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Associate Prof. Md. Obaidur Rahaman

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Editorial Note

European University of Bangladesh is now in its permanent campus is located at the busiest gateway of Dhaka City - Gabtoli, Mirpur. We have successfully completed the construction of its 5.5 Lac sqft massive academic building. The University has by now more than 14,000 students, 400 Teachers – and around 350 support staff. We received more than 30 research-based articles for publication. After peer-reviewing we have selected five articles for the current issue. So, it was a Herculean task to choose seven articles out of thirty.

This sixth Issue contains 5 (five) articles covering multi-disciplinary issues. The first article deals with the concept of **"Analysis of Denial of Service Attack on Wireless Sensor Networks"**, The paper discusses about various DoS attack on wireless platform with detailed pros and cons. The attacking procedure of various virus and their prevention is elaborately discussed here.

The second article entitled, **"Design and Implementation of Free Space Optical (FSO) Network Under Turbulent Conditions."**, In this paper a technology named Free Space Optical Network has been discussed. The authors have shown how this technology works. They have performed different experimental tests here and have compared them using different mathematical formulation.

The third article authored by Md. Zakir Hossain , deals with **"Strengthening the Concrete Structural Models Using Various Types of Confinement".**

The fourth article is authored by Md. Abid Hassan Mojkury and Dr. Md. Ashraful Islam Khan, deals with **"Modeling and Forecasting of Infant and Child Mortality Rates in Bangladesh Through Classical OLS and Support Vector Machine".**

The fifth article is titled **"Impact of Social Media Marketing on Customer Purchase Decision: An Investigation on FMCG (Fast Moving Consumer Goods) Industry of Bangladesh**". This article shows a elaborate customer review of FMCG industry of Bangladesh

". It is hoped that all these articles will be of great interest to the readers of our journal.

European University of Bangladesh is a third-generation university with a clear vision to deal with a social problem --- higher education for poor students. With this end in view, we have kept our tuition fees very low, which is affordable for the economically backward section of our society. Also, we are publishing two articles in this current issue dealing with the social responsibilities, in keeping with our principal focus of disseminating education at low cost.

Associate Prof. Md. Obaidur Rahaman
Editor

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Analysis of Denial of Service Attack on Wireless Sensor Networks

Jannatun Naeem Muna*
Rownak Abdullah**
Md. Obaidur Rahman*

Abstract

Wireless sensor networks are the new emerging technologies that are the combination of wireless devices, small, effective sensors and special embedded system design with them. Basically WSN gathers data from very sensitive and harsh environments. Then after processing,they transmit all the information to base station or user application for their further use. But in their design,there is some design constraints like less memory,power or less secured system. For this they have faced lots of attacks . Denial of service (DOS) is one of the most crucial of them which attacks the whole network system on each layer separately and makes the whole network paralysed and jeopardized. In this review paper, all the attacks of DOS are discussed and their countermeasures are also discussed here attack wise.

Keywords: Denial of Service (DOS), Detection, Wireless Sensor Networks (WSN)

Introduction:

Wireless sensor networks are getting much attention and popularity day by day because of its vast application on different parts of human life. It is basically making life easier by getting the updated information from its combination of wireless technology, tiny sensors and embedded systems and devices. WSN can work in any environment like rain , sunlight, cold breeze and also in harsh environment. So it also has to face some attack on it . Denial of service (DOS) is one of those attacks . Because of its design constraints , it is much weaker against those attacks. So in order to get the proper feedback from the sensor nodes of WSN proper counter measures should be taken against those attacks. Wireless sensor networks are basically a sensory system which sense the different parts of environment and gather needed information . It is used in different sectors like monitoring of traffics, to diagnosis of healthcare problems, nuclear plantation, military network communication,weather update and information collection, ensuring security of a system etc. Wireless sensor networks must deliver security, integrity and correct output. But because of low power consumption, their tiny body structure and limitations of memory, DOS attack easily takes place and security vulnerability increases . Wireless sensor networks are much easier to implement in any situation and environment ,it is also very cost effective super fast than any other sensory device. tacks .

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So the use of WSN is increasing rapidly. Also the attack generation is much more easier so proper countermeasures should be taken against it. Basically different network layers have to face different types of attacks . So in this paper, DOS attacks on different network layers are discussed properly and the available countermeasures are also available in this paper for ensuring the security, non repudiation and integrity of different layers.

Background Study

Properties of wireless sensor networks and its constraints

A wireless sensor network is basically an embedded system which has 3 parts. First, it has some sensor which will sense the parameters.Then it is embedded tiny body where these sensors and other equipment like flash memory, batteries for power, etc and a medium by which it transfers, the collected data to end point application. Sensor plays the most vital role by sensing the environment, gather the proper information and transmitingt this data to the user applications for further use. The sensor is consists of 4 major works:

a) **Sensing the environment** sensors gather the information and there is an ADC (analogue to digital converter)inside it which converts the collected analogue data into digital signal.

b) **Processing the sensed data:** then this digitized data is processed by a processor after that it remains in storage memory of it. But the capacity of both the processor and memory is very low and short span.

c) **Transmission and receiving these processed data:** transfer and receiving of this data is done by a single transceiver module.

d) **Power supply:** Solar cells, batteries are the best options for power supplies. There is something alarming in the design of wireless sensor networks and that is their limited capacity of storage and also limited capacity of processing. These two constraints put them in danger and make a way for the intruder and hackers people to attack using these lacking. As wireless sensor networks give first priority to decreasing the costs,they make a huge lacking on other sides like increasing their capabilities or giving strong secured sensor system. So the main constraints of WSN are:

- There is only one flash memory and one RAM flash memory, so after installing all the application and operating system programs there remains only few spaces that is not sufficient.

- There is no segmentation in the messages and the message size of WSN is very small.

- In WSN, same data and information can be collected by more than one nodes or many nodes. So unnecessary data redundancy occurs.

- As it has low capacity processor, it's low computational capability is found and very low bandwidth and radio frequency are very high.

- There can be hundred of nodes or more than that in one WSN .So identifying each node with separate global address is quite challenging and impossible.

- Location management for the nodes of harsh and unmanageable environment is much difficult.

Wireless Sensor Networks Design issues :
Development of wireless sensor networks are not easy task as it has to contain a lot of sensors and circuits including external hardware in their tiny embedded system. It has to must ensure some parameters for working appropriately. Like :

Fault Tolerance Sensor nodes can fail anytime anywhere because of its physical damage or other attack issues. So it must be implemented in their design protocol to identify this sensor failure as soon as possible and inform the other part any other connected sensor.

Scalability The sensor node and other chips must be scalable for any other neighbouring networks so that it can work on different levels of sensing the parameters.

Hardware Constraints In every wireless sensor network, there must be four components : a power supply system, a unit for transmission, a separate unit for the sensors but not the least a processing unit for processing rest of the 3 parts. Despite having this, additional equipments or devices can be added or subtracted from the system.

Production Cost Above , we must keep that in mind that the whole system have to be cost effective and budget friendly for people of all clasees who want to afford it.

Network topology of sensors We have to design such a system, where network topology can be maintained properly by reducing the wasting energy. There are basically 4 pure topologies like : bus , star, mesh and ring.

Transmission media We need to choose such a medium where the loss will be minimum, which will be robust free and can transmit fluently without any pause or breaking.

Wireless Sensor Networks Types:
Mobile WSN
Multimedia WSN
Terrestrial WSN
Underground WSN
Underwater WSN

Application of wireless sensor networks:
Machine health monitoring
Data logging
Earth/Environmental sensing
Monitoring Air Pollution
Landslide detection
Forest Fire Detection
Monitoring water quality
Natural disaster prevention
Water waste monitoring
Producing wine

Security Requirements :
Security requirements basically ensure that the transmitted data over the medium will be secured and no one will alter or delete any important information of it. Each and every node will be authorized by

authorities and only they can take part in data exchange and passing. No trusted nodes can be masquerade by any malicious node. There must be integrity, non repudiation , confidentiality and security in every message passing.

Threat Model

Threats can be generated by the intruders or the outsiders of the network. When an insider attacks the system, then it is called native attack and it is much dangerous and harmful for the system than the outside attacks as the attacker knows many confidential and hidden information of that system network. Also it is very challenging to find out the insider. Also when an attacker attacks the system and change or alters the information of the message, it is called active attack. But in passive attack, no alterations can be done by the attacker.

Denial of service attacks and its effects:

When the attacker makes the system or the network inaccessible and uncontrollable , it is called denial of service attacks. DOS attack can be found in the network like software bug, complicated accessing of application, exhaustion of resources etc. Basically DOS attack is generated intentionally and it hampers the total system capabilities and stop the regular functionality of the system steps. In most of the situations, attacker creates DOS attack to disturb, interrupt or destroy the whole network. After this DOS takes place, some situation arise. That are :

- Sensors can transfer abnormally more data packets by gaining energy
- Intermediate and sender/ receiver nodes are not working - Clusters are not uniformly distributed
- There remains a chance of high loss of the transmitted packets
- An attacker can create a jam in the medium by remaining there and can send malicious traffic
- Attacker can create false message by taking the control of any nodes in WSN
- Attackers can target to do the power drainage of the sensors by
- Attacker can also create a unfavorable situation to prevent DOS attack also as they have much resources and techniques.
- They can loss energy of sensor nodes by creating false communication and keeping the nodesbusy.

Denial of service attack format:

Basically DOS attacks don't need any special program or place for generating the attack. It only targets the lacking or the vulnerability of the network communication and attack. DOS attacks mainly continuously stream some fake requests and send them to the server. Then the server usually responses with real answers . But after this, when attacker continuously streams repeated values, the server get confused and shut down.That's how the attacker successfully paralyses the system and prevents it from working. Denial of service attack creates an immense loss on organizations , office, financial sectors, confidential data and many more. We can detect denial of service attacks symptoms by following some steps.

1. Using traffic analytic tools to detect any DOS symptoms.
2. If an individual single IP range or IP address is generating a numerous amount of traffific, then it is suspicious.
3. If a single behavioral profile like a user/ web browser/ geo location is sending a flood of traffic then it is a symptom of DOS attack.
4. A request from an unexplained surge to become an endpoint.
5. Odd traffic patterns like the pattern does not look natural or it is giving spikes in the odd hours of working.

Related Work

In this section,basically different papers are discussed with their method,pros and cons of detecting DOS attacks on wireless sensor [1-5] networks. In [6] and [7], Denial of Service Attacks are categorized . In [6], these are basically the layers where the attack occurs. The layers are : Physical layer DOS attacks, Link layer DOS attacks, Network layer DOS attacks and Transport layer DOS attack. There are primary and secondary security goals for preventing security attacks in WSNs which should be supported by the security mechanisms. Confidentiality,Availability Authentication and Integrity are the four primary goals on the other hand Secure Localization,Time Synchronization, Self-Organization, and Data Freshness are the four secondary goals for WSNs. Two subcategories of security attacks for WSNs can be categorized, Passive attacks and Active attacks. The well-known counter measures and security mechanisms of all the attacks are also mentioned in this article. In [2],this article contains custom dataset of intelligent underwater wireless sensor network which can be divided into four categories of DoS attacks (gray hole, black hole, scheduling attacks and flooding).Method used to train datasets is Artificial Neural Networks to classify them into different DoS attacks. The experimental work carried out here has a high classification rate and accuracy, which is worth mentioning attack with the suggested dataset.To create the structure of an intrusion detection system to resist DoS attacks at an affordable cost is the main goal of this paper.The results considered have been successfully classified as a DoS attack with higher detection rate. In [8], The purpose of this research is to design WSN DoS attack detection system with energy consumption, optimized cost,security and complexity.The data set is structured as the DoS attacks are divided into four types: gray holes, black holes,scheduling and flooding. For testing performance of DoS detection on WSN dataset decision tree and support vector Machine learning [9-13] algorithms are used. Experimental results shows that decision tree technology has achieved higher True positive rate and lower false positive rate achieved by Support vector machines. The rate of percentage : 99.86 percentage vs 99.62 percentage and 0.05 percentage vs 0.09 percentage respectively.In [14], DoS attacks and various Countermeasures have been discussed in this report. Some of the defense mechanism provided also has some limitations and can defeated by the attacker's counterattack.Most threat types can be overcome by Authentication and anti-replay mechanism. Other methods can also avoid or detect and recover from attacks, but these solutions can also be defeated by some counter mechanisms. This is why we need to find some specific remedies and research them to protect DoS. In [15], A hierarchical clustering system (HCS) is proposed to improve accuracy to prevent DoS attacks and extend network life. In the proposed mechanism,Hierarchical Cluster System (HCS) without any specific cluster head is formed based on the energy level of the sensor node. any abnormal packages through detection can be detected by nodes with super energy.Refusal of sleep attacks is a serious difficulty in wireless sensor networks.The result of solving this difficulty was implemented. HCS protocol is very suitable for largescale The internet. The protocol described above can also manage the denial of sleep attacks in the following ways Find the detection and in [16],This article reviews denial of service attacks(DoS) in the information system by using citation mapping tools and citation networks analysis (CNA). For implementation a framework is presented for defense mechanism against DoS attacks. Citation network analysis also Shown in the results.To identify important works related to research citation network analysis in Web of Science (WoS) is used. Types of DoS attacks and defense mechanisms for defending security attacks with the help of intelligent systems are proposed in this paper. To Protect information systems Information security policy also plays an important role. In [17] an [18], Different layers of WSN features, constraints and types of various DoS attacks are focused in this paper.In many cases, the attack may overlap each other. Any intentional or unintentional DoS situation in WSN needs to be resolved by powerful mechanism. Always recommend develop and deploy appropriate measures in WSN.in [19],This article examines DoS attacks and Propose a strategy based on clustering technology. This method is compared with other related methods Agreement, the results show that our method can effectively detect and defend against DoS attacks for wireless sensor network.In this article, a unique detection and defense method called DoS attacks in WSN is proposed. Hash function and encryption technology used to ensure the authenticity and integrity of data in the network. DOSAC scheme

generates unique code and hash value to verify transmission data pack. The simulation results show that can effectively detect and defend DoS attacks in WSNs.In [20],The purpose of this survey is to provide up-to-date information on different types of DoS attacks and defense technologies of WSN, the improved changes, according to recent works.Information about attacks and their defense mechanisms, focusing on the different layers of the hybrid layered model have been structured.This method clearly specifies which type of DoS threats will be encountered at which layer, and what is the corresponding defense technology. This survey also makes it easier for people to consider different changes in prevention mechanisms, which can lead to major improvements and safer networks. It also provides key analysis and comparison of these defense technologies for further improvement. In [21],This research work analyzes the performance of professionals constitute Optimized energy-based constraint DoS detection algorithm, which has three different modules, such as energy, bandwidth and attacker detection unit and compare with existing Offloading Denial of Service Attack Detection with Energy Constraint in WSN.The proposed work has been implemented by using a network simulator. From the simulation results it can be seen that the proposed OBES algorithm is efficient because it provides more usable energy
and reduces latency less data packet loss, longer network life. The OBES algorithm can achieve a higher network lifetime before and after the attack detection model. It helps reduce energy consumption, high security and long network life wireless sensor network. In [22],This article covers the basic threats that are threatening WSN is available every day. The main part of this article describes DOS's attack on WSN and solutions suggested by literature used to detect and resolve specific attacks.The attack will cause the WSN to be completely or partially shut down.Therefore, a lot of research is not surprising once a day to protect WSN from different and various DOS attacks. DOS attacks can be divided into multiple categories. The attacks are classified according to the protocol stack layer [23].The most threatening attack is a DOS attack on a physical device layer, on connection layer, at the network layer, transport layer.

Comparative Study

In TCP-IP model there are five layers these are physical layer, link layer, network layer, transport layer and application layer. Different kinds of layers have different kinds of DOS attacks. In this section, we will show a comparative analysis on different types of DOS attacks and counter measures.

Attacks on application layer

Path based denial of service

In response a network when some packets are inserted into the
leaf nods they travel to base station and waste the energy, bandwidth of that node. For this reason one authenticated become unable to trans fer the data to base station .

Overwhelming sensor node

For application layer it is a very common attack. In these types of attacks some fake nodes can overwhelm the whole system by prompting the sensors. For this big portion of traffific is sent to end points. So bandwidth and power both are unnecessarily wasted.

Attacks on Transport layer

Content Attack

In this type of attack, the attackers change the serial of the message and insert unnecessary or fake contents in it message.

Synchronize flood attack

In this type of attack the attackers send continuous connection request, As a result all the resources become blocked and exhausted. For these requests the system reaches on maximum limit and starts to ignore the legitimate requests.

