree and conserve a list of all nodes joining the network. This list is being kept in a dynamic table which is updated continually. Its task is to periodically send hello messages in order to be informed about the condition of the network. Every node in a group must send an acknowledgement (ACK) to inform the master node concerning the packets that have received or a negative acknowledge (NACK) if a transmission failed. Nodes in a multicast network function either as destination or as relay to transmit messages to the rest of the network. In cases where a failure of acceptance of a message occurs from one node during transmissions a request of retransmission must be forwarded only to the specific node. Consequently, the other nodes of the group when they realize that a retransmission occur they ignore the content of the message and they forward it to the destination node where the failure happened.

In a multicast network an amount of messages concerns the joining or leaving a group from a node, the rearranging of the network topology and the failures that occur during transmissions. The master of the group is being informed for every condition of the wireless network and this implies the normal function of it. Focusing in an educational environment the transmission of a video conference or a multimedia presentation from an instructor facilitates the forward of the packets and reducing the consumption of the resources especially the battery power. Students and staff also can utilize multicast structure to communicate with database systems in the campus and attend e-learning courses, or to keep notes and guidance for projects and group co operations. The place restrictions does not limit the multicast transmission as the members – nodes can work dispersed within the bounds of range of communication. Ad-hoc wireless networks and especially multicasting function additively to the training models and enhance them to new educational forms. The ability to work with wireless multicasting technology reduces the cost of resources and increases the edutainment capacity of members.

4 Educational Models and Architectures

Wireless networks can give network access in every classroom with no or minimal renovation costs. The Wireless Classrooms require only the installation of the access points, which can be placed strategically throughout the building and can usually be installed without interruption of the regular classroom schedule (see Figure 1). Additionally, it is a valuable factor since without any modification (or visible wiring) to the existing physical structure/classroom we can provide network connectivity (Prakash Nair 2002).

The difference between wiring laboratories in a campus and wireless classrooms is in their roles and objectives. In a wireless network where mobility and roaming are supported, students can move from class to class and remain connected to the network without any interruptions. The information and educational material is available consecutively by using database technology and metadata which maximize reusability and maintenance of existing system. For example, suppose you have a wireless access point that connects the wireless network to the backbone of the campus. The covered area of this point is satisfactory enough to connect every node in the campus area and permitting according to predefined rules. Security is also defined such as communications among groups. The mobility is not as large as it would be expected like in an ad-hoc network where nodes are moving without a predefined manner. Furthermore, during time breaks or free time they can be connected to the school backbone and search to the library wirelessly, or exchange information and cooperate with each others. Another usability of the ad-hoc wireless networks can be found in environmental courses where students should be in the forest or sticks. By using PDAs or notebooks can be connected to the backbone of the campus and transfer the results of their surveys. A user friendly environment will help users to exchange data with a local database and communicate with a supervisor to take guidance. As the most critical factor for the implementation of a network is cost saving it has been proven that educational environments which make use of a wireless infrastructure can be less expensive than a wiring network installation. The equipment that will be used will be limited to the minimum as it can be arranged to be transferred from classroom to classroom according to course needs. Another important factor is that ad-hoc wireless networks can develop and evaluate communication patterns and possible infrastructure for interconnected embedded technologies among devices.

A major advantage in a wireless network is the multicasting approaches of communication. Wiring networks have been used to exchange data and to communicate through the Internet. Wireless networks provide another type of communication especially in education where someone can multicast data to a group community. Multicast applications provide a variety of options for supporting a collaborative and individual teaching environment. A major problem in ad-hoc wireless networks is to minimize the unnecessary messages that transmit one computer to another especially during multicasting transmissions. Many efforts have shown remarkably results concerning the way of communication in ad-hoc wireless networks where nothing is stable. Especially in an ad-hoc network the educational model is being enhanced and supplemented with efficiency of moving around the campus and interfering with educational material beyond time and place restrictions.

