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Preliminary communication

Network Performance Measurement through Machine to Machine Communication in Tele-Robotics System

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Abstract: Machine-to-machine (M2M) communication devices communicate and exchange information with each other in an independent manner to perform necessary tasks. The machine communicates with another machine over a wireless network. Wireless communication opens up the environment to huge vulnerabilities, making it very easy for hackers to gain access to sensitive information and carry out malicious actions. This paper proposes an M2M communication system through the internet in Tele-Robotics and provides network performance security. Tele-robotic systems are designed for surgery, treatment and diagnostics to be conducted across short or long distances while utilizing wireless communication networks. The systems also provide a low delay and secure communication system for the tele-robotics community and data security. The system can perform tasks autonomously and intelligently, minimizing the burden on medical staff and improving the quality and system performance of patient care. In the medical field, surgeons and patients are located at different places and connected through public networks. So the design of a medical sensor node network with LEACH protocol for secure and reliable communication ensures through the attack and without attack performance. Finally, the simulation results show low delay and reliable secure network transmission.

Keywords: Machine-to-Machine (M2M) communication; medical field introduction; network performance security; tele-robotic; wireless sensor network

1 INTRODUCTION

Machine-to-machine communication (M2M) refers to the exchange of information between two devices. It is a key component in the fast-growing Internet of things (IoT), an ever-growing connection of devices in the home, workplace, and industry. M2M communication can be simple, like one-way data transmission, or complex, like multiplexed signals that allow devices to share a decision-making process. In the medical device industry, M2M communication is one of the fastest-growing sectors. According to Global Info Research, the connected medical device market is projected to expand from $939 million in 2018 to $2.7 billion by 2023, with the largest growth forecast for the United States. M2M communication faces various security challenges. Much vulnerability arises from the lack of a central authority and a wireless medium of transmission. Route creation and data transmission are two important functions of the routing algorithm. These two stages must be protected from attackers. The routing Protocol must be strong enough to withstand various attacks. Thus, reliable communication means a secure routing algorithm [1]. Tele-robotics is an integral part of the broader field of telemedicine. The main aim is to provide medical care for long distances and removes the need for both the doctor and the patient to be physically present in the same place. Consultation by far the possibility of diagnosis and treatment can greatly affect the life of patients with limited access to specialist health services [2]. Tele-robotics is practically lead by special doctors where there are no medical institutions or specialists. In addition to medical isolation, Tele-robotic is very important in eliminating medical issues in building countries, disaster places, and war areas where ongoing medical services are not available or do not have time to shift the patient to the hospital [3]. In the mid-1980s, robotic systems were introduced into medicine and today they affect a wide range of medical areas [4, 5]. In a Tele-robotic system, a remote manipulator controls the operator of the object, receives visual and information, and transmits it to the control position. Local and remote systems are called master and slave systems, entire master-slave is a system of remote control of the manipulator program [9] [10]. Figure 1 presents the Tele-robotic system consists of information of melody system for robot-supported telemetry applications.

The underlying system of telerobotic is telepresence. Tele-presence assumes that all information of the remote environment is inherently provided by the operator [11]. The main connection is created in master and slave communication to called machine to machine communication through the internet. The length of nodes from each other is vast; the data transfer delay may disturb the system and ultimately affect the performance of the healthcare professional. The communication quality and performance metrics are important in telerobotic M2M communication. Security and privacy are very important aspects of any communication. Network performance is reduced if a malicious node is present in the network. The incorrect behavior of the node presents malicious packet drop attacks, disturb the routing rules, data transmission is corrupted, packets are dropped and data is lost. So the presented systems provide a low delay and secure communication for the telerobotic community and data security. The system can perform tasks autonomously and intelligently, minimizing the burden on medical staff and improving the quality and system performance of patient care. The LEACH routing protocol is presented to make communication reliable and robust with the medical sensor node network. Once the network is created, network performance of the system is analyzed with or without DoS or Man-in-Middle attacks.