De-Synchronize attack

In this types of attack fake re-transmission requests are generated for missed contents or frames. It basically drains the energy of end systems by generating spoof messages.

Attacks on Network layer

Hello flooding

Hello flooding is one kind of flooding attack in which huge traffic is generated by unnecessary messages. So it makes all the channel congested. Attackers use RF transmitters to generate these attacks.

Spoofing

Spoofing attack is one of the most serious attacks. In this type of attack the attackers inside the network and cuts off all the communication packets which are sent to it. It is very much difficult to identify because it can pretend as a base station too and can forward packets in different nodes disguised with a fake identity and harms all the transmissions of different nodes. One attacker may have multiple fake identity as well.

Black whole attack

It is one of the most dangerous attacks in network layer. It is a very well known attack all over the world. In this type of attack a false node pretends and becomes a authenticated node.

Attacks on Data Link layer

Denial of sleep

Denial of sleep attack basically targets the MAC layer. A simultaneous fake traffic tries to keep the node always awake. So for these nodes, radio can not go to sleep mode and power sources are heavily drained.

Collision

These types of attacks take place when an equal frequency channel try to access it for continuous transmission. Packet collisions are increased for this. Interrogation attacks basically generate some fake RTS(Request to send) which make the node busy and the real RTS is missed by the node. It is a very well known attack.

Attacks on Physical layer

Node Tampering

By these types of attacks nodes are physically tempered. By damaging the node the attacker can retrieve sensitive information(Keys) and communicate in higher level.

Jamming

In physical layer it is the most common type of attack. By generating false traffic the attackers make the network jammed. For this reason the authenticated transmissions cannot be done. There are different kinds of jamming attacks like Reactive, Random, Content or Deceptive.

TABLE I
DIFFERENT DOS ATTACKS ON DIFFERENT LAYERS

Attack Name	Affected Layer	Counter Measure
Path based denial of service Overwhelming sensor node	Application Layer	One way hash chain Sensor modification
Content attack Synchronize flood attack De-synchronize attack	Transport Layer	Client puzzle Full packet authentication Reducing connection Message observation mechanism TCP SYN Cookies
Black whole attack Spoofing Hello flooding	Network Layer	Multi-path routing DSR based protocol Acknowledgement mechanism Clustering Approaches Geo-location and energy aware protocol
Denial of sleep Collision Interrogation	Data Link Layer	Anti-replay Packet authentication MAC layer authentication Error correcting code Collaborative hierarchical model
Node Tempering Jamming	Physical Layer	Jamming repot Go blind technique Path re-routing Spread spectrum communication Camouflaging

Open Issues and Conclusion

Wireless Sensor Networks are nowadays a most picked up and trendy topic for research and development topic. Because of having low cost design and friendly interface for use, it is everywhere for gathering information from sensitive places. But it has many constraints which was discussed in previous sections and for this it has to face many serious attacks. There is a saying that prevention is better than cure and for this case, it is hundred percent applicable. If the proper attack management system and measure can be ready before the attacker can take a chance, then the wireless sensor networks will be much secured and exact. Also the design issues can be changed so that it can consume more memory and can have more battery life to serve more. So future work must be on prevention techniques before the attacks rather than dynamically facing the attack. Recently a work has been imposed to prevent denial of service attacks having the title a work has been imposed to prevent denial of service attacks having the title CO-FAIS (cooperative fuzzy artificial immune system) which can be great research to prevent and cure all types of DoS before it took place. can be a great research to prevent and cure all types. Nowadays wireless sensor networks are gaining much popularity for their simple design structure, less complexity in computation and cost effectiveness. But this simple design led this whole system into danger. For this simple and easy structure, attackers can easily cut off different layers security settings . In this paper, different kinds of DOS attacks in different different layers of TCP/IP model has been showed . Also the countermeasures of each individual attacks are being discussed. But there is no fifixed attack and no fixed solutions for all the attack prevention. So in order to assure the data and transportation security, the design must be upgraded , high encryption and more reliable devices should be introduced and all the nodes must be error less individually.

Counter Measure Name	Affected Layer Name	Counter Measure Techniques
One way hash chain	Application layer	This method basically prevent path based DOS attack. A packet verification system is applied here with one way hash chain.
Sensor modification	Application layer	Sensors need to be modified so that it can not be overwhelmed by the fake nodes so that they only can except the authenticated node.
Client puzzle	Transport layer	In this type of defense technique attackers need to solve a complex puzzle of cryptography to build the connection. So attackers must have great computational power to solve this puzzle.
Full packet authentication	Transport layer	This method is less reliable but it can defense against attackers authentication by the help of a header defense mechanism.
Reducing connection	Transport layer	This defense mechanism can protect the nodes from draining the power sources but this can terminate the connection.
Message observation mechanism	Transport layer	In this types of defense mechanism message numbers and message contents are considered and if the messages not normal then it is forwarded to junk message list.
TCP SYN Cookies	Transport layer	This defense technique is little bit computationally expensive. Here SYN messages of clients are encoded , the messages are forwarded to client and all these works are done by the cookies.
Multi-path routing	Network layer	This defense technique is used to prevent black whole attack. Here the same data is repeatedly forwarded on different routs and the probability of these data is increased for going to the actual destination.
DSR based protocol	Network layer	Dynamic source routing(DSR) is used against spoofing attack. Here all the nodes are treated by their reaching ability to the destination node. Once a node got failed it is marked as a negative node.
Acknowledgement mechanism	Network layer	This defense mechanism ensure that all the packets are forwarded serially after getting the acknowledgement packet from the other side. This defense mechanism can also be used to prevent black whole attack.
Clustering Approaches	Network layer	This defense technique is used to preven hello flooding attack. A cluster head is made by joining the nodes of cluster.
Geo-location and energy aware protocol	Network layer	This defense technique is also used to prevent hello flooding attack. All the nodes must be acknowledge about their and their neighbors location in order to exchange data.
Anti-replay	Data Link layer	Anti-replay technique is used to prevent interrogation attack. It verify much old packets and drop it.
Packet authentication	Data Link layer	It gives solution against Denial of Sleep attack. This attack can also generate after having the layer encryption so proper measurement like jam identification, anti replay security, securing the broadcasts and strengthening the link layer authentication is a must.
MAC layer authentication	Data Link layer	Interrogation attack is being reduced by this technique. In this measure, replayed and repeated packets are also dropped by the system.
Error correcting code	Data Link layer	Though this defense technique has some overhead like resource consumption ,it can fight against collision attacks.
Collaborative hierarchical model	Data Link layer	This defense technique can increase the battery life of the nodes and can fight against denial of sleep attack. It also cut off and detect the fake packets.
Jamming report	Physical layer	There is a time gap between the jamming attacks and by using this lacking of the attacker a report based mechanism is applied to prevent jamming report.
Go blind technique	Physical layer	It works against node tampering. The mechanism of going fully blind is applied when the node is being tampered.
Path re-routing	Physical layer	It works against the jamming attack. By ignoring the attacked path in the whole system, new altered or route can be taken for further communications.
Spread spectrum	Physical layer	Preventing the attacker to follow the real sequence of the hop, code spreading is used and thus jamming can be defeated.
Communication Camouflaging	Physical layer	It also works against node tampering . The external body of the node is made fully tamper proof.

Table 2 COUNTER MEASURES OF DIFFERENT DOS ATTACKS

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Design and Implementation of Free Space Optical(FSO) Network under Turbulent Conditions

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Tabassum Hasnat Reshmi*

Abstract: ***Free-space optical (FSO) transmission for optical fiber communication system referred as one kind of sustainable and suitable technology for broadband wireless connection that is gaining attention for its low installation cost and high data rate transmission capability with unlicensed spectrum. Free-space optical communications (FSOs) cultivated in a clear atmosphere are small but due to the variety of temperature, it may suffer from fluctuations of radio. It is utilized by the bit error rate scheme and binary phase shift keying. The probability of embarrassment obtained after crossing the atmosphere has been modeled using the probability density function (PDF) Rayleigh distribution by rating the performance of a turbulent system from weak to strong. The improvement varies for different turbulence power and modulation systems. Moreover, the bit error rate performance utilizing BPSK modulation in the subscriber becomes much better under unstable atmospheric states. Another novelty of this study has been found 3500m is the effective transmission length for the developed Rayleigh Distribution Model***

Index Term: Free-space optical (FSO) communication, Bit Error Rate (BER), Binary Phase Shift Keying (BPSK), Turbulence, Atmospheric Effect.

Introduction

Free-space Optical (FSO) system uses a fiber cable which employs light energy for data transmission optimizing air medium [1]. Telecommunication system considers FSO that is an optical fiber system which transmits light by transmitting data [3]. Instead of placing light strands in glass fibers, they are transmitted through the atmosphere in narrow rays.

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Light sources and detectors are employed in Free-space optical (FSO) for transmission and receiving of information through the optical fiber communication. [3-4]. The incentive for FSO is to maintain the benefits of higher rate (up to 1 gigabyte per second) for data transmission. Time and cost can also be reduced by utilizing optical fiber communication schemes. [1-3]. Light transmission from one telescope to another telescope is possible using highly powered optical source in a FSO system. [1]. At this point, the high-sensitivity receiver is connected through the resulting telescope via the optical fiber.

In building to building or block to block, aircraft satellite uses FSO communication system. [2-5]. This protocol is generally implemented for military systems because most of the systems works for 1-3 km and uses LASER technology in parallel to alleviate distance problems [3-7].

Objective of this Work

The described work has only focused an effective Free-space Optical (FSO) data transmission that is highly sensitive to the atmospheric turbulence. So, if Rayleigh Distribution method has been applied here, an FSO system will work more efficiently in a complex weather condition. So, the two more objectives of this work are, applying Rayleigh Distribution Model and analyzing SNR & BER for BPSK Modulation scheme to design a perfect FSO communication system. New mathematical expressions have been developed here for implying in the communication system of Free Space.

Channel Modeling

A turbulent model worked in a composite environment for an FSO system which can work properly in such type of environment in a channel modelling system [3].The energy parameter is consumed by its steadiness and is adjusted with the inside scale of a compound system with a particular cell size. Another important thing is the refractive index that differs in various types of turbulent phases and causes amplitude and phase fluctuations The performance of an FSO may be imbalanced by the atmospheric massiveness and after that, the level of faded signal will rise [2-4].The fading strength is affected by the span of link, wavelength of the optical radiation and the channel's refractive index structure parameter Cn^2. Thus the model is defined using the Rytov variance σ_R^2. The turbulence-induced fading probability is $\sigma_R^2<1$ and this can define the limit of validity of the model [6-10].

$$\sigma_R^2 = 1.2\ 3\ Cn^2\ k^{7/6}\ L^{11/6} \quad \text{.....(1) [21]}$$

Lognormal Distribution

LASER light's log intensity I has been approached in the lognormal distribution modelling and it will search the turbulent atmosphere which has the mean value $-\sigma_1/2$. So, probability density function of the irradiance of received signal,

$$f(I) = \frac{1}{(2\pi\sigma_R^2)^{1/2} I} \exp\left\{-\frac{(\ln\ln(\frac{I}{I^0}) + \frac{d^2}{2})^2}{2\sigma_R^2}\right\},\ I \geq 0 \quad \text{.....(2) [21]}$$

The Negative Exponential Distribution

The link has approximately a length of several kilometers. The number of individualistic disintegrating becomes larger in a condition of irradiance with fluctuations (i.e. steeper mode and beyond). In the turbulent avenue and in this situation the irradiance fluctuations of the peak values in the field covering is generally hold and empirically verified for bowing to the 'Rayleigh Distribution' method that implies dismissive exponential results [16-19]. This is given below:

$$f(I) = \frac{1}{I_0} \exp\left(\frac{-I}{I_0}\right), I \geq 0 \quad \text{.....(3) [21]}$$

Gamma-Gamma Distribution

The multiplied result of two self-sufficient random processes lodged a statistical model that factorizes the irradiance with a Gamma function (Probability Density Function). The PDF of the intensity fluctuation is given by [13-17].

$$f(I) = \frac{2(\alpha\beta)^{(\alpha+\beta)/2}}{\Gamma(\alpha)\Gamma(\beta)} I^{\frac{(\alpha+\beta)}{2}-1} K_{(\alpha-\beta)}(2\sqrt{\alpha\beta I}), I>0 \quad \text{..... (4)}$$

I is the strength of transmission wave, (.) is the Gamma probability function, and $K_{\alpha\beta}$ is Bessel function (modified). The parameters α and β states the scintillation consummated by plane waves. For zero inner scale, [17-19],

$$\alpha = \frac{1}{\exp\exp\left[\frac{0.49\,\sigma_R^2}{(1+1.11\,\sigma_R^{\frac{12}{5}})^{\frac{5}{6}}}\right]-1} \quad \text{.....(5)}$$

$$\beta = \frac{1}{\exp\exp\left[\frac{0.51\,\sigma_R^2}{(1+0.69\,\sigma_R^{\frac{12}{5}})^{\frac{5}{6}}}\right]-1} \quad \text{.....(6) [21]}$$

Rayleigh Distribution

The channel gain is described by the Rayleigh model. For the Rayleigh state, the index of brightness is 1. The probability density function of Rayleigh is more concerted in comparatively faded estimations. The probability function for Rayleigh distribution,

$$f(I) = \frac{1}{\sigma_R^2} \exp\left\{-\frac{I}{2\,\sigma_R^2}\right\}, I \geq 0 \quad \text{..... (7)}$$

Modulation Schemes

In Free-space optical (FSO) data transmission systems, the optical source intensity is modulated for transmitting signals through a channel. Considering the efficiency of power and bandwidth, the modulation scheme requires a simple design, low cost accomplishment and immune system to background radiations interference.

On-Off keying Scheme

On-Off Keying (OOK) considers the intensely modulated channels which considers direct detection [6]. It is a simpler type modulation strategy of amplitude shift keying. The received signal of photocurrent is reactively correlated to the optical power. For each bit of time, it is assumed that the receiver eliminates constant biases due to illuminated background area and integrates the photocurrent. Due to atmospheric misalignment, intensity fluctuation of a signal affected the received signal y, as well as connecting sounds. It is modelled as: [9-13].

$y = h\, R_x + n$ ..... (8)

Here, (R_x is the intensity of transmitted signal, here the channel state, y is the resulting electrical signal, and n is signal-independent additive white Gaussian noise with variance σ_n^2 [9].

Binary Phase Shift Keying Scheme

General form for BPSK follows the equation [16-18]:

$S_n(t) = \sqrt{\frac{2E_b}{T_b}} cos\,(2\pi f t + \pi(1-n)), \rightarrow n = 0,1$ ..... (9)

There are two phases, 0 and 1. Binary data can be brought with the following signals:

For binary 0,

$S_0(t) = \sqrt{\frac{2E_b}{T_b}} cos\ cos\,(2\pi f t + \pi) = -\sqrt{\frac{2E_b}{T_b}} cos\ cos\,(2\pi f t)$ ..... (10)

For binary 1,

$S_1(t) = \sqrt{\frac{2E_b}{T_b}} cos\ cos\,(2\pi f t)$ ..... (11) [22]

Where f is the frequency of the base band.

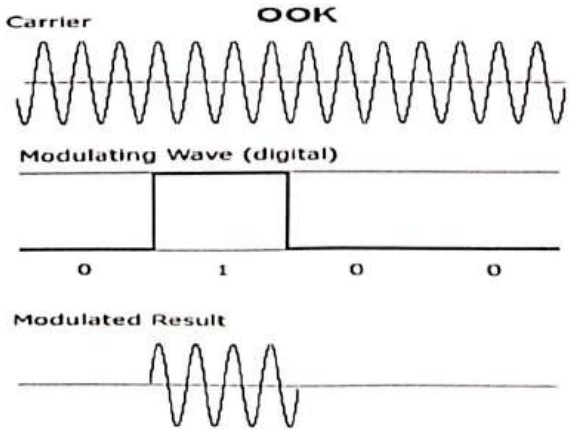

Fig. 1: On-Off Keying

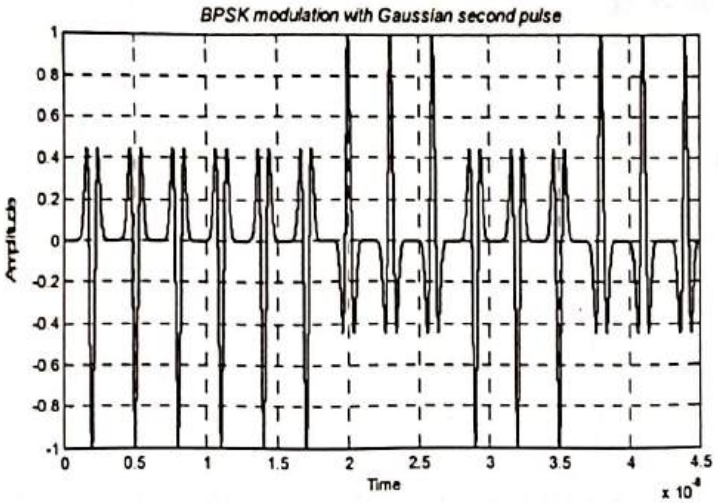

Fig. 2: Binary Phase Shift Keying (BPSK)

Considering subcarrier for all disordered conditions, the bit error rate of always give better output than on-off keying.