Ad-hoc wireless networks can be used as a platform to distribute distance learning and to provide wireless learning environment services. The distance learning and wireless learning environment could include, for example, videoconferencing between mobile phone, PC, VoIP-phone and traditional phone or streaming video content from a learning content database. Ad-hoc networks could be used in educational purposes by including

- Access to searchable databases,
- Administrative services (timetables, student records),
- Small text-based simulations,
- Dictionaries, vocabularies, thesaurus,
- Presentation (video, multimedia applications) and
- Control of the status of a machine (i.e. robot).

An advanced-user interface will help users to log in to the backbone of the school or to the server through the access points. The wireless network will be monitored in order to permit access to the databases and facilitate users by allocating laptops or other mobile devices to the access point. Many projects are developing especially in providing information to users who travel and inform them for sightseeing and online language translations. The educational content can be designed properly in the same way by using modules so that to be shared in text mode or graphical or multimedia mode and help users to use any type of wireless devise.

The architecture of an educational environment using wireless technology can be based to its current infrastructure of the wiring backbone network and be enhanced in the future by replacing computers lab with wireless devices. The replacement of the existing personal computers with notebooks will maximize the usability of the classrooms by using the so far traditional laboratories. The wireless access points will be the only medium to facilitate the communication between mobile computer laboratories with both Internet and local servers. Thus, the education will be continued and enhanced even when the school is closed with the assistance of proper software which will be developed to provide courses or other helpful facilities.

4.1 Mobility and Traffic Models

Assume that an existence of 50 nodes move in an area of 1000m x 1000m. The nominal channel bit rate is 2Mbps. The nominal radio range is 200m. The network capacity is a function of the actual route used for relaying data packets as well as physical locations of all nodes on the route.

Assume that a very large number of nodes are uniformly distributed in the 1000m x 1000m rectangular area, and only one node within any circular cell area of size pi x R^2 can transmit at any instant. Since nodes can be anywhere in this region, transmissions can occupy bandwidth in a larger 1400m x 1400m area. This larger area can occupy at most 1400m x 1400m / pi x R^2 cells. Considering that nominal range R is equal 200m the maximum network capacity of the area is approximately 15.6 x 2 = 31.2 Mbps, where 15.6 is the number of cells in this area.