The need for research work provides telerobotics with significant progress to show how the surgery is performed in the operating room. It combines technological and clinical progress in the development of new robotic systems and surgical techniques to improve the quality and results of surgical intervention. Telerobotic and various imaging techniques act as intermediaries between the surgeon's hand, eye, and surgery site, respectively, but these two elements are part of a larger information system that continues to evolve and affect all aspects of surgery and medicine in general. Providing this technology to surgeons has led to the development of new surgical techniques that would otherwise be impossible. The clinical knowledge gained from these new systems and the understanding of their potential will lead to the development of new and more effective telerobotic systems in the future. The paper is organized as section 1 presents introduction, section 2 shows related work. Section 3 and 4 covers proposed research work and simulation results respectively. Finally last section summarizes points in conclusion.

2 RELATED WORK

M2M communication allows the development of a range of applications, such as smart networks, smart robots, smart transport, and home networks. In [12] analyze the M2M communication and intelligent network environment. The structure of the machine network and its possible applications has been proposed in [13]. Other learning experiments include such as Meteorological Services, Environmental Pollution prevention, integrated video services, etc. [14-17]. In [18] various design issues, such as describing different limitations of sensor assemblies, applications, etc. Was introduces a system for health surveillance in [19]. In [20] proposes an implementation of patient monitoring [21] and [22] presents a patient monitoring WAP system.

Tele-robotic systems should play an important role in the medical field [6]. The first successful remote operation, called Operation Lindbergh, was performed in 2001, using the Zeus Robotic System [7]. Laparoscopic gallbladder surgery was carried on patients in Strasbourg, France, while surgeons were based in New York, USA. Although the first remote operation took place only in 2001 but the tele-operative system was introduced much earlier. The automatic endoscope system uses the vocal arm for minimally invasive surgery to hold the endoscope [8]. The first surgical robot systems build for eye surgery at Northwestern University [23]. It travels through a virtual long-distance traffic center (RCM) at the sclera entry point [24]. A hypodermic needle is attached to the parallel mechanism and inserted through the sclera. A doctor and robot work together with one tool [25]. Tele-manipulator on a big system gives natural feedback. There was a strong sense that there was a large-scale position is not as important as reducing the tremor. In [26, 27] includes virtual devices for continuous hand manipulation, which are movement restrictions applied in software. In [28, 29] ETH developed in Zurich with magnetic control different from the current development. This is a magnetic control micro-robot platform that uses remote communication, using a primer connection. In [30] proposes an alternative parallel robot structure capable of performing virtual RCM motion through the sclera and the entry point. In [31] developed a handheld robotic device called Micron for microsurgery. The Micron concept is to measure the surgeon's hand movements, use advanced filtering technology to separate unwanted movements such as tremors from deliberate movements, and use robotic end effectors to adjust the tip of the instrument for unwanted movements. The Micron detects dynamic motion using an accelerometer and the final effectors of the robot. In [32] advanced robotic system for microsurgical keratoplasty was developed.

In [33] developed more accurate slave telesurgical pathologies of the throat and upper respiratory tract, it has the advantage of distal dexterity and functional self-enhancement. In [34] it has been shown that robotic electrode array inserts significantly reduce input forces when inserting a cochlear implant compared to unmanaged electrode arrays. In [35] build acceleration noninvasive Radiosurgery System that can compensate for the limited target movement, unlike the localization system. The delay could have serious consequences on the performance and control of systems.

In [36] review on the topic of two-way teleoperation, with several approaches, was presented. It covers a range of methodologies, including the passivity-based monitoring proposed to address the above-mentioned problems. In [37] applied the concept of wave variables, an extension of the theory of passivity, to time-delayed teleoperations that are unknown but contain a constant time delay. The work in [38] studied a Force-feedback algorithm, called a-Force, reflection activities, and experimental work; they use the method of minimally invasive surgical applications, communications delays. In [39] several unanswered questions and provides a clear description of IoT security research. Many of the dangers associated with this heterogeneous security infrastructure and privacy policies require a deep explanation. In [40] presents an overview of the access control approach attempts to improve security. The author not only summarizes the approach to access control but also provides an overview of existing limitations and unresolved issues. In [41] provides a model for predicting health risk through a wireless sensor network. The work [42] discussed performance measurement for 4G and 5G enabled architecture in telesurgery.

M2M technology is fast for health monitoring applications without human interference smart devices of WSN and mobile device networks provide remote monitoring of health data. M2M communication addresses several important challenges and the key challenges include security, standardization, privacy, software development, reliability, and communication delay.