Signal to Noise Ratio

Ratio of the level of signal wave to the level of noise is called as signal to noise ratio (SNR).

$$SNR = \frac{P_{signal}}{P_{signal} - P_{received}} \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots (12)$$

$$SNR_{dB} = 10log_{10}(SNR) \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots (13)\ [23]$$

Bit Error Rate (BER)

While data streaming, the errors per bit for per unit time range is defined as bit error rate. It can be amended because of any kind of bit synchronization errors, distortion, noise, interference.

The bit error rate of BPSK is:

$$BER = \frac{1}{2} erfc\left(\sqrt{\frac{SNR}{\sqrt{2}}}\right) \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots \quad (14)$$

$$BER_{Average} = \int BER \cdot f(I)\, dI \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots \quad (15)$$

Observation and Result

All the verifications have been done using MATLAB R2015a. The model is simulated for all weather conditions. We have related Rayleigh Model, SNR, BER, Positive extinction coefficient (α = 0.12*10^-6) and Irradiance (I = 0.001:0.01:4) using the parameters [15-18].

Transmission Power Vs Receiving Power without Atmospheric Effect

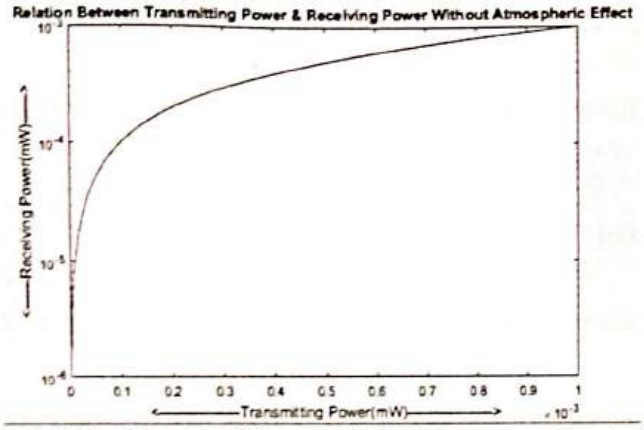

Fig. 3: The Curve of Transmitting Power vs Receiving Power

In spite of having some basic transmission losses with the increase in transmission length the receiving power increases considering the effective transmission length with the increasing of transmitting power.

PDF for Rayleigh Distribution

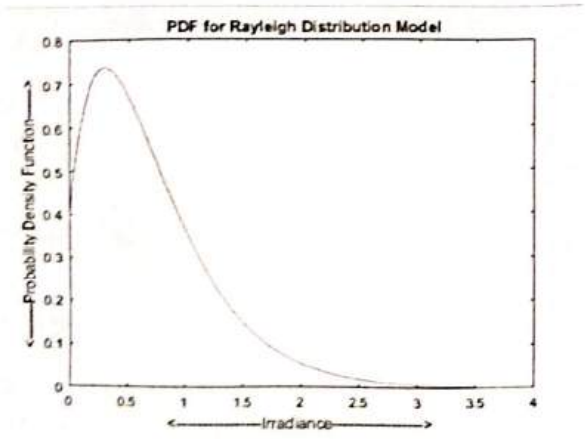

Fig. 4: The curve of Probability Density Function Vs Irradiance

Fig. 4 shows that, how the probability density function changes with respect to the irradiance. The index of brightness for the Rayleigh state is 1. Probability Density Function of Rayleigh is more concerted at comparatively faded situations.

The equation for Rayleigh distribution,

$$f(I)=\frac{1}{\sigma_R^2} exp\{-\frac{I}{2\sigma_R^2}\}, I\geq 0 \quad \text{.....(16)}$$

In the above equation, with a variation of 0.01 irradiance varies from 0.001 to 4. If transmission length varies, the simulation for Rayleigh distribution varies as well.

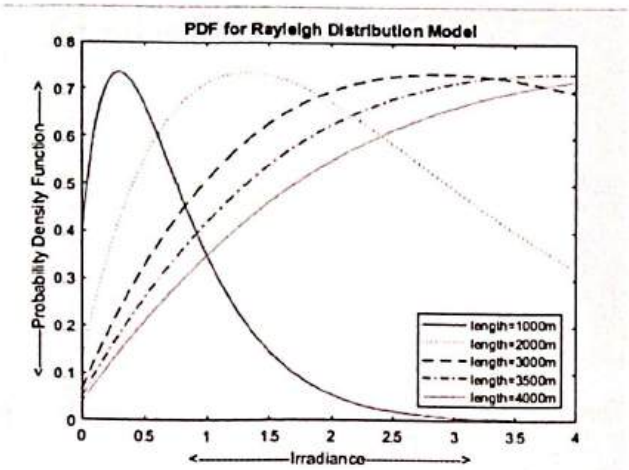

Fig. 5: Comparison of Probability Density Function and Irradiance for Different Transmission Length

In this curve, after 3500m, probability density function will go to saturation mode.

Transmission Power vs Receiving Power with Atmospheric Effect:

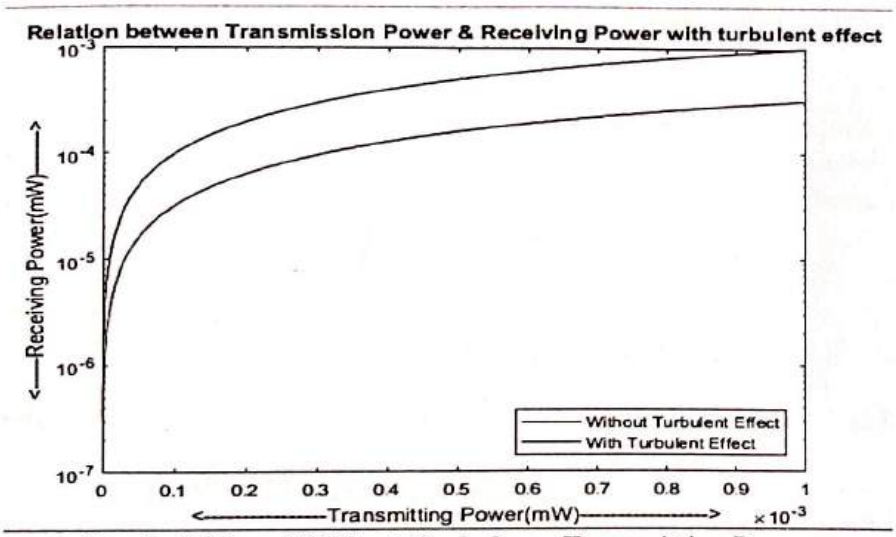

Fig. 6: With and Without Turbulence Transmitting Power vs Receiving Power

Fig. 6 shows that, blue colored curve and red colored curve changes respectively. After observing we can say that, red line curve shows some power losses.
Here is the equation,

$$P_R = P_T exp(-\alpha L) * f(I) \quad \text{.....(17)}$$

Where,
P_R= Receiving Power.

P_T = Transmitting Power.
f (l) = PDF for Rayleigh Distribution
α = Positive extinction coefficient
L = Transmission length in meter.

Transmitting Power Vs Signal to Noise Ratio (SNR)

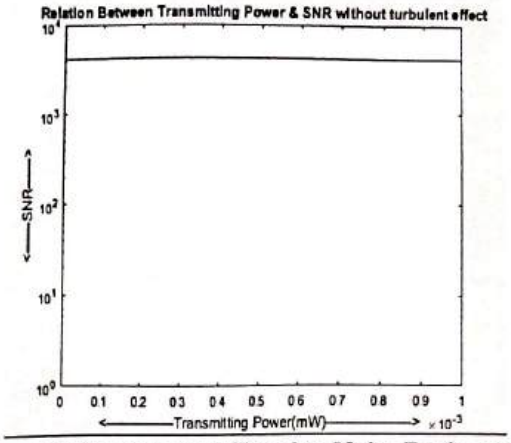

Fig. 7: Transmission power vs Signal to Noise Ratio except Turbulence

Fig. 7 shows that, with respect to the transmission power curve, signal to noise ratio remains constant.

Bit Error Rate (BER) for BPSK Modulation

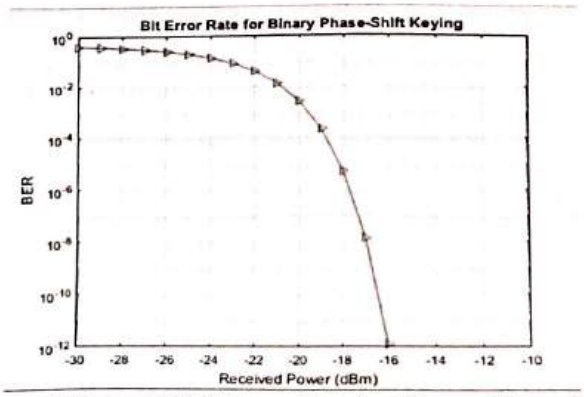

Fig. 8: Received Power Vs Bit Error Rate for Binary Phase Shift Keying

In Fig. 8, when the obtained power increases, bit error rate (BER) decreases.
Bit Error Rate (BER) for binary phase shift keying:

$$BER = \frac{1}{2} erfc\left(\sqrt{\frac{SNR}{2 \cdot \sqrt{2}}}\right) \quad \ldots\ldots (18)$$

The equation of SNR is:

$$SNR = \frac{SNR_{Rms}}{\sigma_{Th}^2 + \sigma_{Sh}^2} \quad \ldots\ldots (19)$$

Where, $SNR_{Rms} = \frac{I_{sc}^2}{2}$ ..... (20)

The calculation of photo-diode current :

$$I_{sc} = R_d P_r (1000/L) \quad \ldots\ldots (21)$$

The calculation of Thermal noise :

$$\sigma^2_{Th} = \frac{4KTB}{R_l} \qquad (22)$$

The equation of shot noise :

$$\sigma^2_{Sh} = 2qB(I_{sc} + I_b) \qquad (23)$$

If transmission length varies, the resulting curve of the bit error rate will also varies with respect to receiving power [24].

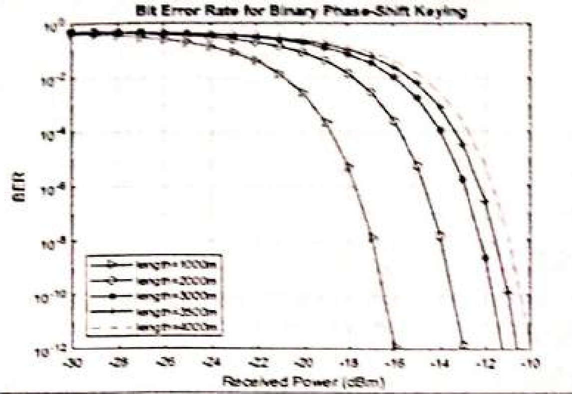

Fig. 9: Received Power Vs Bit Error Rate for Binary Phase Shift Keying

In Fig. 9, bit error rate increases with respect to the transmission length and also for different transmission lengths. Here, bit error rate for 3500m is the ideal case. There are some points given below in spite of having some problems which are investigated here for an FSO communication link:

1. In this paper, a correlation between the receiving power and bit error rate has been introduced. If the channel length increases bit error rate also increases. As example, for an assuming value of -16 dBm, bit error rate for 1000m transmission length is 10^{-12} m and for 3000 m transmission length it is 10^{-2} m.

2. Used Rayleigh distribution model instead of Gamma-Gamma model which is easy for channel modeling. We have used BPSK modulation instead of OOK modulation. The bit error rate performance of subcarrier utilizing binary phase shift keying is always better than that of OOK for all complex atmospheric conditions.

Future Work

- Further research will be focused on assortments of wavelengths and ideal number of optical wavelengths conception for different atmospheric conditions [18].
- Reliability and suitability of the FSO link should be ameliorated where the link can be established by taking survey of a particular area.
- The performance of optical source and detectors with the longer length of the waveform can be observed and the effect of fog on the optical beam can be minimized [17-20].

Conclusion

FSO communication system can provide a better alternative for a secure communication system. The demand of high bandwidth can be a prime cause of it [11-14]. The research work is focused

for a optimum transmission for different atmospheric states for a Free Space Optical(FSO) communication [15-19]. New mathematical expression like Rayleigh Distribution has been developed to improve transmission length, transmitting and received power and the decreasing of Bit Error Rate (BER) [13-18]. A correlation between transmitting power and receiving power has been introduced with and without atmospheric effect. Also developed an ideal transmission length which is 3500m for channel modeling.

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Strengthening the Concrete Structural Models using various types of confinement

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Abstract

Now-a-days frequently occurred earthquake has raised cautionary signals in Bangladesh about the possible, colossal earthquake in the near future, whose impact can be devastating. In this paper the main objective is to investigate the seismic response and also the failure mode of the various models, since the column is that the most critical part of the structural elements, column type models are chosen. Another purpose is to assess the suitability of various retrofit measures to enhance structural strength. Sixteen concrete column models without and with three kinds of confinement i.e; wire mesh, tape and Fiber Reinforced Polymer (FRP) are tested to investigate their seismic behavior. Model to prototype ratio 1:3.68 is maintained, to match the ratio of the earthquake ground motion of the shake table which was calibrated from the EI Centro earthquake (1940) ground data. Experimental results from the shake table show that the confined structural models have greater capacity in terms of strength and ductility than the unconfined structural models. FRP confined models show better seismic resistance capacity among all the models. Comparisons between experimental and numerical results show outstanding agreement in terms of maximum displacement of structural models.

Keywords: *Earthquake, Fiber Reinforced Polymer (FRP), shake table, tape confinement, wire mesh.*

1. Introduction

Urbanization in Bangladesh has been rapidly taking place over the last few decades and a numerous number of buildings constructed throughout the country without maintaining standard construction practice and proper planning [1]. Those concrete buildings are more susceptible to damage and collapse, causing havoc in the densely populated area mainly in cities, even if a moderate earthquake occurred originating from nearby faults. So, evaluating the seismic adequacy of the existing structure and strengthened to desire level of seismic resistance is important to mitigate the destruction. The usual experimental technique for earthquake engineering is shaking table testing [2].

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A prototype concrete structure or a scaling down model of an existing building on a shake table should plainly give better evaluation [3-5]. But to make the procedure simple and on account of the capacity of shake table, concrete structural models are used with some measures of confinement to evaluate their effectiveness [6-7].

2. Theoretical Background

2.1. Scaling Laws

Usually micro-concrete model is used to simulate normal concrete structure during earthquake simulation test [8-13]. In this research, similitude laws are used to predict the nonlinear seismic response of prototype structures.

2.1.1. Similitude Ratios in this work

In this work a similitude scale of 1:3.68 is used, because the EI Centro earthquake plate used here was calibrated from the original EI Centro Earthquake (1940) ground vibration motion data divided by a scaling factor 3.68.

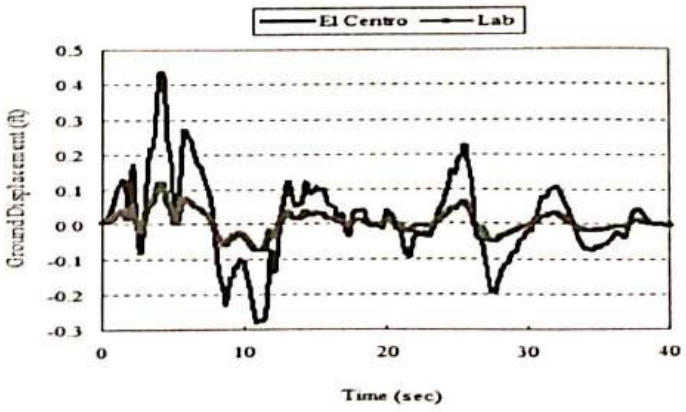

Fig. 2.1.1. Ground Motion for Laboratory Shake Table and El Centro earthquake

2.2. Ductility

The ability of structure to undergo large inelastic deformation in post-elastic range without a substantial reduction in strength with ductility a building can continue to resist seismic forces without collapsing.

2.3. Confinement

Concrete can be confined/restrained transversely by reinforcement consisting of steel, tape FRP (Fiber Reinforced Polymer)

The advantages of FRP are

- Excellent high strength to thickness or weight ratio.
- Enhanced stiffness, Shear and Tensile capacities.

