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From the Desk of Editor-in-Chief

MESSAGE

I feel pride in publishing the fourth issue of 'Multidisciplinary International Research Journal of Gujarat Technological University'.

This issue includes articles from Heat Transfer, Cyber Security, Concrete Structure, Cloud Computing, 5S implementation in Manufacturing industry, Malware Analysis & Detection and Engineering and Diagrid & Hexagrid structures from Engineering discipline. It also includes article on Employee Engagement from Management discipline and Development & Validation of Bio Analytical method from Pharmacy discipline.

I hope the readers will be satisfied with the quality of these articles and these articles will motivate them for further research in similar areas.

On behalf of Gujarat Technological University I thank GTU editorial board members & international editorial board members for their efforts in reviewing these articles for publication in this issue.

Dr. Pankajray Patel
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DRIVERS OF EMPLOYEE ENGAGEMENT AT SELECTED IT COMPANIES OF AHMEDABAD CITY

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ABSTRACT

One of the most important authority of top management in all organisations, is employee betrothal be it profit making or non-profit making, small or big. To develop and maintain engagement in their human resource, organisations of all sizes and types have started investing in employee engagement initiatives. As manufacturing organisations in most cases have different working environment, employee engagement in IT companies, has different perspectives. In IT companies, highest level of dedication and engagement from employees is expected. To understand the effect of drivers of employee engagement in IT companies is the main point of this survey. Along with ANOVA with gender as unconventional variable, cross engagement and Chi square was applicable to age and work experience. Based on assenter's gender, there was a demographically notable change in drivers of employee betrothal. On various activities of employee engagement, a notable change was reported. The important factor of employee engagement is career advancement opportunities and rewards and recognitions. As the findings of the study can be used to their advantage, this research paper aims to evaluate the employee engagement levels in IT industry in Ahmedabad City and recommend ways and means to improve engagement levels in the industry.

Keywords: Employee Engagement, IT companies, Challenges, One way ANOVA

1. INTRODUCTION

In today's fast-paced global business environment, most organizations today realize that a 'satisfied and happy' employee is not necessarily the best employee in terms of productivity & performance. Employees have become main interest for the management in the firm, whether it is a manufacturing or service sector organisation. Before some years there was a common apprehension and belief that IT, IT-empowered, and services-oriented organisations were centered on employees, the other sectors including manufacturing were reasoned having a sluggish posture towards employees. The notable advantage and dis-advantage is due to workforce which is the only active, present, lively resource available with the organisation. There

are two sets of employees i.e. one who are engaged, motivated, and emotionally attached to their organisation and work and the other who are non-engaged and not attached to their work or the organisation. The first set of employees gives higher productivity and low overturn which becomes a source of competing advantage, while the other becomes a burden with low productivity and high cost to the organisation. To develop and maintain engagement in their human resources, nowadays organisations of all sizes and types have started investing essentially in human resource practices and their effective management. When the employees are in change appearance not associated linked completely with either group, the problems for managers become stiffer. To make an elegant balance between firms yearning from them and their career yearning, they weigh the positive and negatives. Managers are now realizing pressing needs of investment in "engaging their human resource" and yielding the short and long-term benefits of it.

1. Notion of Employee Engagement

Understanding and practicing the concept of employee engagement in its full scope has become the need of the hour for the business world, researchers and academia. Early research on the concept of employee engagement was put forth by Kahn (1990) which provided solid foundation for the subsequent research work on the concept of employee engagement. For the first time the term "engagement" was introduced by Kahn in 1990 which got published in Academy of Management Journal in his article "The Psychological Conditions of Personal Engagement and Disengagement at Work". Kahn defined personal engagement at work as "the harnessing of employees' selves to their job roles; in engagement, employees employ and engage themselves physically and cognitively during job performances." Kahn was of the view that psychological presence in a job role involves three aspects. i.e. physical, emotional, and cognitive. To connect with their co-workers, managers, and the top management, engagement is something about creating the growth opportunities for employees at all levels. Kahn also expressed his views on disengagement saying when employees are disengaged, they loose their interest in the job and would withdraw themselves from the job or the work. Drawing the perspectives from the early research and the subsequent efforts employee engagement is about originating a work environment where the employees are psychologically and cognitively attached to their work and are ready to walk an extra mile to perform their job.

1. RESEARCH GAP

Several studies have identified Employee Engagement as one of the most critical HR challenges faced by the organisations nowadays (SHRM, 2017). Indian industry and the workforce, being a multi-lingual and multi-cultural society needs special attention as far as the employee engagement challenges are concerned. Furthermore, the role of female and male members of the society is perceived differently with female

members carrying additional family responsibilities. The rapidly evolving technological advancements, intensive market competition, and related stress make employee engagement a very complex challenge for the IT industry. The industry has to come up with tailored solutions to address this challenge of its time. There have been number of studies undertaken to identify the drivers and antecedents of employee engagement as well the relationship of the employee engagement construct with other variables. But the gender-wise employee engagement challenges remain a grey area which is yet to be explored. This study throws light on these aspects with gender being independent variable for the study.