3 PROPOSED RESEARCH WORK

M2M is a kind of network in which a large number of smart devices decide to generate information, exchange it, and cooperate without human direct interference. With the different applications and numerous advantages, M2M networks in their design face several technical challenges. One of the key issues holding back the growth of M2M communications is their security.

The presented system will consist of three units: a master station is an expert system, a slave station is a patient system, and a communication connection that allows data exchange by stations. Block diagram of the proposed system is shown in Fig. 1. The patient on-site, US probe is maintained to operate by the robotic arm system, follow the approach of management master/slave. The thin robot placed on the patient by paramedics. When the robot controller adopts classical force feedback control [43], which allows limiting the force to 20 N for patient comfort and safety, the robot control data update rate is up to 1 kHz without loss or jitter, and teleoperation becomes transparent [44]. The robot is controlled by an open circuit through a communication connection, but by a closed-circuit locally controlled in the patient's position. Eliminate this approach and instability in handling the problems. It has also been shown that the design of this robot allows geometric control [45].

In place of the master, the medical inspector moves the dummy of the ultrasound probe required for echo monitoring. The system also includes an actuator that can control the perception of power and feel the effect of the telerobot.

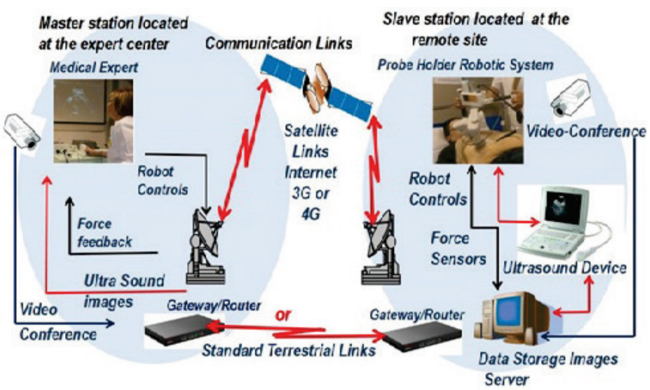

Figure 1 M2M communication through the internet in Tele-Robotics and network performance security [46]

The expert's hand movement is perceived, information is transmitted in real-time to the robot platform via a communication line (ground or satellite), and the operating system copies this movement. An important step in the field of information security is to prevent threats and vulnerabilities at the initial design stage. M2M communication consists of various vulnerabilities and security challenges such as physical security, resource constraints, heterogeneity, delay constraints, and scalability. The problem is to ensure communication security and maintain communication in the presence of adversaries throughout the topology of an unknown, frequently changing multi-hop wireless network. To solve this complex problem and ensure comprehensive security, both stages of communication, route discovery, and data transmission must be protected. However, M2M has faced serious security threats that typically affect end-to-end delay, buffer mechanism, response time, and overall network throughput, packet dropping, less packet delivery ratio, resulting in reduced performance. Therefore, it is economically difficult to manage such networks. Nodes are behaved maliciously by disproportionate network activity and thereby dropping packets to reduce efficiency. For secure or safe communication proposes a LEACH routing protocol with various medical sensor nodes, such as cameras, health checkup machines, computers, printers, etc.

A wireless sensor network uses a hierarchical routing protocol called LEACH, which extends the network life. Using the LEACH Protocol, medical sensor nodes are placed in clusters, and one node of these nodes act as a cluster head (CH) based on their energy and the distance from the medical sensor node to the base station (BS). CH is responsible to collect the data from its cluster and transmit to the BS. In process of data transmission more energy is consumed. LEACH enhances the network life without attack and reduces the power consumption of the WSN. This makes the system more secure and useful in the medical field.

4 SIMULATION RESULT AND DISCUSSION

A square area of 1000 × 1000 m is created by setting up 100 medical sensor nodes in the WSN as the basis for this study. The code is executed in the simulator NS-2 and the initial site settings are given randomly. To model the network, each node is given the initial energy in Joules units, and after the simulation, the total energy consumption is analyzed. First, create a LEACH protocol, and that legitimate traffic is generated. After that introduces a DoS or Man-in-Middle attack to analyze its impact on network performance. Next, measure performance parameters such as throughput, packet delivery speed (PDR), delay, overhead, and energy consumption of node. Experiments have made it possible to increase the service life of the network by about 20-25% using the proposed method. In traditional protocols, CH is created on the probability function, and CHs are selected in each round. The continuous simulation process provided that all nodes are consumed with energy values. The utilized simulation factors shows in Tab. 1.