- Chemical Resistance, Flexible, Thin Section and Economical.

Typical Application includes piers, Columns, beams, Slabs, Retaining walls, Bridges, pipes

2.4. Moment-Curvature Analysis

Moment-curvature analysis is an essential component in determining the capacity of reinforced concrete structures. The load-deformation behavior of a concrete section using nonlinear material stress-strain relationships can be predicted using a moment-curvature analysis. A moment-curvature diagram plots the curvatures against corresponding moments, thus establishing the ductile capacity of a cross section [14-19]. In this work, the moment-curvature of the concrete columns was determined using a computer program written in FORTRAN, which is useful for nonlinear analysis as it provides a methodology to assess the moment and curvature capacities of a cross-section.

3. Experimental Setup:

3.1. Preparation of Models:

Scaled modeling is not uncommon in Engineering. In this work, Simple concrete structured model is used. For laboratory test, sixteen model is constructed which are divided into two different sizes. Both types have an equal foundation of 1 feet by 1 feet. But the length and Diameter are different. One type has a 24-inch length and 1.5-inch diameter where another has an 18-inch length and 1.25-inch diameter.

Forms for all concrete Structure must be tight, strong and rigid. So steel molds are used for model construction. Molds are placed in such a way for convenient casting. The concrete is made using 1:1.5:3 ratio of cement to sand to aggregate by volume. Here passing #4 and retaining #8 sieve's brick chips are used as aggregate. The W/C ratio of 0.55 is used.

Fig. 3.1: Steel Mold Fig.3.2: Placing Concrete Fig.3.3: After Concrete Casting

3.1.1. Confinement of models:

In order to strengthen concrete structures against Seismic loading, Confinement is an important option. Among different types of confinement option, Fiber Reinforcement polymer (FRP), wire mesh and tape are used in this experiment

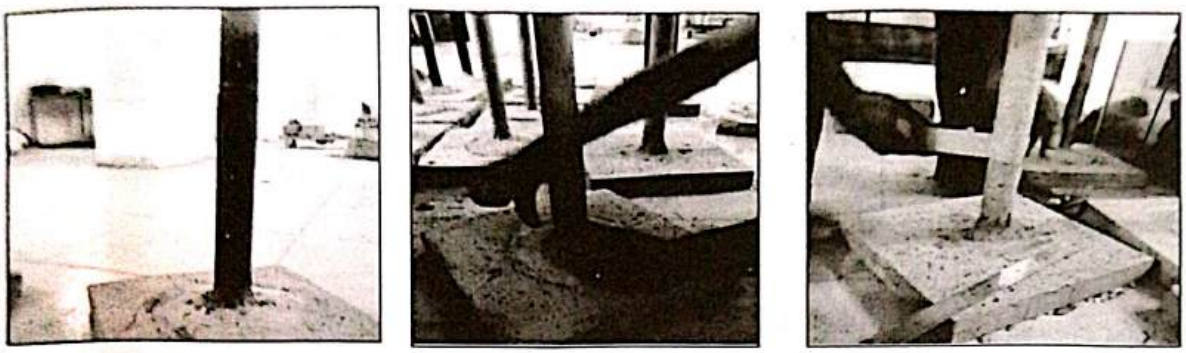

Fig.3.1.1: Confinement by FRP, wire mesh and Tape

3.1.2. Addition of superstructure mass:

Structural molds were constructed excluding the mass at the top because of construction difficulties. So, mass is added in the system before the testing of model with sand bags and weight blocks.

3.2. Shake Table Test:

An experimental platform that simulates earthquake motion to verify seismic performance of building structure. Shake table is used to test structural models and components, usually to the point of failure. The shake table set up in the structural mechanics and strength lab in the Department of CE at UAP consists of molds structure, shaking plate, EI Centro earthquake Plate (marked), Motion regulating motor, etc. There is a rotating shift which is fixed a motor and rotates under the plate, which makes the plate more forward. The motor has a capacity of 1750 rpm and its speed can regulated to run at three time durations i.e. 15 sec, 20 sec , 25 sec structural models are placed on the base of the Shake Table using four connecting bolts. A steel cap is used on top to carry mass easily. A marker is set on top of mold which gives the displacement record on the moveable paper.

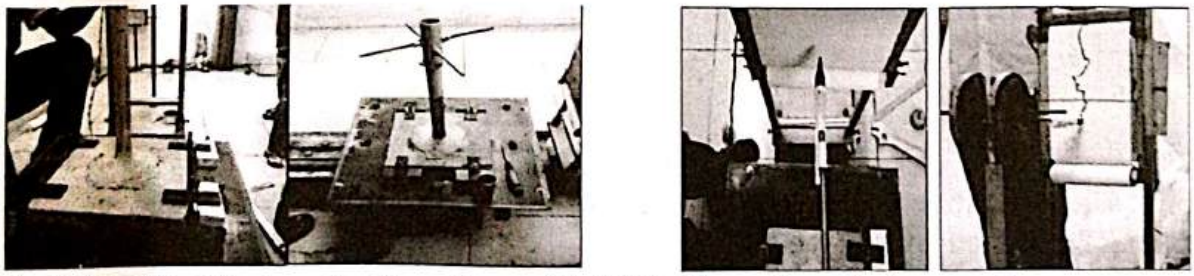

Fig.3.2.1: Model set up for Experiment Fig.3.2.2: Recording displacement

4. Numerical and Experimental Results

4.1. Shake Table Test

The columns were tested in the earthquake shake table described earlier, superposing additional masses (i.e., sand bag and weight blocks) at the column tip and running the structural models for 15 seconds. The additional mass is increased until the column fails; i.e., initiated by its concrete failing in tension, causing the

sectional failure and collapse of the column.

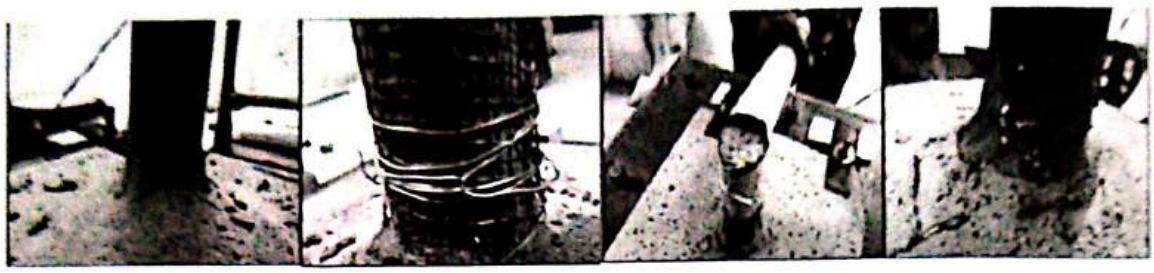

Fig.4.1: Failure of the Models with different confinement types.

4.2. Numerical Analysis

Nonlinear dynamic analysis is conducted in order to evaluate the seismic performance of the structure. A structure subjected to earthquake is expected to show inelastic behavior, that is, the deformation is a member does not proportional to the internal force. Moment curvature of the column section is taken as the basic starting point of numerical analysis in this work, from which the other aspect of nonlinear dynamic analysis is made [20-24]. From the moment –curvature graph some important parameters obtained these include the initial flexural rigidity (EI), yield curvature ( ) and ultimate curvature (ult) values taken from the moment-curvature relations, which are then used to calculate stiffness the lateral k (= $3EI/L^3$), yield deflection (Δ_y) and ultimate deflection (Δ_{ult}); i.e., Δ (= $L^2/3$). Nonlinear dynamic analyses are done using FORTRAN programming. To run the program mass, yield deflection of individual structural model is used, while relative displacement vs. time graph can give the maximum displacement.

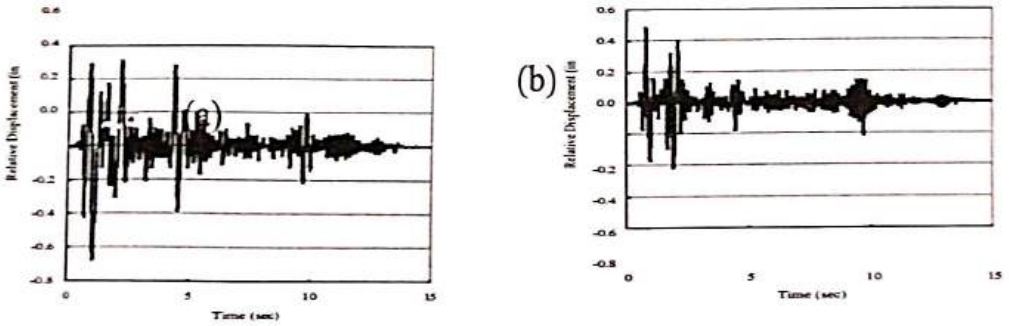

Fig.: 4.1 Result from nonlinear seismic analysis for unconfined column model (a) and FRP confined column model (b).

4.3. Comparison of Experimental and Numerical Results

Fig. 4.2 and Fig.4.3 show the numerical and experimental displacement vs. time of unconfined and FRP confined model.

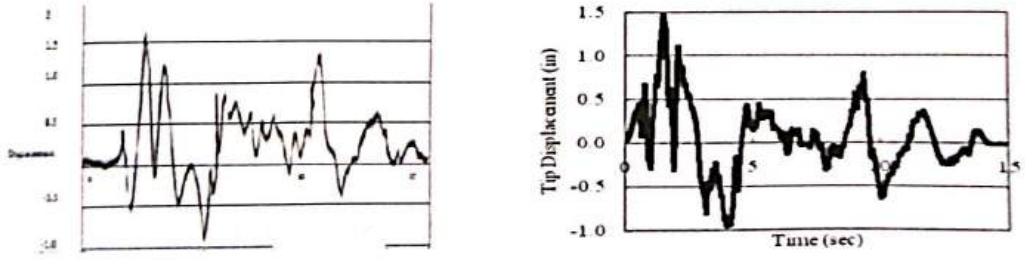

Fig.:4.2 Comparison between (a) Experimental, and (b) Numerical displacement for unconfined models

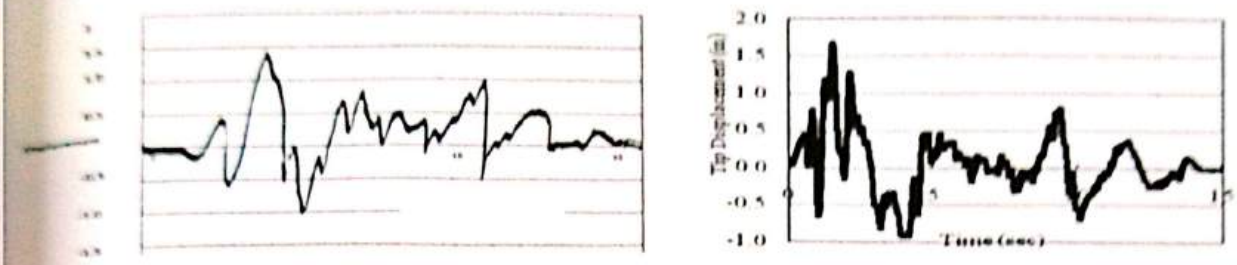

Fig.:4.3 Comparison between (a) Experimental, and (b) Numerical displacement for FRP models

Table 4.1- Comparison of Experimental and Numerical Results

Sample No.	Confinement Options	$\Delta_{max(Exp)}$(in)	$\Delta_{max(Num)}$(in)
1	Unconfined	1.50	1.57
2		1.60	1.61
3		1.20	1.47
4		1.20	1.71
5	Mesh-Confined	1.65	1.60
6		1.90	1.55
7		1.15	1.63
8		1.30	1.59
9	Tape-Confined	1.55	1.45
10		1.50	1.78
11		1.40	1.48
12		1.50	1.43
13	FRP-Confined	1.40	1.60
14		1.40	1.60
15		1.60	1.62
16		1.50	1.60

5. Conclusions

- Seismic performances of confined models were found to be better than unconfined models; i.e., by providing external confinement using FRP, wire mesh, tape to the structural model the strength and ductility are improved significantly.
- Experimental results obtained from shake table test of different confined

structural models when compared with numerical simulation results for displacement are found to be quite similar.

- The difference between the numerical and experimental result of unconfined structure in much closer than result for confined (FRP) structure.
- Parametric studies show the marked variation of dynamic responses depending on the superimposed mass on the columns and ground motion simulation times. The displacements are found to decrease significantly with decreased mass and slower ground motion (run for longer durations).

Acknowledgement

The generous cooperation of Fosroc Inc. in the confinement by Fiber Reinforced Polymer (FRP) is gratefully acknowledged.

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Modeling and Forecasting of Infant and Child Mortality Rates in Bangladesh Through Classical OLS and Support Vector Machine

Md. Abid Hassan Mojkury*

Dr. Md. Ashraful Islam Khan*

Abstract

Obtaining reliable mortality rate estimates is often most difficult in developing countries where infant and child mortality rate is relatively high, well-functioning vital registration systems are lacking and the data that are available are often subject to large sampling errors and of poor quality. The current study uses the infant and child mortality data from different sources for Modeling and Forecasting of Infant and child rates of Bangladesh and also comparison of these forecasting data with the estimated traditional sources to observe the inconsistency among different sources. Nonlinear support vector machines (SVMs) and the autoregressive models to forecast the infant and child mortality rates and observe the performances of such models via in-sample and out-of-sample error. To observe forecasting performance used different mean square error. Along with variant econometric techniques the Support Vector Machine (SVM) has addressed the issue of data inconsistency of various sources of data with MDG Target of Bangladesh. By applying Classical OLS and SVM with in-sampling and out-of - sampling forecast. it was found that in the long run the different data are remarkably differing from each other. The notation for consideration of BDHS data was that how the forecasts converge or differ from the true values.

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To maintain a standard and structural procedures, effective training and coordination with the users make sure the assurance from the capability of data computation.

Careful and deeply concern about data modification, ensure data quality control, correctly documentation and reporting the data quality. The major contribution of this study is to examine the actual scenario of the conventional and non-conventional data through the variant time series model.

Background Study

Population is both the bane and boon of a nation. Demographers are frequently hired to produce population information when census and related data are not available [1,2]. An estimated and forecasted population gives information about the real population based on past populations through different methods including regression, component etc [3]. Information about the future population is referred to as either a projection or a forecast and can be differentiated according to the expected likelihood of their outcomes [4-6].

However, infant and child mortality is the main barrier to prevent rapid population growth in under developed and developing countries. In addition, the improvement in infant and child survival leads to rapid population growth, and, subsequently, to a shift in reproductive behavior (Galloway, Lee, and Hammel 1998; Matthiessen and McCann 1978; Schofield, Reher, and Bideau 1991) [7]. On the other hand, the higher child and Infant mortality rates motivate couples to overproduce [8]. Several empirical studies advocated on the determinants of infant and child mortality including women's education improvement (see, e.g., Shapiro and Tenikue, 2017), breastfeeding (Sankar et al., 2015), etc to reduce infant and child mortality rates. Such historical data is not available for Bangladesh to critically deal with all the findings of the above mentioned scholars[9]. Therefore, this study aims to forecast the infant and child mortality rates of Bangladesh through recently developed mathematics intensive modeling techniques [10-11].

Obtaining reliable infant mortality rate estimates is often most difficult in developing countries where infant mortality is relatively high, well-functioning vital registration systems are lacking and the data that are available often subject to large sampling errors and of poor quality (Alexander and Alkema (2016), and reporting system (Rostami et. al, 2015 and Chakrabarty, 2015). Corsi (2009) proposed the

Heterogeneous Autoregressive Realized Volatility model as an alternative to the ARFIMA model, based on the HARCH (Heterogeneous ARCH) model of Müller et al. (1997b) and this model has quickly become popular for modeling the volatility dynamics due to its ease estimation and extendibility of the baseline model [12-17]. This model employs a few predictor terms, the past information over different horizons (typically a day, a week, and a month average), and is capable to producing slow-decay patterns in autocorrelations exhibited by many time series data [25-30]. Another efficient semi-parametric approach is Support Vector Machine (SVM), introduced by Vepnik (1995), that guarantees to obtain a globally optimal solution (see, e.g., Cristianini and Shawe-Taylor, 2000), which solves the problems of multiple local optima in which the neural network usually get trapped into [31-36]. In the very beginning, Müller et al. (1997a) applied SVM for time series forecasting to compare the performance of ϵ- insensitive loss and Huber's robust loss function [18-21]. Specifically, this paper aims to observe the forecasting performance of the AR, HAR model and also apply the SVM approach in AR and HAR model to empirically forecast the infant and child mortality rates of Bangladesh [22].