1. OBJECTIVES OF THE STUDY

(a) To understand the gender specific drivers of employee engagement in selected IT companies of Ahmedabad City.

(b) To deduce empirical evidence on the influence of drivers on employee engagement.

2. RESEARCH METHODOLOGY

The research is a conclusive and quantitative research which would help in understanding the drivers of the employee engagement in selected IT companies and decide upon the best course of action in future. Data was collected from self-designed questionnaire administered to 100 employees at selected IT companies having more than 50 crores annual turnover and employing more than 300 employees. Convenient and judgmental sampling method has been used to select the respondents based on the research objectives. 60 male and 40 female employees both from supervisory and senior management were selected as respondents for the research. A questionnaire was developed taking the drivers of employee engagement which employed a 5-point Likert scale to indicate the perceptions of the respondents' employee engagement. The employees gave their response in the scale of 1- Strongly Agree, 2- Agree, 3- Neutral, 4- Disagree, 5- Strongly Disagree.

The content validity of the instrument was tested by consulting internal and external experts. To analyze the data, the statistical cross tabulations and Chi-square was applied to age and work experience, along with one-way ANOVA with gender as independent variable with the help of SPSS (Statistical Package of Social Science) software version 21.

3. LITERATURE REVIEW

Most often employee engagement has been defined as the amount of prudent effort demonstrated by employees in their job (Frank, Finnegan, & Taylor, 2004) and effusive and mental commitment to the organisation (Baumruk, 2004; Richman, 2006; Shaw, 2005). A psychological state which is seen to surround the three extents of engagements discussed by Kahn (1990) and seizure the common theme running through all the definitions, although it is recognized and accepted that employee engagement is a multi-fold construct, as antecedently suggested by Kahn (1990), Truss, Soane, Edwards, Wisdom, Croll, and Burnett (2006).

According to a study conducted by NASSCOM, IT industry in India has witnessed widespread growth which has attracted enormous foreign direct investment (FDI). This inflow of FDI has contributed significantly to the growth of the GDP, employment generation, and an increase in the export of IT services. The research report also states that the paramount challenge for the industry is not just keeping the employees satisfied but to engage the employees for better productivity, longer association, and individual career advancement. As the IT sector is predominantly service-oriented, the importance of hiring, attracting, motivating, managing, and retaining the highly-ambitious workforce has become the need of the hour.

Open Communication culture, Loyalty, Equitable Compensation, Interpersonal Orientation, Advancement Opportunities and Career Growth are the most prominent engagement drivers within the Public and Private sector banks (Rashmi, Rakhi, and Trupti, 2014).

(Farai & Steven, 2012) stressed on the importance of employee engagement in the hospitality industry in their study. The study also emphasized on employee engagement as the driver of competitive advantage in the two organisations they surveyed in their study. The findings from both the hotels demonstrated the difference between the two organisations. The study presented a strong evidence that work groups having high level of engagement outperform the work groups with lower level of engagement. The study clearly indicated that the hotel with higher level of employee engagement enjoyed competitive edge with the market share of over 43 per cent.

The key drivers of ‘Employee Engagement’ and its different characteristic together with the ways to measure it, (Sidhanta & Roy, 2010) in their study “Employee Engagement; Engaging the 21st century manpower” tried to identify modern ‘Employee Engagement’ practices in corporate and distinct ways to handle disengaged employees. The article also surveyed the research finding on the effect of employee

engagement on manufacturing, gainfulness of the firms, customer experience and other related views, convoyed by firms like Gallup, Hay Group and ISR. To create a highly prompted manpower, that will work together to achieve the common goals of the firms, it was convoyed that high levels of employee engagement would lead to elevated employee commitment and psychological involvement towards the job.

The highly motivated and engaged workforce will determinately make the organisation more successful in terms of financial and non-financial performance parameters found out the study of (Bedarkar & Pandita, 2014) on the drivers of employee engagement effecting three engagement drivers, namely communication, work life balance and leadership. A model surveying these drivers were abstracted which would lead to employee and organisational performance.

4. FINDINGS AND DISCUSSION

Crosstabs (Cross tabulations and Chi-Square) using SPSS on age and work experience of respondents were collected for the study. Table 1 depicts all responses that were considered valid for the study.