Table 1 Simulation factors

Parameter	Values
Number of IoT/Machines/Sensor nodes	100, 200, 300, 400, 500, 600
No. of Attackers	10 % of nodes
Pattern of traffic	CBR
Connections number	10
Sink	Base Station (BS)
Area	1000 × 1000 (Long distance communications)
MAC	802.11
Topology	Random deployment
Routing Protocol	LEACH (state-of-art)
Initial Energy	0.5 J
Transmitter energy consumption	16.7 nJ
Receiver energy consumption	36.1 nJ
Simulation Time	200 seconds

Fig. 2 shows the throughput of the network in kbps, in which the *X*-axis represents the medical sensor nodes such as cameras, health checkup machines, computers, printers, etc. and the *Y*-axis represents the throughput values of nodes.

It shows LEACH protocol with and without attack and indicates the performance of the system. LEACH-A indicates the LEACH protocol with the attack. Throughput is the calculation of data successfully transmitted from the sending node to the receiving node over a specified time. The result shows LEACH without attack gives higher throughput values than LEACH-A with attacks. The Average throughput values of LEACH without attack are 63.88 kbps and LEACH-A with an attack is 58.56 kbps.

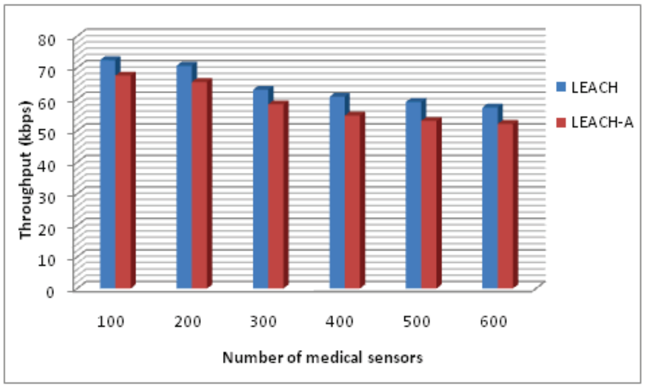

Figure 2 Throughput

Fig. 3 shows the packet delivery ratio (PDR) of the system in percent, in which the *X*-axis represents the medical sensor nodes and the *Y*-axis represents the PDR. PDR calculation is the percentage of the receiving to send packets. The PDR using LEACH protocol without attack is more than LEACH-A with the attack. The PDR values of LEACH without attack are 89.25 % and LEACH-A with an attack is 69.98 % respectively.

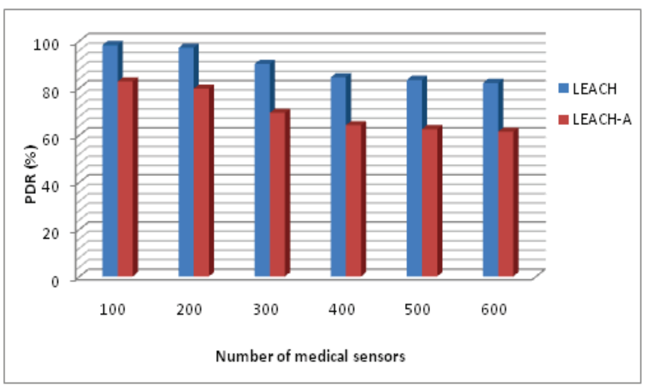

Figure 3 Packet delivery ratio

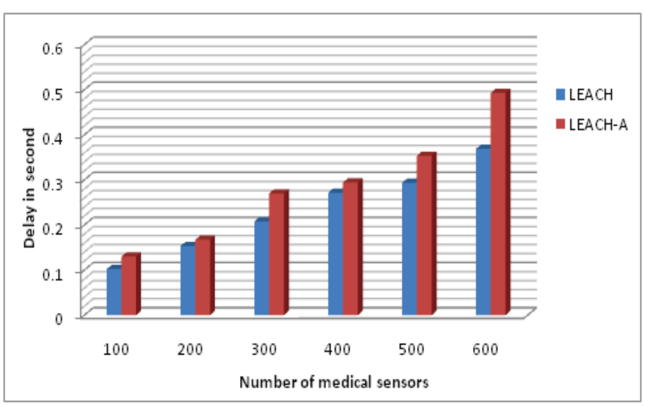

Figure 4 Delay

Fig. 4 shows the Delay in the network where the *X*-axis represents the sensor nodes and the *Y*-axis represents the delay of the system in a second. Delay is the amount of time that the source's physical layer takes to send a packet over a link. The delay of the LEACH protocol without attack is less than LEACH-A with the attack. The delay in second of LEACH and LEACH-A are 0.2327 and 0.2845 respectively and the difference is +0.0518.