2. Methods

2.1 Data and sample

World Bank data (1959-2019) and UN IGME data (1950-2019) are used for Modeling and forecasting [23]. World Bank stores data over 1300 variables for all the member countries and UN IGME (Lower, Median, and Upper) stores more than 580 countries data (Here, Lower and Upper refer to the lower bound and upper bound of 90% uncertainty interval). The UN IGME data set that was launched on 19 October 2019, see www.childmortality.org for further information [24]. Taking considered the infant and child mortality data from World Bank data and UN IGME-2019 sheet. As mentioned above, Variant Time Series model [37-40] (Classical AR and HAR model) considers past information over different horizons, for modeling purpose make averages of the 5-years and 10-years rate for the model

purpose. Here considered Bangladesh Demographic and Health Survey (BDHS-2017) data of infant and child mortality rates.

Modern statistical tools (R-Packages, OxMatrics program) are used for Modeling and Forecasting. Here forecast the infant and child mortality rate of Bangladesh with considering the World Bank and UN IGME data for modeling and Forecasting from the period 1959 to 2018 with Autoregressive (AR) model, Heterogeneous Autoregressive (HAR) Model and Support Vector Machine (SVM) and observe the forecasting performance of all models considered through different mean squares. Before fitting the model, earlier selected the appropriate lag(s) based on the Akaike information criterion (AIC) and Bayesian information criterion (BIC). Finally compare the forecasted data with the BDHS data. Models are discussed below.

2.2 AR Models:

In an AR(p) model the future value of a variable is assumed to be a linear combination of p past observations and a random error together with a constant term. Mathematically the AR(p) model can be expressed as,

$$y_t = \beta_0 + \sum_{i=1}^{p} \beta_i y_{t-i} + \epsilon_t$$

$$y_t = \beta_0 + \beta_1 y_{t-1} + \beta_2 y_{t-2} + \cdots \ldots . . + \beta_p y_{t-p} + \epsilon_t \, (1)$$

Here y_t and ϵ_t are respectively the actual value and random error (or random shock) at time period t, β_i (i= 1,2,..., p) are model parameters and β_0 is a constant. The integer constant p is known as the order of the model. Sometimes the constant term is omitted for simplicity. Therefore, the AR models for infant and child mortality are respectively,

$$IM_{t+h} = \beta_0 + \beta_1 IM_t$$

and

$$CM_{t+h} = \beta_0 + \beta_1 CM_t$$

2.3 HAR Models:

Here considered the arithmetic averages of 5-year and 10-years rates for both the infant and child mortality rates. Thomas Malthus (1798) mentioned that Human beings are supposed to double every 25 years, hence, 25-year average could be an effective variable but the data for Bangladesh are not sufficient enough to make 25-years average. Therefore, the HAR model for child and infant mortality are we have considered respectively as,

$$CM_{t+h} = \beta_0 + \beta_1 CM_t + \beta_2 CM_{5,t} + \beta_3 CM_{10,t} + \epsilon_{t+1}$$

and

$$IM_{t+h} = \beta_0 + \beta_1 IM_t + \beta_2 IM_{5,t} + \beta_3 IM_{10,t} + \epsilon_{t+1}$$

Where CM and IM are child mortality and infant mortality respectively.

2.4 The Support Vector Machines (SVMs):

The Support Vector Machines (SVMs) were introduced by Vapnik (1995) based on the statistical learning theory, which had been developed over the last three decades by Vapnik, Chervonenkis and others (see, Vapnik 1982, 1995) from a nonlinear generalization of the Generalized Portrait algorithm (see, e.g., Vapnik and Lerner 1963, Vapnik and Chervonenkis 1964). SVMs were developed to solve the classification problem, but recently they have been extended to the domain of regression problems (e.g.,Vapnik et al.1997). The SVMs usually map data to a high-dimensional feature space and apply a simple linear method to the data in that high-dimensional space nonlinearly related to the input space. Moreover, even though can think of SVMs as a linear algorithm in a high-dimensional space, in practice, it does not involve any computations in that high-dimensional space (see, e.g., Karatzoglou and Meyer 2006). The terminology for SVMs can be slightly confusing in the literature. In few literatures, SVM refers to both classification and regression with support vector methods. In this paper, the tern SVM will be used for the Nonlinear Support Vector Regression (NL-SVR). Here use Polynomial kernel function and Laplacian kernel function for SVMs. The general form of the Polynomial kernel function is,

$$K(x, y) \equiv (\text{scale}.\ (x, y) + \text{offset})^{\text{degree}}$$

And the Laplacian kernel function is,

$$K(x, y) \equiv \exp(-\frac{\|x - y\|}{\sigma})$$

See. e.g.Smola and Schölkopf (1998) for further discussion.

2.5 Different mean square errors:

Here compare the forecasting performances of the classical HAR and SVM-HAR models first estimate model (2) and (3) by ordinary least squares (OLS) method. Next apply SVM by setting the values $C=1$ and ϵ =0.1 to these models and named SVM-HAR models. Apply R 3.4.3-win32's Kernlab package for SVM-HAR class models.

The forecasting performance of competing models is evaluated using standard forecast appraisal criteria, namely, Root mean square error (RMSE), Mean absolute error (MAE), Root mean square percent error (RMSPE), and Mean absolute percent error (MAPE). The following formula for RMSE, MAE, RMSPE and MAPE are given below:

Root mean square error

$$(\text{RMSE}) = \sqrt{\frac{1}{N}\sum_{t=1}^{T}(CM_t - CM_{t|t-1})^2},$$

Mean absolute error

$$(\text{MAE}) = \frac{1}{N}\sum_{t=1}^{T}|CM_t - CM_{t|t-1}|,$$

Root mean square percent error

$$(\text{RMSPE}) = \sqrt{\frac{1}{N}\sum_{t=1}^{T}(1 - \frac{CM_{t|t-1}}{CM_t})^2},$$

Mean absolute percent error

$$(\text{MAPE}) = \sqrt{\sum_{t=1}^{T}|1 - \frac{CM_{t|t-1}}{CM_t}|}$$

Where CM_tdenotes Child Mortality rate for the year t and $CM_{t|t-1}$ denotes one-year ahead child

mortality forecast. Similar mean square errors will be computed for Infant mortality rate also. Where, N represents the total number of observations.

2.6 Calculation of AIC and BIC:

Akaike information criterion (AIC) and Bayes information criterion (BIC) these information criteria are designed explicitly for model selection. Model selection criteria generally involve information criteria function calculations for each of the models. Here pick the model for which the function is maximized or minimized. The AIC and BIC results based on their standard definitions, which include the constant term from the log likelihood function. The following form of log likelihood function (LL) for VAR(p), as shown by Hamilton (1994, 295-296).

$$LL = \left(\frac{T}{2}\right)\{\ln(|\Sigma|) - K\ln(2\pi) - K\}$$

Where T is the number of observations, K is the number of equations, and Σ is the maximum likelihood estimate of $E[E[u_t u_t']]$, where u_t is the K*1 vector of disturbances. Because,

$$\ln(|\Sigma^{1}|) = -\ln(|\Sigma|)$$

This can rewrite the log likelihood as,

$$LL = -\left(\frac{T}{2}\right)\{\ln(|\Sigma|) + K\ln(2\pi) + K\}$$

AIC and BIC function based on the log likelihood function defined above.

$$AIC(p) = -2\left(\frac{LL}{T}\right) + 2\frac{t_p}{T}$$

$$BIC(p) = -2\left(\frac{LL}{T}\right) + 2\frac{\ln(T)}{T}t_p$$

where LL stands for the log likelihood for a VAR(p) (shown above), T is the number of observations, and p is the number of lags.

3. Results:

3.1 Modeling Fitting:

Here Autoregressive model presents the outputs of AR model including the estimated values of the

parameters, standard errors and the probability values of parameters for all data have been considered [41-44].

From the calculation, here observed highly significant results for all data sets that guaranteed the existence of AR effect among the infant mortality rates. For World Bank data, the estimators of the AR Model parameters are *-4.71* (ρ=*0.01*) and *1.02* (ρ=*0.00*) with standard errors are *0.51* and *0.01* respectively which are highly significant.

For UN IGME (Lower Estimate) data, the estimators of the AR Model parameters are *-4.29* (ρ=*0.00*) and *1.02* (ρ=*0.00*) with standard errors are *0.51* and *0.004* respectively which are also highly significant. When considered UN IGME (Median Estimate) data, the estimators of the AR Model parameters become *26.62* (ρ=*0.00*) and *0.91* (ρ=*0.00*) with standard errors are *2.08* and *0.02* respectively which are also highly significant. Finally for UN IGME (Upper Estimate) data, the estimators of the AR Model parameters become are *22.60* (ρ=*0.00*) and *0.85* (ρ=*0.00*) with standard errors are *2.49* and *0.01* respectively which are highly significant too.

The statistical significance the estimated parameters guaranteed a strong relationship of current years' infant mortality rate to the previous years' infant mortality rates for all data sets. HAR Model presents the outputs for heterogeneous autoregressive model.

From the HAR Model, here observed highly significant results of HAR model for all data sets. All the parameters have significant effect accept five day's average of UN IGME Median data. These indicate a strong relationship among the current year's infant mortality rate and the previous years' infant mortality rates as observed for AR model.

The estimated values of the model parameters with probability values and standard errors are$(\beta_0 = -0.64, \rho = 0.01, SE = 0.24)$,$(\beta_1 = 1.68, \rho = 0.00, SE = 0.02)$, $(\beta_2 = -0.90, \rho = 0.00, SE = 0.02)$ and $(\beta_3 = 0.22, \rho = 0.00, SE = 0.02)$ respectively for World Bank data.

These results observed for UN IGME (Lower Estimate) data as$(\beta_0 = -0.74, \rho = 0.00, SE = 0.14)$,$(\beta_1 = 1.73, \rho = 0.00, SE = 0.02)$,$(\beta_2 = -1.00, \rho = 0.00, SE = 0.04)$ and $(\beta_3 = 0.27,$

$\rho = 0.00, SE = 0.02$) respectively. For UN IGME (Median Estimate) data these results become($\beta_0 = 13.31, \rho = 0.00, SE = 1.08$),($\beta_1 = -0.25, \rho = 0.03, SE = 0.51$), ($\beta_2 = -0.11, \rho = 0.89, SE = 0.73$) and ($\beta_3 = 1.24, \rho = 0.00, SE = 0.23$) respectively. Finally for UN IGME (Upper Estimate) data these results become($\beta_0 = 13.05, \rho = 0.00, SE = 0.89$), ($\beta_1 = 0.61, \rho = 0.01, SE = 0.46$), ($\beta_2 = -1.34, \rho = 0.04, SE = 0.64$) and ($\beta_3 = 1.62, \rho = 0.00, SE = 0.20$) respectively.

3.2 Calculation of Different Mean Square Error

Moreover, it is necessary to mention that have been considered only the Laplacian and Polynomial kernels for the support vector machine with default parameter setup and also observe linear trends in all the data sets have considered. It is known that in case of linear time series and if all the necessary assumptions hold then the classical models will perform best. But in real world, such types of linear data may not observe. Nonlinearity should come in the real data. As Alexander and Alkema (2016) mentioned uncertainty regarding data in developing and under developed world.

Let us now observe the mean squares results. For World Bank data and for the in sample forecast of infant mortality rate, the minimum values of RMSE, MAE, RMSPE (0.1300, 0.1064, 0.0012) observed for classical HAR model followed by AR(P) and classical AR models. The minimum MAPE value observed for classical AR model followed by classical HAR and AR(P) models. When out of sample forecasting comes out, the classical HAR model performed best compared to all other models. The minimum values of RMSE, MAE, RMSPE, MAPE observed 0.2264, 0.1939, 0.0070, 0.0762 respectively.

Table 3.1: Calculation of Mean square error of Infant Mortality Rate forecasting

		In Sampling				Out Sampling			
	R^2	RMSE	MAE	RMSPE	MAPE	RMSE	MAE	RMSPE	MAPE
World Bank data									
AR	**0.9993**	0.8418	0.8418	0.0095	**0.0095**	2.0407	2.0017	0.0605	0.2384
AR_SVM (P)	**0.9993**	0.8418	0.7529	0.0095	0.0887	3.5240	3.5230	0.0099	0.3113
AR_SVM (L)	0.9909	2.4680	2.2190	0.0319	0.1608	55.480	53.550	1.6530	1.2382
HAR	0.9990	**0.1300**	**0.1064**	**0.0012**	0.0317	**0.2264**	**0.1939**	**0.0070**	**0.0762**
HAR_SVM(P)	0.9949	2.3290	2.1000	0.0239	0.1456	4.5040	4.3500	0.1359	0.3534
HAR_SVM(L)	0.9913	3.0370	2.9270	0.0353	0.1772	38.440	35.820	1.1810	1.0230
UN_IGME(Lower) data									
AR	0.9663	**0.9451**	0.8138	0.0089	0.0874	1.6197	1.5953	0.0506	0.2180
AR_SVM (P)	0.9947	2.4715	2.2450	0.0309	0.1569	7.1710	5.5600	0.1096	0.2561
AR_SVM (L)	0.9555	3.8610	3.8559	0.1155	0.3354	72.410	72.050	2.2050	1.4560
HAR	**0.9999**	1.5280	**0.1183**	**0.0013**	**0.0318**	**0.2040**	**0.1756**	**0.0068**	**0.0744**
HAR_SVM (P)	0.9949	2.4070	2.1890	0.0249	0.1476	0.4092	0.3600	0.0124	0.1026
HAR_SVM(L)	0.9904	3.3330	3.2820	0.0363	0.1817	60.502	57.980	1.9300	1.330
UN_IGME(Median) data									
AR	0.9830	4.1160	3.6120	0.0340	0.1718	10.440	10.190	0.2388	0.4729

AR_SVM (P)	0.9829	4.1270	3.5790	0.0350	0.1717	11.019	10.781	0.2514	0.4859
AR_SVM (L)	0.9220	8.8250	6.2400	0.0970	0.2427	75.990	75.540	1.684	1.2760
HAR	**0.9981**	**1.3940**	**1.17980**	**0.0136**	**0.1020**	**5.6850**	**5.5590**	**0.1296**	**0.3489**
HAR_SVM (P)	0.9944	2.3590	2.1360	0.0215	0.1349	7.6850	7.4940	0.1758	0.4056
HAR_SVM (L)	0.9574	6.5230	4.7080	0.0604	0.2008	74.540	73.905	1.6580	1.2640
UN_IGME(Upper) data									
AR	0.9804	5.1030	4.2140	0.0350	0.1748	8.5710	8.2786	0.1913	0.4201
AR_SVM (P)	0.9803	5.1270	4.2330	0.0351	0.1753	9.0050	8.7130	0.2007	0.4308
AR_SVM (L)	0.9051	11.240	7.6280	0.0989	0.2522	80.980	80.550	1.7280	1.2940
HAR	**0.9986**	**1.3540**	**1.1515**	**0.0132**	**0.0996**	5.6675	5.5320	0.1248	0.3422
HAR_SVM (P)	0.9643	2.7620	2.4990	0.0212	0.1384	**4.8020**	**4.5680**	**0.1083**	**0.3133**
HAR_SVM (L)	0.9416	8.8160	5.7560	0.0592	0.2064	79.950	79.180	1.7169	1.2860

For UN IGME lower, median and upper estimate data, classical HAR model gives better in sample forecasting performances. All most all the in sample mean squares errors are minimum compared to other models. Only the RMSE for lower estimate data observed minimum for classical AR model. Based on the R^2 values, may conclude that all the models I have considered are fitted well. The highest value of R^2 for World Bank data observed 0.9993 for classical AR model and AR-SVM(P) models followed by classical HAR model. For UN IGME (Lower Estimate, Median Estimate and Upper

Estimate) data, the highest value of R^2 observed 0.9999, 0.9981 and 0.9986 respectively for classical HAR model followed by HAR(P) for lower and median estimate data and classical AR model for upper estimate data.

When out of sample mean squares errors come out, classical HAR models perform best for UN IGME lower and median estimate data but HAR-SVM(P) model performed best for UN IGME upper estimate data. However, Shamiri and Isa (2009) pointed out that should not be fooled into thinking of one model with the best fit is the one.