Table 1: Case Processing Summary

	Cases					
	Valid		Missing		Total	
	N	Percent	N	Percent	N	Percent
WorkExp * AGE	100	100.00%	0	0.00%	100	100.00%

Source: Created by Author

Table 2: Work Experience * Age Cross Tabulation

Work Exp.		Age							Total
		19-25	26-30	31-35	36-40	41-45	46-50	>50	
0.5	% within AGE	3.90 %	4.70%	1.90%	0.00%	0.00%	0.00%	0.00%	10.50%
1	% within AGE	2.70 %	0.80%	1.20%	0.00%	0.00%	0.00%	0.00%	4.70%
2	% within AGE	1.90 %	5.40%	4.70%	0.80%	0.00%	0.00%	0.00%	12.80%
3	% within AGE	3.50 %	5.80%	1.90%	0.40%	0.00%	0.00%	0.00%	11.60%

4	% within AGE	3.50 %	2.30%	3.50%	0.80%	0.40%	0.00%	0.00%	10.50%
5	% within AGE	8.50 %	22.90%	15.10%	1.20%	0.00%	0.80%	0.40%	48.80%
6	% within AGE	0.00 %	0.00%	0.80%	0.40%	0.00%	0.00%	0.00%	1.20%
TOTAL	% within AGE	24.00 %	41.90%	29.10%	3.50%	0.40%	0.80%	0.40%	100.00%

Source: Created by Author

Table 3: Chi-Square Tests

	Value	**df**	**Asymp. Sig. (2-sided)**
Pearson Chi-Square	134.931 a	78	.225
Likelihood Ratio	108.54	78	.896
Linear-by-Linear	10.195	1	.001
Association			
N of Valid Cases	258		

Source: Created by Author

Table 2 displays work experience and age cross tabulations along with modal frequencies of the response collected for the study. In age column, respondents with 26-30 years displayed highest percentage count, followed by 31-35 years as next highest percentage count of the sample taken for the study. Similarly in work experience row, respondents with five year work experience showed highest percentage count, followed by two year work experience as next in percentage count to it. The lowest percentage count was reported in 41-45, 46-50 and above age columns of the response. Similarly the work experience column reported lowest in one year rows of response for the study.

Table 3 provides the summary statistic information, the Pearson Chi-square value is 134.931, which is associated with (p- value is .225) of 22.5% risk of being wrong in rejecting the null hypothesis. This is too great a risk (far exceeding our standard of 5% risk), so we are unable to report any statistical difference between work experience and age cross tabulation in this sample taken for study.

Further, one-way multivariate analysis of variance i.e. one-way ANOVA is used to determine whether there are any differences between independent groups on more than one continuous dependent variable. We have used gender as independent variable into fixed factor, and all the statements on various drivers of employee

engagement as dependent variables for the study. There were 60 males and 40 females reported in sample taken for the study.

Table 4: Descriptive Statistics

EE Drivers	Gender	Mean	Std. Deviation	N
Salary & Benefits	Male	5.25	3.06	60
	Female	5.72	2.89	40
	Total	5.35	3.03	100
HR Policy	Male	5.93	1.81	60
	Female	6.44	1.97	40
	Total	6.03	1.86	100
Career Advancement	Male	6.18	1.91	60
	Female	7.50	1.40	40
	Total	**6.45**	1.89	100
Reward & Recognition	Male	6.28	1.83	60
	Female	5.89	1.21	40
	Total	**6.20**	1.73	100
Colleagues	Male	5.40	1.91	60
	Female	4.89	2.10	40
	Total	5.29	1.96	100
Perceived Supervisor's Support	Male	6.51	1.99	60
	Female	5.89	2.20	40
	Total	**6.38**	2.05	100
Organisation itself	Male	4.40	2.45	60
	Female	3.56	1.36	40
	Total	4.22	2.29	100
Vision & Mission of the organisation	Male	1.72	1.45	60
	Female	1.61	0.90	40
	Total	1.70	1.35	100
Respectful Job	Male	3.21	2.02	60
	Female	3.50	2.61	40
	Total	3.27	2.16	100

Source: Created by Author

Table 4 provides the descriptive statistics on various drivers of employee engagement where highest mean was observed in Career Advancement opportunities, the lowest mean was observed for vision and mission of the organization.

Table 5: EE Drivers in Rank Order based on Male Gender

EE Drivers (In Rank Order)	Mean	Std. Deviation
Perceived Supervisor's Support	6.51	1.99
Reward & Recognition	6.28	1.83
Career Advancement	6.18	1.91
HR Policy	5.93	1.81
Colleagues	5.4	1.91
Salary & Benefits	5.25	3.06
Organisation itself	4.4	2.45
Respectful Job	3.21	2.02
Vision & Mission of the organisation	1.72	1.45

Source: Created by Author

Table 5 provides descriptive statistics on Drives of Employee Engagement based on Male Gender. The Table shows that the highest mean observed was for Perceived Supervisor Support and the lowest mean was observed for Vision and Mission of the organization.