Fig. 5 shows the communication overhead of the system in a millisecond, in which the *X*-axis represents the medical sensor nodes such as cameras, health checkup machines, computers, printers, etc. and *Y*-axis represents the communication overhead of the system.

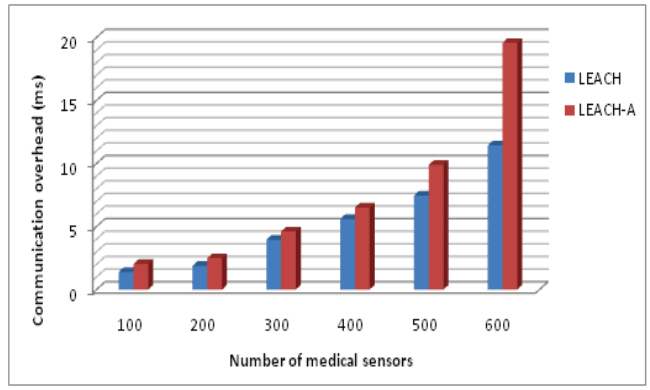

Figure 5 Communication overhead

Communication overhead is the ratio of actual communication time and computed communication time for actual communication time. The communication overhead of the LEACH protocol without attack is less than the LEACH-A protocol with the attack. The communication overhead in milliseconds (ms) of LEACH protocol without attack is 5.28 and LEACH-A with an attack is 7.51 respectively and the difference is +2.23.

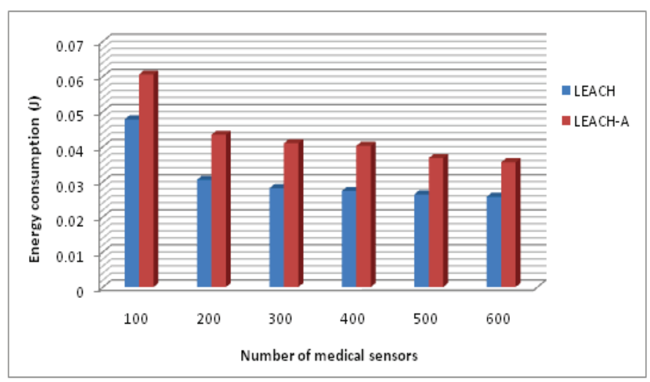

Figure 6 Energy consumption

Energy is the main issue in WSN, in order to enhance energy efficiency, it requires creation of virtual nodes to increase the throughput. Fig. 6 shows the energy consumption of the node. The result shows that the LEACH-A with attack consumes more energy than LEACH without attack. The energy consumption of LEACH protocol without attack is 0.031 (J) and LEACH-A protocol with an attack is 0.04294 (J) respectively and the difference is +0.01194 (J).

5 CONCLUSION

In healthcare, machine-to-machine communication (M2M) provides a new way of service for a patient's life. M2M utilizes wireless communication technology that enables automatic instructions between devices, such as starting, stopping, sending and receiving data. This paper proposes an M2M communication system through the internet in Tele-Robotics, the main goal is to generate various tasks automatically without human interference and minimizing the burden on the medical staff, and improving the quality and system performance of patient care. Medical telerobotics shows a powerful impact on healthcare. An indicator of this possibility is the fact that Tele-robotics has been considered in many applications and medical specialties, which are revealed in this review. The wireless technology allows the device to receive M2M communication and adjust the implant performance based on biometric feedback from the doctor. With the safety of critical operations in healthcare, securing a network against attacks is highly important. Resources in a sensor network are scarce in terms of energy and the biggest performance parameters in the medical field are delay, throughput, PDR, and communication overhead. Here performance metric parameters measured for LEACH and LEACH-A protocol. Simulation results show LEACH has better performance in terms of energy-saving and low delay over LEACH-A.

Notice

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