Table 3.2: Ranking of Mean square error for Infant Mortality Rate forecasting

Errors / Models	In Sampling						Out of Sampling					
	RMSE	MAE	RMSPE	MAPE	Average Rank	Overall Rank	RMSE	MAE	RMSPE	MAPE	Average Rank	Overall Rank
World Bank data												
AR	2.5	3	2.5	1	2.25	2nd	2	2	3	2	2.25	2nd
AR_SVM (P)	2.5	2	2.5	3	2.5	3rd	3	3	2	3	2.75	3rd
AR_SVM (L)	5	5	5	5	5	5th	6	6	6	6	6	6th
HAR	1	1	1	2	1.25	**1st**	1	1	1	1	1	**1st**
HAR_SVM(P)	4	4	4	4	4	4th	4	4	4	4	4	4th
HAR_SVM(L)	6	6	6	6	6	6th	5	5	5	5	5	5th
UN_IGME(Lower) data												
AR	1	2	2	2	1.75	2nd	3	3	3	3	3	3rd
AR_SVM (P)	4	4	4	4	4	4th	4	4	4	4	4	4th
AR_SVM (L)	6	6	6	6	6	6th	6	6	6	6	6	6th
HAR	2	1	1	1	1.25	**1st**	1	1	1	1	1	**1st**
HAR_SVM (P)	3	3	3	3	3	3rd	2	2	2	2	2	2nd
HAR_SVM(L)	5	5	5	5	5	5th	5	5	5	5	5	5th
UN_IGME(Median) data												
AR	3	4	3	4	3.5	3rd	3	4	3	3	3.25	3rd
AR_SVM (P)	4	3	4	3	3.5	3rd	4	3	4	4	3.75	4th
AR_SVM (L)	6	6	6	6	6	5th	6	6	6	6	6	6th
HAR	1	1	1	1	1	**1st**	1	1	1	1	1	**1st**
HAR_SVM (P)	2	2	2	2	2	2nd	2	2	2	2	2	2nd
HAR_SVM (L)	5	5	5	5	5	4th	5	5	5	5	5	5th
UN_IGME(Upper) data												
AR	3	3	3	3	3	3rd	3	3	3	3	3	3rd

AR_SVM (P)	4	4	4	4	4	4th	4	4	4	4	4	4th
AR_SVM (L)	6	6	6	6	6	6th	6	6	6	6	6	6th
HAR	1	1	1	1	1	**1st**	2	2	2	2	2	2nd
HAR_SVM (P)	2	2	2	2	2	2nd	1	1	1	1	1	**1st**
HAR_SVM (L)	5	5	5	5	5	5th	5	5	5	5	5	5th

From the above table, it is clear that the classical HAR model perform best most of the times. For World Bank, UN_IGME (Lower and Median estimate) data sets, classical HAR model ranked 1st for both in sample and out of sample forecasting. For UN_IGME (Upper estimate) data set classical HAR performed best in the in sample forecasting but for out of sample forecasting HAR_SVM (P) performed best. It is still complicated to found the 2nd and 3rd best performed model based on the above results in Table 3.2. To explain the performances, here computed the overall average ranks (in sample and out of sample and both) and presented the results in Table 3.3.

Table 3: Overall Ranking of Mean square error for Infant Mortality Rate forecasting

Errors / Models	In Sampling					Out of Sampling					Overall Rank	
	World Bank Data	UN IGME(Lower) data	UN IGME(Median)	UN IGME(Upper)	Average Rank	World Bank Data	UN IGME(Lower)	UN IGME(Median) data	UN IGME(Upper)	Average Rank		
AR	2.25	1.75	3.5	3	2.63	2.25	3	3.25	3	2.88	2.84	3rd
AR_SVM (P)	2.5	4	3.5	4	3.50	2.75	4	3.75	4	3.63	3.61	4th
AR_SVM (L)	5	6	6	6	5.75	6	6	6	6	6	5.96	6th
HAR	1.25	1.25	1	1	1.13	1	1	1	2	1.25	1.23	**1st**
HAR_SVM(P)	4	3	2	2	2.75	4	2	2	1	2.25	2.34	2nd
HAR_SVM(L)	6	5	5	5	5.25	5	5	5	5	5	5.05	5th

Performing Similar calculation for Child Mortality Rates dataset, here also observed that the classical HAR model performed best for all situations and data sets followed by HAR_SVM (P), classical AR, AR_SVM(P), HAR_SVM(L) and AR_SVM(L).

3.3 Graphical Representations

For Graphical presentation, observed classical HAR forests lies together with the true values for World Bank data. Similar results observed for UN IGME lower and median estimate data but for UN IGME upper estimate data, the HAR-SVM (P) forecasts lies near to the true value.

At last, for more refine statement here plotted all data sets (Infant and Child Mortality rates) and their forecasts with BDHS data to observe the patters of infant and child mortality rates and observe that the UN IGME estimate data have converged to the BDHS data from 2004 to 2017 but the out of sample forecast for UN IGME lower estimate forecast converges to the BDHS data. Other forecasts did not converge to BDHS data.

Annex 1: Graphical Presentation

At last, for more refine statement here plotted all data sets (Infant and Child Mortality rates) and their forecasts with BDHS data to observe the patters of infant and child mortality rates and observe that the UN IGME estimate data have converged to the BDHS data from 2004 to 2017 but the out of sample forecast for UN IGME lower estimate forecast converges to the BDHS data. Other forecasts did not converge to BDHS data.For Graphical presentation, observed classical HAR forests lies together with the true values for World Bank data. Similar results observed for UN IGME lower and median estimate data but for UN IGME upper estimate data, the HAR-SVM (P) forecasts lies near to the true value.

4 Discussion and Conclusions:

4.1 Discussion and Comparison

To evaluate a country's progress in reducing infant mortality, it is important to obtain accurate

estimates; be able to project infant mortality levels; and have some indication of the uncertainty in the

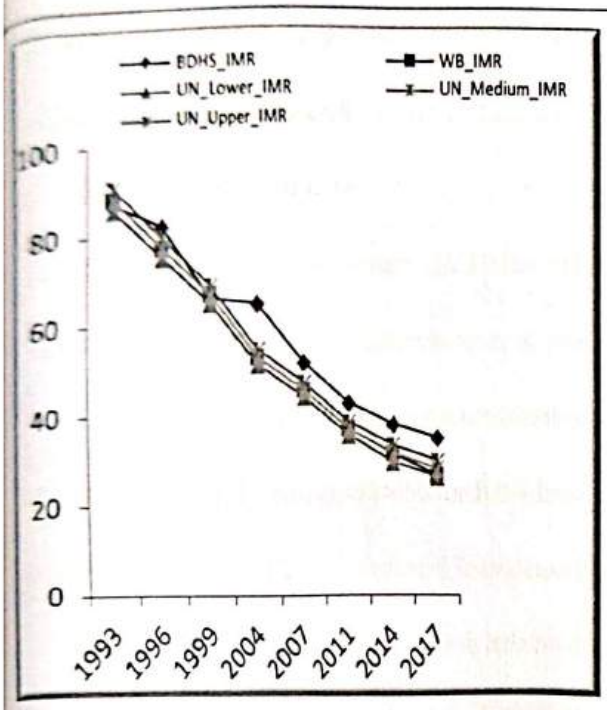

Figure 3.1: Infant Mortality rate for All dataset

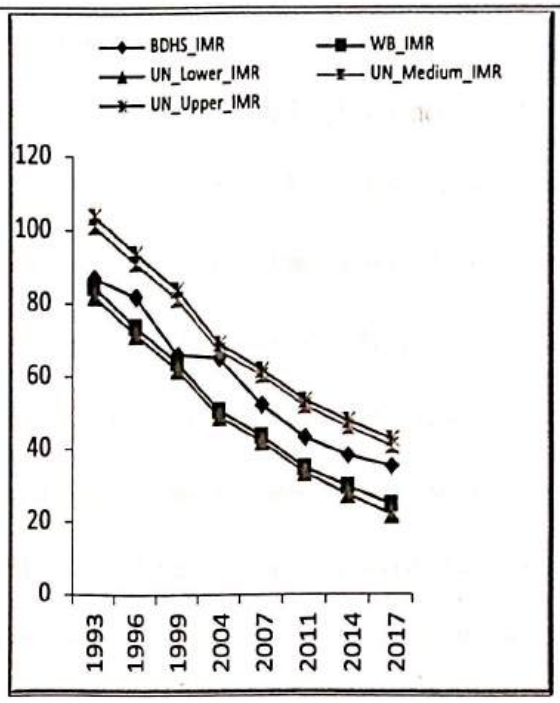

Figure 3.2: Infant Mortality rate for BDHS data with all Forecasts data

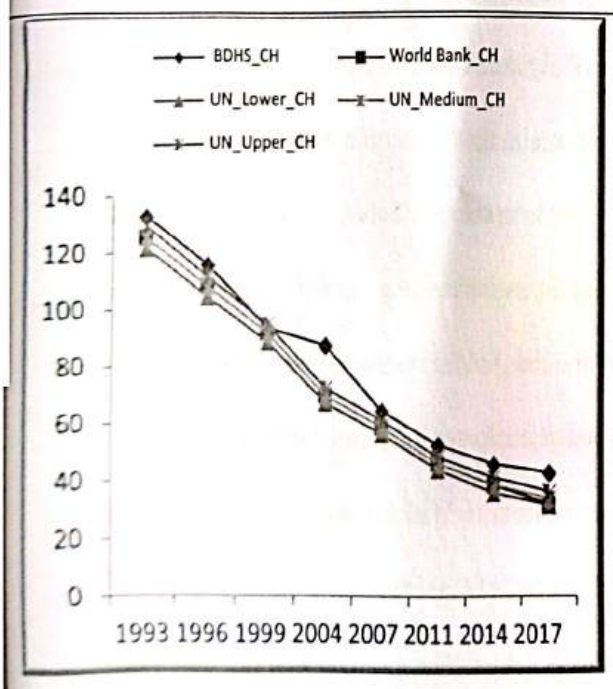

Figure 4.1: Child Mortality rate for All dataset

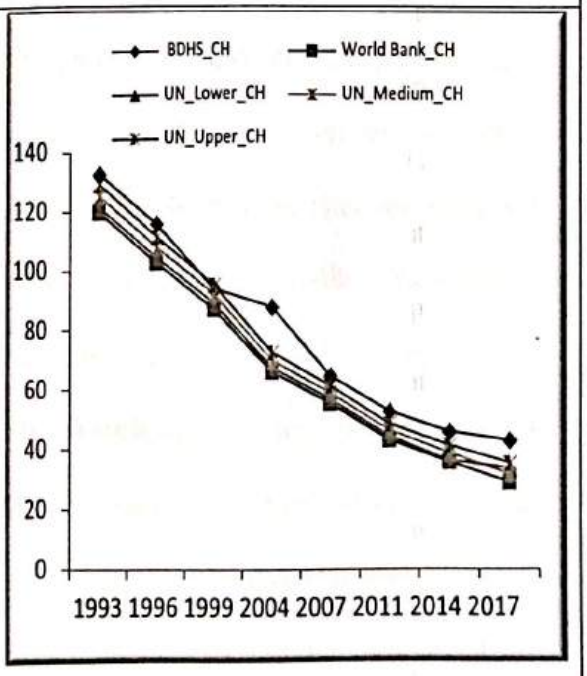

Figure 4.2: Child Mortality rate for BDHS data with all Forecasts data

estimates and projections. In practice, obtaining reliable infant mortality rate estimates is often most difficult in developing countries where infant mortality is relatively high, well-functioning vital registration systems are lacking and the data that are available are often subject to large sampling errors and of poor quality. This situation calls for the use of statistical models to help estimate underlying mortality trends.

UN IGME lower, median and upper estimate data, classical HAR model gives better in sample forecasting performances. All most all the in sample mean squares errors are minimum compared to other models. Only the RMSE for lower estimate data observed minimum for classical AR model.

When out of sample mean squares errors come out, classical HAR models perform best for UN IGME lower and median estimate data but HAR-SVM(P) model performed best for UN IGME upper estimate data. Here the classical HAR model performs best most of the times. For World Bank, UN_IGME (Lower and Median estimate) data sets, classical HAR model ranked 1st for both in sample and out of sample forecasting. For UN_IGME (Upper estimate) data set classical HAR performed best in the in sample forecasting but for out of sample forecasting HAR_SVM(P) performed best. It is still complicated to found the 2nd and 3rd best performed model based on the above results in Table 2. To explain the performances, here computed the overall average ranks (in sample and out of sample and both) and also observed classical HAR forests lies together with the true values for World Bank data. Similar results observed for UN IGME lower and median estimate data but for UN IGME upper estimate data, the HAR_SVM(P) forecasts lies near to the true value. Further observed similar mean squares errors explanations. Then plotted all data sets and their forecasts with BDHS data to observe the patters of infant mortality rates (explained BDHS data earlier in Methods section). The UN IGME estimate data have converged to the BDHS data from 2004 to 2014 but the out of sample forecast for UN IGME lower estimate forecast converges to the BDHS data. Other forecasts did not converge to BDHS data.

Akaike Information criterion (AIC) and the Bayesian Information criterion (BIC) are applied to select the order of time series model; certainly it is the crucial and difficult task of choosing an order for a

model in time series analysis.

However, based on the smallest value of AIC and BIC, I have selected the first order AR model for forecasting out of 25 lag orders for World Bank and UN IGME data of Infant and Child Mortality rate. After selecting lag, fitted the model for classical AR, classical HAR, SVM-AR (P). SVM-AR(L), SVM-HAR(P) and SVM-HAR(L) models for World Bank and UN IGME data. Here observed highly significant results for all models. All the models were best fitted with higher R^2values. The classical HAR models for all data set fitted best.

Then to find out the forecasting performance, calculate four Mean Square errors for all models and all data sets. Both the in sample and out-of-sample forecasting performances are outstanding for the classical HAR models than classical AR, SVM-AR(P), SVM-AR(L) and SVM-HAR(P), SVM-HAR(L) models for both infant and child mortality rate forecasting. Here considered only Polynomial kernel and Laplacian with default parameter setup.

For Graphical presentation here observed classical HAR forests lies together with the true values for World Bank data. Similar results observed for UN IGME lower and median estimate data but for UN IGME upper estimate data, the HAR-SVM(P) forecasts lies near to the true value.

At last, for more refine statement here plotted all data sets and their forecasts with BDHS data to observe the patters of infant and child mortality rates and observe that the UN IGME estimate data have converged to the BDHS data from 2004 to 2018 but the out of sample forecast for UN IGME lower estimate forecast converges to the BDHS data. Other forecasts did not converge to BDHS data.

All findings strongly recommend that the classical HAR model performed best for all situations and data sets followed by HAR_SVM (P), classical AR, AR_SVM(P), HAR_SVM(L) and AR_SVM(L). Almost Similar Pattern observed for Child Mortality Rates estimate. Various time series model (Autoregressive Model, Heterogeneous Autoregressive Model, Support Vector Machine) are used to investigate the Modeling and Forecasting of child mortality rate for World Bank and UN IGME data. One major finding was that the different data have been found are remarkably differing from each other. The notation for consideration of BDHS data was that how the forecasts converge or differ from the

true values. Since BDHS data a survey based, therefore, may be faith on the accuracy level of the data. Lastly observe that the out of sample forecast of UN IGME lower estimate data nearly coincides with the BDHS data.

4.2 Recommendations:

Since the data quality is of the key factors to deal with demographic dynamics, therefore, as a developing nation the government of Bangladesh (GoB) should take initiative for building a data library immediately for ensuring sustainable development. As already leant that the most important challenge for the majority of developing countries having not well-functioning vital registration systems due to issues with data quality (Leontine Alkema, et. al 2013). Though Bangladesh Government started the birth registration system already but the accessibility of data is still a big problem. For a unique Database system there need to follow a specific and routine guideline few recommend to follow the followings. For maintaining a standards and structural procedures, Effective training and coordination with the users make sure the assurance from the capability of data computation. Careful and deeply concern about data modification Ensure data quality control correctly documentation and reporting the data quality. Some of them are.

- To maintain a standards and structural procedures
- Effective training and coordination with the users
- Make sure the assurance from the capability of data computation.
- Careful and deeply concern about data modification
- Ensure data quality control

- Correctly documentation and reporting the data quality

4.3 Concluding Remarks:

In this paper used variant time series model (classical AR, classical HAR model SVM (Polynomial, Laplacian kernel)) to observe the modeling and forecasting performance of infant and child mortality rates and concluded that the classical HAR model gives better forecasting performance. The SVM class models failed to perform well. Due to time constraint, failed to extend this study. In future would like to study the following events:

First, in this study only considered Bangladeshi Infant and Child Mortality data. The comparison of other developing countries (i.e india, Srilanka, Nepal) could be another interesting work.

Second, here forecasted the Bangladeshi infant and child mortality rates, but other related variable, Maternal Mortality, Prenatal Mortality, life expectancy, TFR, should be included in the study. The comparative study between those with other countries could produce interesting outcomes.