Table 6: EE Drivers in Rank Order based on Female Gender

EE Drivers (In Rank Order)	Mean	Std. Deviation
Career Advancement	7.5	1.4
HR Policy	6.44	1.97
Reward & Recognition	5.89	1.21
Perceived Supervisor's Support	5.89	2.2
Salary & Benefits	5.72	2.89
Colleagues	4.89	2.1
Organisation itself	3.56	1.36
Respectful Job	3.5	2.61
Vision & Mission of the organisation	1.61	0.9

Source: Created by Author

Table 6 provides descriptive statistics on Drives of Employee Engagement based on Female Gender. The Table shows that the highest mean observed was for Career Advancement and the lowest mean was observed for Vision and Mission of the organization.

CONCLUSION

Employee Engagement is an emotional attachment employees have towards the work they do, the organisation, its business activities, and its values. To understand and measure the employees' perception on drivers of employee engagement being practiced in the IT industry, the survey has been convoyed on 100 employees of selected IT companies from the Ahmedabad City. It aimed to study the current level of employee engagement and the drivers for employee engagement in the IT sector in Ahmedabad City with a special focus on gender as an independent variable. In the sample responses taken for study, a positive effect on employee engagement drivers have been found. Almost all the employees of the selected IT businesses believed engagement as the significant factor contributing to the individual and the organisational success. According to the survey Supervisor's Support play a most significant role in engaging male employees, followed by Reward & Recognition, Career Advancement opportunities and HR Policies. This implies that the male employees tend to give more importance to the support and guidance they receive from their supervisor, the salary and other benefits the organisation offers, and the opportunities they have for their career growth at the workplace. The study shows that for female employees Career Advancement opportunities play most important role in engaging them, followed by HR Policies, Reward & Recognition, and Supervisor's Support. Female employees seem to give more importance to good HR policies and thereby provision of leaves, flexi-timings, and other benefits. They also seem motivated by the kind of support they receive from their supervisors. Employees want the rewards to be transparent and merit-based, while they feel that the recognitions must be immediate. Some of the organisations do show sign of nepotism or favoritism while promoting the employees or sending them for an offshore overseas project. The management should look into this and make policies and selection criteria for such projects much fairer and equitable. Furthermore, the study reveals that, for both, male and female employees, the top four engagement drivers remain the same with different rank order. The study shows that both, male and female employees, are least motivated by the Vision and Mission of the organisation. This reveals that the employees are unaware of the organization's business activities and its objectives in a larger sense. Organisations must make an effort to inform all employees as to what is happening in the organisation and engage their employees through more periodic communications on organization's progress towards its business goals. Both male and female employees, tend to expect almost a same degree of respect at their work and enjoy a 'meaningful' work.

The study also shows that employees who have higher-level of support from their supervisor in terms of freedom, autonomy, decision-making, and performance feedback are highly engaged. Components behind work engagement are gratifying Career Advancement opportunities, Reward & Recognition, Perceived Supervisor's Support and HR Policies. Across the globe and particularly in India, more and more studies are being conducted on this most-practiced, popular, and airy concept. Similar kind of research can be undertaken to other cities of the country to gain more insights into the drivers of employee engagement.

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DESIGNING OF A PROFICIENT HEAT EXCHANGER BY USING SPIRAL TUBE FOR AUGMENTATION OF HEAT TRANSFER

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Abstract

Heat exchangers are the equipment that exchanges the heat energy between the surface and the fluid. Heat exchangers are used in both day to day life and in industrial applications such as thermal power plant, chemical plant, HVAC, automobiles as radiators. Most of the heat exchangers design depends upon the requirement and space. Depending on the exchanger design methodology, there are a set of geometrical parameters that need to be specified before the start of design. Hence proficient design of heat exchanger is always needed one of them is spiral tube heat exchanger. The present design procedure is different from that of the design procedure of tubular heat exchanger. Archimedean principle of spiral geometry is used while designing the spiral coils for spiral tube heat exchanger. The design of the heat exchanger consists of the specification of the geometry (cross sectional area and length) that transfers the required heat load within the limitations of allowable pressure drop.

Keywords: Spiral Tube Heat Exchanger, LMTD, curvature ratio, effectiveness of HE etc.

Nomenclature

List of symbols

d - Diameter of spiral tube [mm]
D- Diameter of Spiral [mm]
D_{is} -Diameter of shell [mm]
R_h- Radius of header or Straight tube [mm]
P- Pitch of Spiral[mm]
L_s- Length of shell[mm]
L_{st}- Length of header tube [mm]
a- Constant in equation of Spiral [mm]
B- Bend allowances [mm]
L_o- Developed length of spiral [mm]
L_T - Total length of spiral tubes [mm]
r_n- Neutral axis correction radius [mm]
k- Stretch factor or bend factor
t- Thickness of tube [mm]
n- Number of spiral
n_1- Number of header tube
Q- Heat transfer rate of fluid [W]
C_P- Specific heat [KJ/kg k]
T_{h1}- Inlet temperature of hot fluid [ºC]
T_{h2}- Outlet temperature of hot fluid[ºC]
T_{c1}- Inlet temperature of cold fluid [ºC]
T_{c2}- Outlet temperature of cold fluid [ºC]
ΔP- Pressure drop [mm]
U- Overall Heat transfer coefficient [W/m^{2}K]

h- Heat transfer coefficient [W/m^2K]