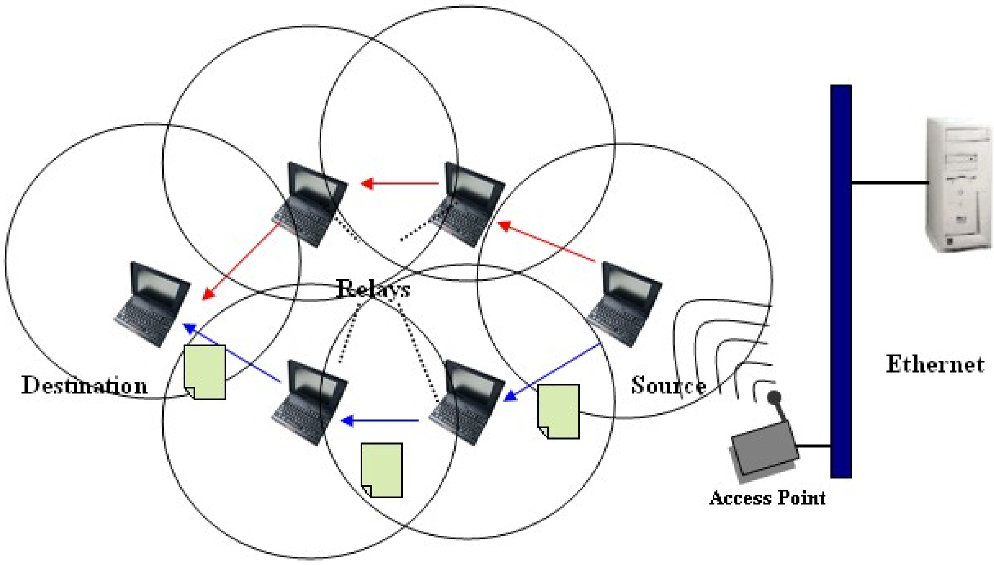

Figure 1. Ad-hoc wireless network

According to (Matthias Grossglauser & David N. C. Tse 2002), (Piyush Gupta & P. R. Kumar (2000) theories, as the number of nodes increases in a specified area, the maximum throughput per source to destination pair decreases approximately at $1/\sqrt{n}$, where n is the number of nodes. This is because the communication must be limited to near neighbors for better spatial reuse. It is almost infeasible to observe direct communication between source and destination at a rapid rate without counting time delays. The delay increases as the mobility decreases. It is important to point out that as the network capacity increases with node mobility; the routing and medium access protocols fail to take advantage of the increased capacity. Analyzing the scenario of (S. Diggavi, M. Grossglauser & D.N.C. Tse 2002) we observe that while nodes are moving inside the specified region the possibility to be a destination in the range of transmission of source node increases and this implies that the delay and the consuming of the bandwidth decreases significantly. But this point of view is not happening in real life except in cases where the mobility area is restricted by high rate mobility nodes.

In a campus area or in an educational institute the movement of nodes is very rare or not continuous. Nodes must work evenly as source, as destination and as a relay for other's packets. The model of having wireless nodes in a classroom environment and exchange data complicates the problem. Especially, in multicasting where the data transmission concerns video or multimedia presentations from a source node to a group of destination nodes who work also as relays, the utilization of the available bandwidth demand a properly management of data transmission avoiding iterations and engagements of channel such as power and useless procedures. In an ad-hoc wireless network located in a classroom the traffic carried by the nodes are relayed traffic.

Problems that occurred in ad-hoc wireless networks concern the knowledge of the network topology during transmissions. The lack of centralized control and the time-varying of network topology determine the use of the routing protocol that will facilitate the multicast transmission. The case of one node to leave the multicast session necessitates the determination of the location of all nodes and the routing tables that each one maintains. Furthermore, the entering of one node to the topology must rearrange the paths and the role of this node to the whole network. Such kind of problems is met in conferences where participants are moving toward the covered area. During the multicast transmission nodes are responsible to forward the packets to all destinations belong to a group community certified to receive these packets and only once. Duplicated packets must be rejected in order to release bandwidth. Each participant must receive the packets from the nearest node rejecting the request of transmission from other nodes with longer distance. Thus, the transmission depends on the ability of one node to send a packet according to other requests and noises that occurring in the channels or in the area.

5 Conclusions

Mobile wireless ad-hoc networks are highly dynamic because of node mobility, unreliable wireless links, and frequent outages. Furthermore, they are sensitive to network load and congestion. For ad-hoc network protocol design, the key of their success is that the protocols are adaptive and generate minimal control message overhead. The ad-hoc network is a fairly new idea which addresses to the problem of forming mobile networks in dynamic fashion. In contrast to the infrastructure network ad-hoc networks provide true ad-hoc features with no need of base stations. However, there is no way of assuring network coverage. It is said that these kinds of networks will be deployed in educational application where the community is dynamic according to courses and groups communications. The utilization of wireless ad-hoc networks compared to traditional cellular systems make ad-hoc networks very appealing in many applications (video, audio, multimedia transmissions). The advantages of ad-hoc networks include the continuously function of the network as there isn't a base station which is the only responsible for the transferring the messages like in cellular systems. Moreover, ad-hoc wireless networks don't rely on wired base stations and therefore are capable of being deployed in places with no existing infrastructures.

Wireless ad-hoc networks take advantage of the nature of the wireless communication medium. In other words, in a wired network the physical cabling is done a priori restricting the connection topology of the nodes. This restriction is not present in the wireless domain and, provided that two nodes are within hearing distance of each other, an instantaneous link between them is automatically formed.

The advantages in educational systems stems from the needs of dynamic networks with cost reduction in technology investments, as laptops can be transferred in every classroom thought to be necessary, with easy instalment of a group communication, with fewer requirements in a campus area and the ability to communicate all the members without being restricted of place and time. Models of education like e-learning or multicasting services give advantages to the ad-hoc networks as the collaboration and the communication with database systems of the campus even outside the classroom and laboratories facilitate the transmission of knowledge. Many efforts have been done in USA and Australia concerning schools and universities and the effects in faculty and students but still the utilization of ad-hoc multicasting wireless networks remains immature to ride high.

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