These topics are left for further research.

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Impact of Social Media Marketing on Customer Purchase Decision: An Investigation on FMCG (Fast Moving Consumer Goods) Industry of Bangladesh.

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Abstract

Social media has transformed the strategies organizations used to follow over the past few years, and as a consequence, this marketing system has generated its role in the modern business world. The massive use of social media is now conveying a platform for fostering brands as well as affecting customers' purchase decisions. The research was accomplished to identify the impact of social media marketing on the customer purchase decision of the FMCG Industry of Bangladesh. Here quantitative research strategy has been followed with a sample size of 80 and simple random sampling method has been applied. Here, Social media marketing as well as Facebook marketing, YouTube marketing, Instagram marketing, and LinkedIn marketing are the independent variables and the customer purchase decision is the dependent variable. According to the research result, among the four independent variables;Facebook marketing and YouTube marketing have the strongest effect on the dependent variable customer purchase decision of the FMCG Industry. FMCG products are convenience product in nature and customers give little time for comparing among different brands, that is why using social media marketing can be beneficial to the marketers for swaying customers' purchase decision in a shorter time as most of the advertisements published in social media are smaller in size in comparison with other traditional media. Social media not only allow consumers to evaluate products but also recommend contacts or friends and in linking current purchases to future purchases. Customers are now often relying on the recommendation and expert opinions from a known person within the social media network. The FMCG firms are seeking opportunities of this growing trend of customers depending on social media for their purchases.

Keywords: Social Media Marketing, Customer Purchase Decision, FMCG (Fast Moving Consumer Goods, Facebook Marketing, Youtube Marketing.

1.Introduction

1.1 Background of the Research

Social media brought new opportunities to businesses to reach out people in the fastest way and most effective way. Businesses are now capable of promoting their brand to people all over the world effortlessly.

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By using social media sites, businesses all over the world have become in the reach of customers and they can find out any information they want from these sites. Business organizations have become capable of being in touch with customers more effectively and efficiently like no other time (Noreen and Han, 2015). They are now capable of getting responses from the customers directly by using social media sites. Social media marketing is form of internet marketing that allows marketers to share and develop different types of content in the sites to let the consumers know about the products and services that they are offering. In social media marketing, the marketers actively get engaged in texting, image sharing, video sharing, content sharing, etc. as well as connect with the customers.

Nowadays, this is very important for every business organization to hold existent customers and gain new ones (Dobele, Steel and Cooper, 2015). When organizations lose their customers, they lose their profit as well. That is why convincing customers by influencing their purchase decision to buy products are very important for business profitability. Again, a customer's purchase decision can be defined as the thought process that leads him to identify a need, generating and evaluating the alternatives, and choosing a specific product for personal use.

Social media has become a personal essential part of an individual's personal life. There are thousands of benefits that social media sites are providing to the business world. Not only small businesses but also startup businesses are able to use social media platform mission, vision and marketing plan of their startups. Social media sites are not bounded by any demographic, geographic rules, and regulations that is why they are more effective and efficient way to reach out topeople throughout the world(Noreen and Han, 2015).Just like other areas social media also has a great impact on influencing customersand their purchase decision. When organizations engage in social media marketing they try to increase communication with customers through content sharing, video sharing, etc. and when customers get attracted to these contents, they become influenced and take positive purchase decisions regarding the company. A simple meme sharing can be a vital element to influence customer for any business.

For the above reason, in this research paper, the researcher will try to find out the impact of social media marketing on customer purchase decisions on the FMCG Industry of Bangladesh.

1.2 FMCG Industry in Bangladesh

During the time of economic uncertainty, the FMCG industries are counted as one of the leading industries serving domestic consumer needs. The country's middle-class population shared with growing per capita income has been a sturdy propagator for the growth of the industry. The universal market size of the industry is anticipated to achieve $1.54 trillion by 2025 with a CAGR of 5.4% (FMCG Market Size and Share | Industry Analysis and Research Report 2025, 2020)
As job opportunities are naturally concerted in the few urban centers of the country, the metropolitans experience enormous sheathes of countryside immigration. As a result, the majority of the expenditure on FMCG products creates from these urban centers. With 35.70% of the nation's population living in metropolitans as of 2017, this number is merely set to boost further and strengthen the industry.
In Bangladesh, the FMCG industry can be divided into three main categories- Foods and Beverage, Personal Care, and Household Care Industries. The foods and Beverage Industry contains all food products such as milk and dairy products, biscuits, and bakery products, soft drinks, tea, frozen foods, ice cream, coffee, baby foods, tobacco, and others. Popular foods and beverage companies in Bangladesh are Acme Agro Vet and Beverages Ltd, ACI Foods Limited, Akij Food and Beverage Ltd, Aarong, BD Foods Limited, Bashundhara Foods and Beverage Industries Limited, Bombay

Sweets and Company Ltd, British American Tobacco Limited, Cocola Food Products Limited, Dhaka Tobacco Limited, Golden Harvest Agro Industries Limited, Globe Soft Drink Ltd, Haque Group of Industries, Ifad Foods Limited, Ispahani Foods Limited, Meghna Group of Industries, Nestle Bangladesh, New Zealand Dairy Products Bangladesh Limited, Nabisco Biscuits and Bread Factory Ltd, Olympic Industries Limited, Pran RFL Group, Partex Beverage Ltd, Perfetti Van Melle Private Limited, Prome Agro Foods Limited, Square Foods and Beverage, Sajeeb Group, Transcom Beverages, and others.

Conversely, the Personal Care industry consists of the products which are used for personal care like perfume, cosmetics, toiletries products, and further linked products. Seven firms have power over 95% of the total market which are Unilever, Keya Cosmetics, Lily Cosmetics, Marks andAllys, Aromatic Cosmetics, Square Toiletries and Kohinoor Chemical Company (Source: Japan Bangladesh Business Centre). The cosmetics industry is highly import oriented. 90% of cosmetic chemicals are imported from different countries. Bangladesh usually import from India, Singapore, Uganda, Thailand and China. Bangladesh imports 41% of total imported cosmetic goods from India.

Household products include the products which are useful to maintain the house like cleaning and decorating. It includes room scents or sprays, detergent powder, liquid detergent, soap noodles and related products. The most popular and available brands of laundry detergent in Bangladesh are Wheel, Rin Power White, Surf Excel, Jasmin, Mr. White, Smart, Ray, Fast Wash, Jet, Tibet, Rocket, Chaka, Keya, Ghari, Tide and others. Popular brands of toilet cleaner in Bangladesh are Harpic, Clean Master, Shakti, Lysol, Swift, Vanish, Tixol, White, Harpoon, Finpic and Ozol. Most popular mosquito aerosol brands are Xpel (Square Toiletries), ACI Mosquito Aerosol Spray (ACI), Hit (Godrej) and Mortein (Reckitt Benckiser). Xpel is the market leader in this segment. Savlon is the market leader in this subcategory and one of the most preferred brands of 2017. Then Dettol holds the second position in this sector. Other available brands available in Bangladesh are Lizol, Zici, Midas, Suthol, Lifebuoy (hand wash), Shinex and Bionil. RFL, Bengal and Partex are three leading companies providing plastic goods in the Bangladesh market.

1.3 Research aim

The research aim is to focus on the impact of social media marketing on the customer purchase decision. This will be done over the FMCG Industry of Bangladesh.

1.4 Research objectives

The objectives of the research are:

- To analyze the FMCG Industry of Bangladesh
- To identify the social media marketing tools used in the FMCG Industry of Bangladesh
- To investigate the impact of social media marketing tools on customer purchase decision
- To recommend some strategies to improve the social media marketing practices in the FMCG Industry of Bangladesh.

3. Literature Review

In the present world, consumers' perception while buying product is changing. Social media has transformed the tactics organizations used to follow over the past few years, and as a consequence, social media marketing has generated its role in the modern business world. Massive use of social media is now delivering a platform for fostering brands as well as affecting customers' purchase decisions. Besides, social media developing a hub for market intelligence as marketers are recognizing customer's purchasing behavior to achieve insights of customer feelings towards brands

(Balakrishnan et al., 2014).

Social media communication is primarily altering the interactions between organizations and customers (Gallaugher and Ransbotham, 2010; Kaplan and Haenlein, 2010).This foundation of relations forms online communities where communication and socializing are the key focus, with followers allocating related interests and knowing about each other by exchanging information (Fowdar and Fowdar, 2013).

At the moment social networks turned out as an alternate communication tool to support remaining relationships and actions to enhance user experiences. Furthermore, social media is counted as an instantaneous, cooperative and low cost communication between an organization and its customers while building more personal relationships with them (Miller et al., 2009; Kelly et al., 2010).

Depending on the nature of construction and collaboration social media can be divided into two groups – profile based and content based (Zhu and Chen, 2015). Profile based social media emphasis on individual member and to encourage social media users to connect with specific information. They are concerned in the user behind the profile (e.g. on Facebook, Twitter, and Whats App).In contrast, Content based social media concentrate on contents, discussions, and comments on the posted content and the purpose is to associate for the users with the contents by a certain profile provider (e.g. on Flickr, Instagram, Pinterest, and YouTube).

Facebook permits organizations to attach with a huge number of customers that the organization will never be able to approach through phone calls, emails or meetings (Luke, 2009). With the economic downturn in this pandemic situation where many companies are trying to find ways to lessen their marketing costs in terms of economic and personnel, Facebook is playing a vital role in creating opportunities to connect directly, rapidly and reliably with millions of distinct customers (Palmer and Koenig-Lewis, 2009). As people are now tired of telemarketing and calls made through call centers, Facebook is an excellent direct-response marketing platform, which can deliver instant and straight responses to marketing queries and difficulties within the least time period(Fowdar and Fowdar, 2013).Through communication with customers, organizations can increase valued perceptions and feedback about the present and possible products and services.

The emergence of vlog by focusing on the YouTube personalities has unveiled as another marketing tool to connect with the consumers. As the vloggers start to share their day to day life activities and fans and followers started to develop a relationship by watching these vlogs, the viewers started to count the vloggers as a trusted source of information and look for their advice (Eyaland Rubin, 2003). Even L'Oréal had launched makeup line through Guru Michelle Phan who is a YouTube beauty vlogger with more than 4.5 million subscribers (Lee and Watkins 2016).

Simultaneously, consumers are not only skeptical about traditional advertising but also allowed to bypass the advertisements which are often counted as being indiscreet and troublesome. Consumers can likely to skip commercials or install ad-blocking software and making it even harder for companies to reach consumers (Lee and Watkins 2016). Features that can make a social media influencer on Instagram effective are their impending grasp through their enormous social network. As Instagram is counted as one of the most popular social networking sites and currently has over 500 million active users, it helps a company to influence the customers by visual image and named in the caption of the photo (Veirman et al., 2017).

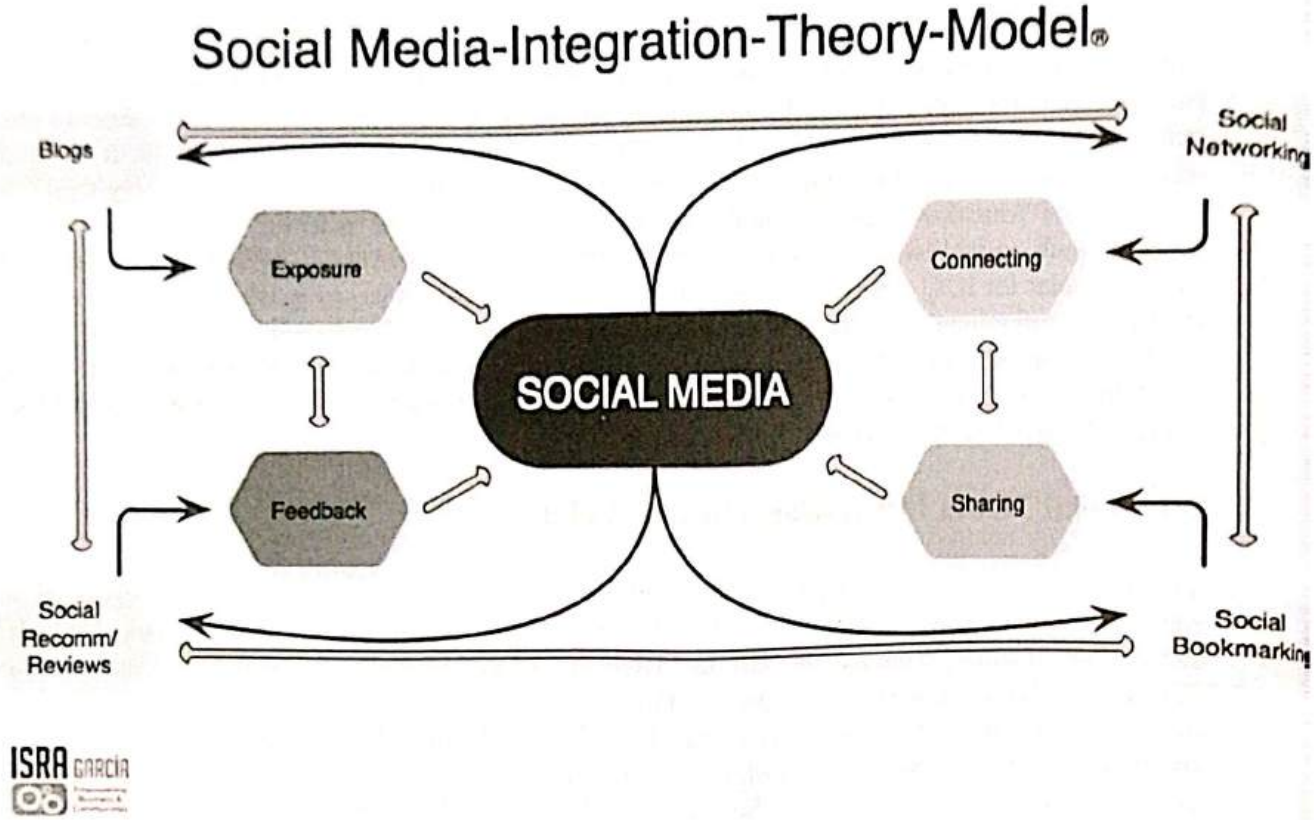
LinkedIn allows marketers to target people based on their jobs, based on their countries, age, location etc. LinkedIn has a systematic manner of interacting with one another so marketers have a great

opportunity to positively make communication with other people as well as different level of professionals through LinkedIn. LinkedIn is an American business and employment-oriented online service that operates via websites and mobile apps which was launched on May 5, 2003. It is mainly used for professional networking, including employers posting jobs and job seekers posting their CVs (Maree and Mutsikiwa, 2019). Unlike facebook, Linkedin is the platform used mainly by the professionals and this website has positioned itself has such website. While facebook is comparatively more popular for B2C segment of marketing, Linked is excellent in targeting B2C customers while its users are professionals and its number is growing day by day. Total of 20% of the marketers prefer it as the second most important site to put an ad on. Around 2 people join linked in every second and it has been growing as a popular website day by day with newer markets opened up from countries like India (Stojaković and Stojaković, 2010).