A_s- Heat transfer surface area [m^2]

R- Capacity ratio

m- mass flow rate of fluid [kg/s]

V- Velocity of fluid [m/s]

R_s- Thermal resistance of spiral tube

R_{st}- Thermal resistance of header tube

m_{np}- mass of nanoparticle [g]

m_{bf} – mass of base fluid [g]

θ- Temperature difference [^0C]

Q_s- Discharge through shell [mm^3/sec]

Q_t- Discharge through spiral tube [mm^3/sec]

D_e- Effective diameter of shell [mm]

Subscripts

h – hot fluid | c- cold fluid | bf – base fluid | max- maximum

o- outer | i-inner | avg –average | s- shell

Greek Symbols

K - Thermal conductivity [W/m K]

$\rho -$ Density [kg/m^3]

$\mu -$ Dynamic viscosity [Pa s]

$\upsilon -$ Kinematic viscosity [m^2/s]

δ- Curvature ratio

ψ- angle of arc [rad]

$\Delta\theta_{LMTD}$ - Log mean temperature difference [^0C]

ε- Effectiveness of heat exchanger

1 INTRODUCTION

Spiral tube heat exchangers are excellent heat exchanger because of far compact and high heat transfer efficiency. Spiral tube heat exchangers consist of one or more spirally wound coils which are, in circular pattern, connected to header through which fluid is entering into the spiral coils. This spiral coil is installed in a shell, where another fluid is circulated around tube, leads to transfer of heat between the two fluids.

Curved tubes has the ability to transfer large amounts of heat with less space and size hence, they have attracted considerable research attention. Many researchers have studied experimentally and numerically the performance of simple helical coils for heat transfer enhancement. Very few researchers have studied the effect of pitch and curvature ratio on the heat exchanger performance. Paper reviewed for this dissertation work are categorize under the helical and spiral tubes, then design of compact heat exchanges and application of Nano fluid for heat transfer augmentation.

Nunez et al. [1] investigated the application of a graphical tool for the preliminary design of heat exchangers. The approach, originally developed for the case of shell and tube heat exchangers, later it is extended to the cases of spiral and welded compact exchangers. Their tool depicts the design space where a number of combinations of geometrical parameters meet the heat duty and allowable pressure drops. The enclosed area between three curves is a design space, a curve that represents the particular heat responsibility and the curves that represent the pressure drop on the hot and cold sides. This demonstration gives the designer the largely view that allows him to bring together design condition with the choice of the unit for a given appliance.

Patil et al. [2] they proposed the simple method for designing of helical coil heat exchanger (HCHE). This HCHE offers lot of advantages over double pipe heat exchanger. One of the important factors of using a helical coil heat exchanger is the space requirement in helical coil heat exchanger is less as compared to straight tube heat exchanger.

Tandal et al. [4] they designed and fabricate the innovative Pancake type heat exchanger for process industry. Cold fluid flows in spiral path while hot fluid flows in axial path. Experimental results and theoretical values are compared by the parameter called overall heat transfer coefficient. An analytical model was developed for carrying out design simulations of the Pancake type heat exchanger. Total of eight pancakes are used in their heat exchanger. The results show the deviation between calculated values of overall heat transfer coefficient from the experimental results and theoretical values obtained from the analytical model are within 12%.

Bhavsar et al. [5] they streamline the design procedure for the spiral tube heat exchanger, as the standard design procedure is not available and the information for designing the spiral tube heat exchanger is in the scatter form. Afterwards they have fabricated the spiral tube heat exchanger and carry our experimentation and measure the performance of the spiral tube heat exchanger. Their results show that spiral tube heat exchanger is compact in size and more heat transfer is occurred as compared to shell and tube heat exchanger.

From the literature reviewed for this work it is found that very little information is available on design of spiral tube heat exchangers that too is limited for both fluids flowing in spiral paths. The design procedure for spiral tube heat exchanger is in scattered form and no specific procedure is available for designing the spiral tube heat exchangers. Therefore, the present research work is carried out for establishing the design procedure of the different compact spiral tube heat exchangers.

1.1 Assumption in Design of Spiral Tube Heat Exchanger

1. Properties of cold water and hot water are considered as constant, at an average value of inlet and outlet temperature with little loss in accuracy.
2. Flow through heat exchanger is fully developed, steady and constant.
3. Fluid stream experiences little or no change in their velocities and elevations hence the Kinetic Energy and Potential energy changes are negligible.
4. Outer surface of heat exchanger is assumed to be perfectly insulated.
5. There is no fouling in heat exchanger.

2 DESIGNING OF SPIRAL TUBE HEAT EXCHANGER

2.1 Design of Shell

There is no standard method available for calculating the various design parameters of the spiral tube heat exchanger, such as shell inside diameter, length of shell, curvature ratio, developed length of spiral tube and total length of spiral tubes. Therefore, the methodology followed by different

researcher studied in literature review is used for the determination of these parameters. Following data shown in Table 1 is considered for calculating the shell parameters.

Table: 1 Design Parameter for Spiral coil

Parameters	Dimensions
O.D. of copper tube, mm (d_o)	12
I.D. of copper tube, mm (d_i)	10
Number of Spiral coils (n)	3
Number of Turns	4
Spiral Pitch, mm (P)	20
I.D. of Spiral, mm (D_i)	114.02
O.D. of Straight tube, mm (d_{ho})	27
I.D. of Straight tube, mm (d_{hi})	25

2.2 Inside Diameter of Shell (D_{is})

Inside diameter of shell is calculated as,

$$D_{is} = 2\,(R_0 + R_{h0}) \qquad \text{(Eqn. 1)}$$

$$R_0 = R_i + 3P \qquad \text{(Eqn. 2)}$$

2.3 Length of Shell (L_s)

Length of shell required for the heat exchanger is calculated as,

$$L_s = \frac{R_0^2 - R_i^2}{a} \qquad \text{(Eqn. 3)}$$

$$a = P\,\frac{\pi}{2} \qquad \text{(Eqn. 4)}$$

2.4 Curvature ratio (δ)

Curvature ratio is the ratio of tube diameter to the diameter of spiral is calculated as,

$$\delta = \frac{d_i}{D_i} \qquad \text{(Eqn. 5)}$$

2.5 Developed Length of Spiral Coil (L_0)

Length of the spiral coil used in spiral tube heat exchanger is calculated as,

$$L_0 = B_1 + B_2 + B_3 + B_4 + B_5 + B_6 + B_7 \qquad \text{(Eqn. 6)}$$

or

$$L_0 = L_1 + L_2 + L_3 + L_4 + L_5 + L_6 + L_7$$

$$B = r_n\,\psi \qquad \text{(Eqn. 7)}$$

$$r_n = (R_i + k\,t) \qquad \text{(Eqn. 8)}$$

$$k = \frac{1}{3} \quad \text{if } R_i \ll 2\,t \qquad \text{(Eqn. 9)}$$

In case of Copper $$k = \frac{1}{2} \quad \text{if } R_i > 2\,t \qquad \text{(Eqn. 10)}$$

2.6 Total length of Copper Tubes in Heat Exchanger (L_T)

The total length of copper tubes required in the heat exchanger is calculated as,

$$L_T = n\, L_0 \qquad \text{(Eqn. 11)}$$

Table: 2 Design Parameter for Spiral Tube Heat Exchanger

Parameter	Tube Side	Shell Side
Inner temperature °C	35	70
Outlet temperature °C	43.3	65
Mass flow rate Kg/s	0.05	0.0833
Density kg/m^3	989.1	979.4
Specific heat KJ/kg K	4.18	4.18
Dynamic viscosity Ns/m^2	5.77 ×10^{-4}	4.2 × 10^{-4}

All the properties of density, specific heat, viscosity, and thermal conductivity of hot water considered for the shell side calculations are obtained at the average of hot inlet and outlet temperature as $T_{h,avg}$.

$$T_{h,avg} = \frac{T_{h1} + T_{h2}}{2} \qquad \text{(Eqn. 12)}$$

Similarly, all the properties of density, specific heat, viscosity, and thermal conductivity of cold water considered for the tube side calculations are obtained at the average of cold inlet and outlet temperature as $T_{c,avg}$.

$$T_{c,avg} = \frac{T_{c1} + T_{c2}}{2} \qquad \text{(Eqn. 13)}$$

2.7 Energy Balance

The amount of heat transfer rate or heat potential is calculated by using following energy balance equations,

$$Q_h = Q_c \qquad \text{(Eqn. 14)}$$

$$m_h\, C_{ph}\, (T_{h1} - T_{h2}) = m_c\, C_{pc}\, (T_{c2} - T_{c1}) \qquad \text{(Eqn. 15)}$$