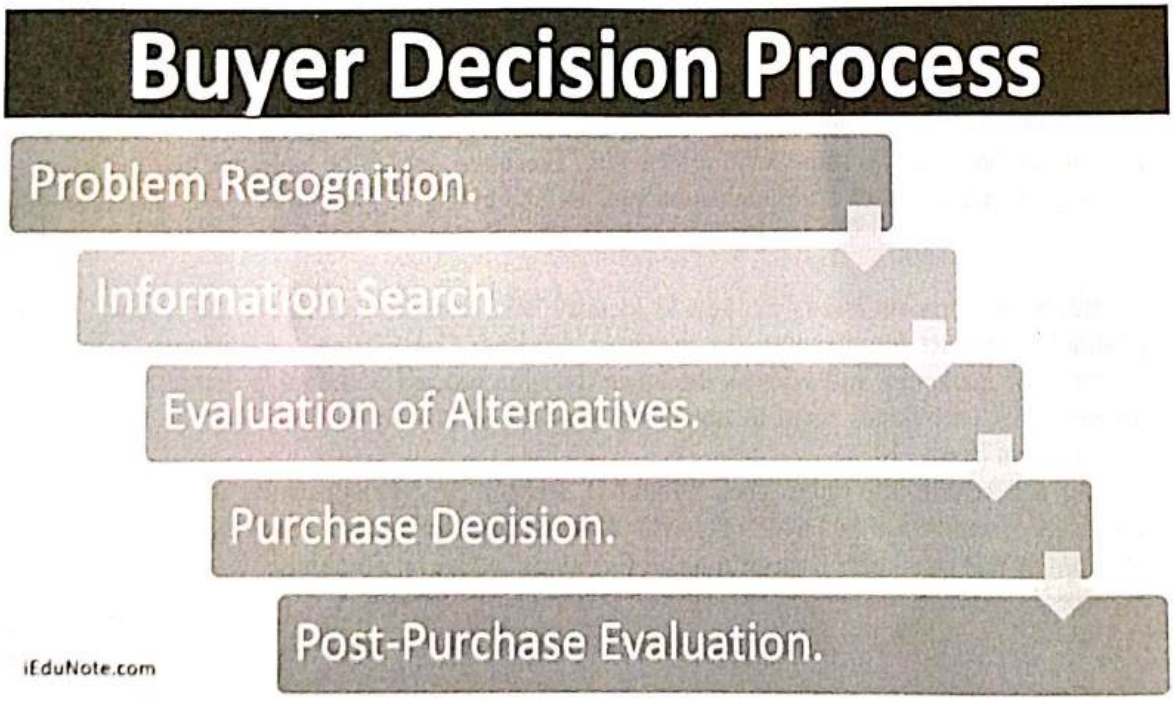
2.1 Social Media Integration Theory Model

To one-to-many integration models works well when examining communications channels or online marketing implementation. However, the interactive Social Media platforms (Facebook, LinkedIn, Del.ici.ous, Twitter, Youtube, Foursquare, Digg in...) have radically changed the communication paradigm. In fact, the study by Chadwick Martin Bailey and iModerate Research Technologies found that consumers are 67% more likely to buy from the brands they follow on Twitter, and 51% more likely to buy from a brand they follow on Facebook (mashable source), showing clearly, that the audience is highly influenced by the Social Media phenomena. What about the breathtaking amount of 3 millions of tweets/day? Another breaking fact is, that Facebook's official company statistics outline that there're 400 million active users all over the world and continues spreading at the light of speed (mashable's source). Analyzing the impact of Social Media in our environment, give us an overall idea that something is happening in the way that communication used to happen.
Due to the rapid adoption of Social Media Marketing as a major communication integration medium, it's necessary to consider how the social interaction has affected the communication process. The exposure, feedback, engagement (connecting) and exchange (sharing) that Social Media platforms provides, it creates a major changes for the traditional communication understanding. Essentially, information flow is no longer considered "one-way street" in which audience received messages through the "I communicate – you receive" mantra. Rather, Social Media integration is seen as an interactive process that enables same-level information exchange among the audience and the brand, creating a long-lasting feedback communication process and giving to the brand a total engagement approach.

Customer purchasing process assists markets to identify how customers inclusive the journey from knowing about a product for planning the purchase decision. Considering the customer's buying process is vital for marketing and sales as the buyer decision process will enable marketers to set a marketing plan that encourages them to obtain the product or service for fulfilling the buyer's or customer's problem (Reny, 2015).
When making a purchase, the buyer goes through a decision process consisting of 5 stages. The marketer's job is to appreciate the buyer's behavior at each stage and the influences that are operating. The figure implies that customers pass through all five stages with every purchase



During need or problem recognition, the customer distinguishes a problem or need that could be contented by a product or service in the market. Problem Recognition is the first stage of the buyer decision process. At this stage, the customer recognizes a need and the buyer feels a difference between his or her actual state and some desired state.



The need may have been activated by internal stimuli (such as hunger or thirst) or external stimuli (such as advertising or word of mouth).

Once the need is recognized, the customer is provoked to seek more information and moves into the information search stage which is the second stage of the purchasing process is searching for information.

After the recognition of needs, the customers attempt to discover goods for gratifying such needs. They search for information about the goods they desire. Customers can get information about goods from different sources. Personal sources include family, friends, neighbors, acquaintance; Commercial sources are advertising, salespeople, dealers, packaging, display, etc.; Public sources contain mass media, customer rating organizations, etc.; Experimental sources consist of handling, examining, using, etc. Such information becomes decisive and confidential (Reny, 2015).

With the information in hand, the customer proceeds to alternative evaluation, throughout the process information is used to appraise" brands in the choice set. While evaluating goods and services customers use diverse bases. Generally customers evaluate the alternatives on the basis of attributes of the product, the degree of importance, belief in the brand, satisfaction, etc. to choose correctly.

After the alternatives have been evaluated, customers decide to purchase products and services. They decide to buy the best brand.

In the final stage of the buyer decision process, post purchase behavior, the customer takes action based on satisfaction or dissatisfaction. The customer determines if they are satisfied or dissatisfied with the purchasing outcome. Here is where cognitive dissonance occurs, "Did I make the right decision".

2.2 Conceptual Framework

According to the following conceptual framework, Social media marketing as well as Facebook marketing, YouTube marketing, Instagram marketing, and LinkedIn marketing are the independent variable in this research and customer purchase decision is the dependent variable in this research. Here, the researcher is going to analyze the impact of social media marketing on customer purchase decision. This will be done over the FMCG Industry of Bangladesh.

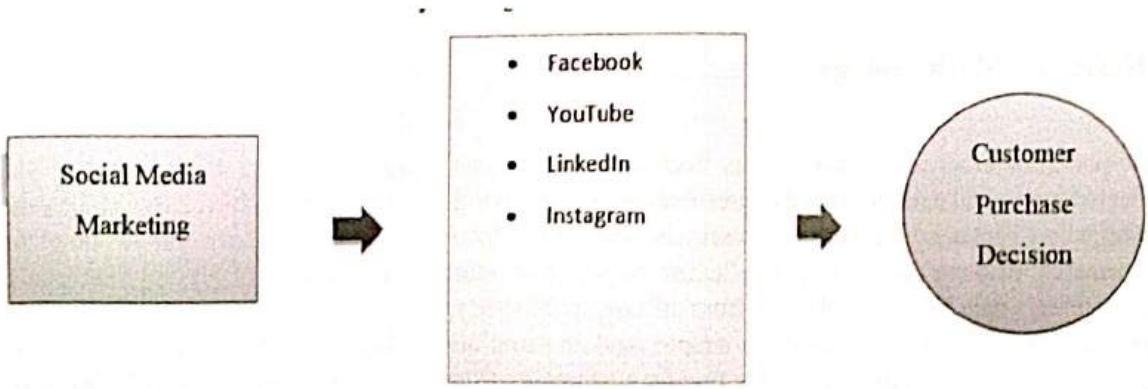


Figure: Conceptual Framework (Source: Own)

Variables		Description
Independent Variables	Social Media Marketing	A way to by which the tagging of the preferences of the customers can be possible and increment of the efficiency of the advertisement
	Facebook Marketing	*Most popular social networking site with over 700 million regular customer 3 types of customizable ads can be provided here*
	LinkedIn Marketing	*Popular for B2B ads among professionals and organizations*
	YouTube Marketing	*Ads attached to the videos or sponsored search options. Also ads appearing as videos before other general contents*
	Instagram Marketing	*Growing popular ad media for pride companies*
Dependent Variables	Customer purchase decision	Decision regarding the purchase of products is generally known as the consumer purchase decision making

3.Research Methodology

The quantitative research strategy has been followed in this research because the researcher has collected numerical data through the questionnaire by following an online survey and analyzed the data statistically to get a valid result. The researcher has used primary data and secondary data to complete the research; primary data has been collected through a structured questionnaire of 5-point likert scale and secondary data has been collected from different published journals, newspaper articles, the internet ands etc. The researcher has used the simple random sampling method; the sample size was 80 and picked the samples randomly from the regular customers of the FMCG industry. Collected data were analyzed by SPSS and the researcher has used different tables, graphs and charts to present the research analysis statistically.

4. Result Analysis and Discussion

4.1 Regression Analysis

Social media marketing as well as Facebook marketing, YouTube marketing, Instagram marketing, and LinkedIn marketing are the independent variable in this research and customer purchase decision is the dependent variable in this research. From the regression analysis, it has been found that the rate

of R Square is .562. So the regression rate shows that dependent variable customer purchase decision of FMCG (Fast Moving Consumer Goods) industry of Bangladesh is moderately affected at the rate of 5.62% by the independent variable social media marketing.

Model Summary				
Model	R	R Square	Adjusted R Square	Std. Error of the Estimate
1	.749[a]	.562	.450	.717
a. Predictors: (Constant), Facebook Marketing , YouTube Marketing, Instagram Marketing , LinkedIn Marketing				

The coefficient table shows the different effect above the dependent variable customer purchase decision (CPD). Now Facebook marketinghavebeta.261, YouTube marketing.272, Instagram marketing.021andLinkedIn marketing adapts a beta of -.127. The research result shows that the highest effect is put by Facebook marketing and YouTube marketing; on the other hand, the lowest effect is put by LinkedIn marketing on the dependent variable customer purchase decision of FMCG (Fast Moving Consumer Goods) industry of Bangladesh.

Coefficients[a]						
Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.
		B	Std. Error	Beta		
1	(Constant)	.650	.492		1.322	.191
	Facebook Marketing	.269	.152	.261	1.767	.082
	YouTube Marketing	.255	.129	.272	1.972	.053
	Instagram Marketing	.018	.139	.021	.131	.896
	LinkedIn Marketing	-.104	.127	-.127	-.821	.415
a. Dependent Variable: Consumer Purchase Decision						

4.2 Correlation Analysis

Both the Pearson correlation analysis and Spearman's rho correlation analysis actually showed the relationships between dependent variable and independent variable. In the following correlation tables, all of the dependent variable and independent variable are correlated with each other positively. Some are strongly correlated as the rate is above .5 and some are weakly correlated as the rate is below .5. So the correlation analysis shows that all types of social media marketing, such as

Facebook marketing, YouTube marketing, Instagram marketing, and LinkedIn marketing has the positive impact on the dependent variable customer purchase decision of FMCG (Fast Moving Consumer Goods) industry of Bangladesh.

Correlations

		Consumer Purchase Decision	Facebook Marketing	YouTube Marketing	Instagram Marketing	LinkedIn Marketing
Consumer Purchase Decision	Pearson Correlation	1	.380**	.467**	.510**	.501**
	Sig. (2-tailed)		.001	.000	.000	.000
	N	80	80	80	80	80
Facebook Marketing	Pearson Correlation	.380**	1	.290**	.312**	.292**
	Sig. (2-tailed)	.001		.009	.005	.009
	N	80	80	80	80	80
YouTube Marketing	Pearson Correlation	.467**	.290**	1	.541**	.426**
	Sig. (2-tailed)	.000	.009		.000	.000
	N	80	80	80	80	80
Instagram Marketing	Pearson Correlation	.510**	.312**	.541**	1	.508**
	Sig. (2-tailed)	.000	.005	.000		.000
	N	80	80	80	80	80
LinkedIn Marketing	Pearson Correlation	.501**	.292**	.426**	.508**	1
	Sig. (2-tailed)	.000	.009	.000	.000	
	N	80	80	80	80	80

**. Correlation is significant at the 0.01 level (2-tailed).

*. Correlation is significant at the 0.05 level (2-tailed).

Correlations

			Consumer Purchase Decision	Facebook Marketing	YouTube Marketing	Instagram Marketing	LinkedIn Marketing
Spearman's rho	Consumer Purchase Decision	Correlation Coefficient	1.000	.329**	.435**	.447**	.451**
		Sig. (2-tailed)	.	.003	.000	.000	.000
		N	80	80	80	80	80
	Facebook Marketing	Correlation Coefficient	.329**	1.000	|242*	.292**	.258*
		Sig. (2-tailed)	.003	.	.030	.008	.021
		N	80	80	80	80	80
	YouTube Marketing	Correlation Coefficient	.435**	.242*	1.000	.533**	.421**
		Sig. (2-tailed)	.000	.030	.	.000	.000
		N	80	80	80	80	80
	Instagram Marketing	Correlation Coefficient	.447**	.292**	.533**	1.000	.496**
		Sig. (2-tailed)	.000	.008	.000	.	.000
		N	80	80	80	80	80
	LinkedIn Marketing	Correlation Coefficient	.451**	.258*	.421**	.496**	1.000
		-Sig. (2-tailed)	.000	.021	.000	.000	.
		N	80	80	80	80	80

*. Correlation is significant at the 0.05 level (2-tailed).

**. Correlation is significant at the 0.01 level (2-tailed)

4.3 Discussion

The study conducted to find out the impact of social media marketing on customer purchasing decisions in fast-moving consumer goods (FMCG) markets. Consumers use FMCGs products daily in their life. Consumers use social media marketing daily too. In this research, both the dependable variable and independent variables are known factors of consumers' daily life. Social media marketing increases the efficiency and profitability of the organization by influencing the customers' purchase making decision. Now a day, Social media marketing plays the most important role for the increment of the popularity of the products or sometimes the popularity of the whole company. For the growth of internet users and social media users, the advertisement by using the different types of media makes it easier for the company to establish or formulate its marketing strategies and capture the market. Social media marketing influences the customers' purchase decision making and adjust

the significance of the customers' profitability and thus affects the consumer's buying decision. There is no doubt that social media has revolutionized the FMCG industry.

Social media marketing has completely changed almost every facet of modern living – from the way, customers listen to music to eating habits – and the FMCG industry is no exception. Facebook, Instagram, LinkedIn, YouTube, Google +, these all have been a platform to reach out to the maximum crowd. As the use of social media is aggregating at a remarkable rate and companies displaying tendencies of assigning an increasing budget to social media to connect and reach customers. Social media not only allow consumers to evaluate products but also recommend contacts or friends and in linking current purchases to future purchases. Customers are now often relying on the recommendation and expert opinions from a known person within asocial media network. The companies are taking benefits of the growing trend of customers depending on social media for their purchases.

The internet is now so crowded that the best way to scramble to the top in order to get content seen and liked is really no dissimilar to a traditional way of networking. The well-connected and the wealthy are those who are set to garner the most social attention, in large part because of the voyeuristic tendency to pursue and appreciate them.
FMCG goods are daily used products of the customers. Marketing through social media can create interest in consumer's minds about a particular product of the FMCG industry which influences their purchase decision. Promotional advertisements of different FMCG products published in social media attract customers and thus customers take the decision to purchase those FMCG products which gave them more benefits.

5. Conclusion and Recommendation

5.1 Conclusion

The researcher has done the research to identify the influence of social media marketing on the customer purchase decision of the FMCG Industry of Bangladesh. Here, quantitative research strategy has been followed. The sample size was 80 andsimple random sampling method has been applied. The research result has exposed that among the four independent variables Facebook marketing and YouTube marketing have the strongest effect on the dependent variable customer purchase decision of the FMCG Industry. As the use of social media is aggregating at a remarkable rate and companies displaying tendencies of assigning an increasing budget to social media to connect and reach customers.FMCG products are categorized as convenience products to customers and they give little time for comparing among different brands, that is why using social media marketing can be beneficial to the marketers for influencing customers' purchase decision in a shorter time as most of the advertisements published in social media are smaller in size in comparison with other traditional media. Social media marketing recommend consumers with contacts or friends and in linking current purchases to future purchases. Customers are focusing on the reviews, recommendation and expert opinions from a known person within the social media network. The FMCG firms are seeking opportunities of the growing trend of customers' depending on social media for their purchases.

5.2 Recommendations

Through this research, it can be said that as a modern tool of communication social media is playing a very significant role in the purchase decision of consumers. Considering findings from the research, the following recommendations are proposed:

- ✓ As one of the discoveries of the research is that- mass people use social media on a regular basis, the marketers can definitely grab the consumer's attention to the FMCG products through lucrative commercials.
- ✓ Most of the participants expressed that among the social media websites; they use Facebook and YouTube most. So marketers of the FMCG industry should pay more attention to use these platforms more effectively. On Instagram and LinkedIn, the customers visit on a rare basis, so marketers may take initiatives to make them visit more. (Posting advertisement through celebrities as a reference in Instagram and professionals in LinkedIn)
- ✓ Marketers of the FMCG industry need to make enough supply of goods for quick delivery because if any kinds of delay occur, consumers may switch to other brands. From acquiring raw materials to deliver the product, whole supply chain activities need to be maintained on time.
- ✓ Marketers need to emphasize on how other social media platforms like Google+ and Twitter can be used to attract customers for FMCGs.
- ✓ Cutting of the middlemen (who are the authorized dealer of FMCGs on behalf of industry) may make the customer more loyal to the brand because the brand value will increase through direct communication.
- ✓ Though people browse social media platforms frequently, they stay there for a limited time. So, marketers need to make sure of quick responses to keep the consumers engage with them.
- ✓ Marketers should investigate how often their competitors are posting updates and conduct frequent industry research to perceive the ideal amount of content to publish per day on each platform of social media and work accordingly.

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