For all the further calculation average of hot and cold heat transfer rate is taken,

$$Q_{avg} = \frac{Q_c + Q_h}{2} \qquad \text{(Eqn. 16)}$$

Heat transfer rate is also calculated from Newton's law of cooling as,

$$Q = U\, A_s\, (\Delta\theta_{(LMTD)}) \qquad \text{(Eqn. 17)}$$

A_s is the outer surface area of heat exchanger in m^2

$$A_s = n\, \pi\, d_0 L_o \qquad \text{(Eqn. 18)}$$

Flow arrangement selected is counter flow and accordingly LMTD is calculated as,

$$\Delta\theta_{(LMTD)} = \frac{(\theta_2 - \theta_1)}{\ln \frac{(\theta_2)}{(\theta_1)}} \qquad \text{(Eqn. 19)}$$

$$\theta_2 = (T_{h2} - T_{c1}) \qquad \text{(Eqn. 20)}$$

$$\theta_1 = (T_{h1} - T_{c2}) \quad \text{(Eqn. 21)}$$

2.8 Effectiveness of Heat Exchanger

Effectiveness of heat exchanger is calculated as,

$$\epsilon = \frac{Q_{avg}}{Q_{max}} \quad \text{(Eqn. 22)}$$

$$Q_{max} = (mC_P)_{min}(T_{h1} - T_{c1}) \quad \text{(Eqn. 23)}$$

2.9 Number of Transfer Units of Heat Exchanger

Number of Transfer Units for counter flow is the measure of effectiveness of heat exchanger, which is calculated as,

$$NTU = \frac{1}{R-1}\ln\left(\frac{R-1}{R\epsilon - 1}\right) \quad \text{(Eqn. 24)}$$

$$R = \frac{C_{min}}{C_{max}} \quad \text{(Eqn. 25)}$$

$$NTU = \frac{U A_s}{C_{min}} \quad \text{(Eqn. 26)}$$

2.10 Reynolds Number (Re) of Tube Fluid

Reynolds number for cold side i.e. the fluid flowing in the spiral tube is calculated as follows,

$$Re_c = \frac{\rho_c V_c d_i}{\mu_c} \quad \text{(Eqn. 27)}$$

Velocity (V) of fluid flowing through the spiral coil is calculated as,

$$Q_t = A_i V_c = \frac{\pi}{4} d_i^{\,2} V_c \quad \text{(Eqn. 28)}$$

2.11 Nusselt Number (Nu) of Tube Fluid

Using Kalb and Seader Correlation for determining the Nusselt number for the flow in the spiral tubes,

$$Nu_c = 0.836\ De^{0.5}\ Pr_c^{\,0.1} \quad \text{(Eqn. 29)}$$

$$De = Re_c \sqrt{\frac{r_i}{R_i}} \quad \text{(Eqn. 30)}$$

$$Pr_c = \frac{\mu_c C_{Pc}}{K_c} \quad \text{(Eqn. 31)}$$

2.12 Heat Transfer Coefficient of Inner Tube Fluid

Heat transfer coefficient on cold side i.e. inside of spiral tube is calculated as,

$$h_c = \frac{Nu_c K_c}{d_i} \quad \text{(Eqn. 32)}$$

2.13 Reynolds Number (Re) of Shell Fluid

Reynolds number for shell side i.e. the fluid flowing in the shell is calculated as follows,

$$Re_h = \frac{\rho_h V_h D_e}{\mu_h} \quad \text{(Eqn.33)}$$

Effective diameter or hydraulic diameter of shell in calculated as;

$$D_e = D_{is} - 2(d_{ho}) - 8(d_o) \quad \text{(Eqn.34)}$$

Velocity of fluid flowing through the shell is calculated as,

$$Q_s = A_e V_h = \frac{\pi}{4} D_e^{\,2} V_h \quad \text{(Eqn. 35)}$$

2.14 Nusselt Number (Nu) of Shell Fluid

Nusselt number for flow in shell side is calculated by the Correlation used in literature,

$$Nu_h = 0.04\ Re_h^{0.8}\ Pr_h^{0.4} \quad \text{(Eqn.36)}$$

$$Pr_h = \frac{\mu_h\ C_{Ph}}{K_h} \quad \text{(Eqn. 37)}$$

2.15 Heat Transfer Coefficient of Shell Fluid

Heat transfer on shell side i.e. at the outside of spiral coil is calculated as,

$$h_h = \frac{Nu_h\ K_h}{d_0} \quad \text{(Eqn. 38)}$$

2.16 Overall Heat Transfer Coefficient

It depends upon on the inside heat transfer coefficient of tube and outside heat transfer coefficient of heat exchanger is calculated as,

$$\frac{1}{U_0} = \frac{1}{A_{si}\ h_c} + R + \frac{1}{h_h\ A_{so}} \quad \text{(Eqn. 39)}$$

$$\frac{1}{R} = \frac{1}{R_{s1}} + \frac{1}{R_{s2}} + \frac{1}{R_{s3}} + \frac{1}{R_{st1}} + \frac{1}{R_{st2}} \quad \text{(Eqn. 40)}$$

Total outer heat transfer surface area is calculated as,

$$A_{so} = (n\ \pi\ d_0\ L_0) + (n_1\ \pi\ d_{ho}\ L_{st}) \quad \text{(Eqn. 41)}$$

Total inside heat transfer surface area is calculated as,

$$A_{si} = (n\ \pi\ d_i\ L_0) + (n_1\ \pi\ d_{hi} L_{st}) \quad \text{(Eqn. 42)}$$

L_s is the length of straight tube, n_1 is straight header tube = 2

$$R_{s1} = R_{s2} = R_{s3} = \frac{(d_0 - d_i)}{2\ \pi\ K\ L_o\ \ln\left(\frac{d_0}{d_i}\right)} \quad \text{(Eqn. 43)}$$

$$R_{st1} = R_{st2} = \frac{(d_{h0} - d_{hi})}{2\ \pi\ K\ L_{st}\ \ln\left(\frac{d_{h0}}{d_{hi}}\right)} \quad \text{(Eqn. 44)}$$

Hence by adopting above design procedure two spiral tube heat exchanger with specifications shown in the table 3 were designed and compared.

Table: 3 Dimensions of Spiral Tube Heat Exchangers

Parameters	Spiral Tube Types	
	Type – A	Type - B
O.D. of copper tube (mm)	12	12
I.D. of copper tube (mm)	10	10
Number of Spiral coils	3	3
Number of Turns	4	4
Spiral Pitch (mm)	25	20
Curvature Ratio	0.1136	0.0877
I.D. of Spiral (mm)	88.5	114.02
O.D. of Spiral (mm)	238.5	234.02

I.D. of Shell (mm)	278	278
O.D. of Shell (mm)	280	280
Length of Shell (mm)	270	270
Thickness of Shell (mm)	1	1
O.D. of Straight tube (mm)	27	27
I.D. of Straight tube (mm)	25	25
Total length of Copper Tube (mm)	5880	5880
Material of Shell	S.S.	S.S.

Fig. 1 and 2 shows the schematic drawing of spiral coils in the Auto Cad software, after calculating the above-mentioned parameters.

Fig1: Spiral Tube Type A

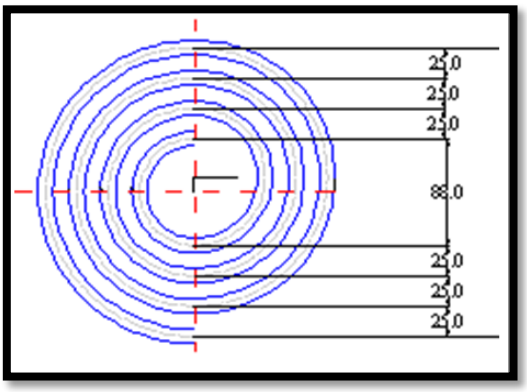

Fig2: Spiral Tube Type B

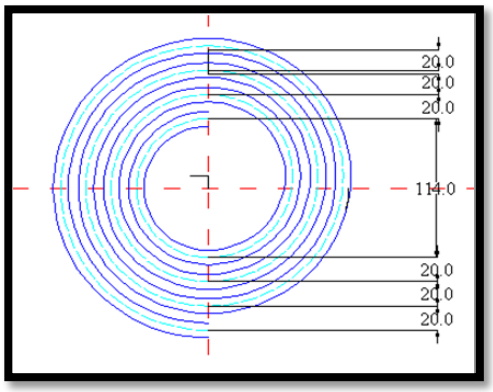

Fig. 3 and 4 shows the photographic image of spiral coils fabricated with the same dimensions obtained by design calculation.

Fig.3 Photographic Image of Spiral Coils Type A

Spiral coils are ready for further joining with the straight header tube.

Fig.4 Photographic Image of Spiral Coils Type B

Following data shown in Table 2 is adopted for further calculation of STHE,

Based on above theory and design calculations of STHE, experimental set up is developed and fabricated. The experimental results clearly states that the high curvature ration and high spiral pitch heat exchanger generates more secondary turbulent flow which is responsible for high heat transfer in the same space. Hence while designing of spiral tube heat exchanger the important parameters are curvature ratio and spiral pitch.

3 CONCLUSION

This paper is an attempt to unite the design procedure for spiral tube heat exchanger by incorporating the mathematical formulas. This leads to the formulation of systematic procedure for designing of heat exchanger. This design method of heat exchanger can be used for designing the similar kind of compact heat exchanger. The main parameters that are to be taken care while designing of heat exchangers is curvature ratio and spiral pitch.

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A SURVEY ON THE USE OF OPEN-SOURCE FIREWALL FOR MAJOR SCADA PROTOCOLS

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ABSTRACT

Supervisory Control and Data Acquisition (SCADA) system is control and monitoring system architecture used in modern industrial control systems and critical infrastructures. Many SCADA protocols have been developed to fulfill the essential requirements of SCADA systems, such as high availability, reliability, and real time response. Among those all protocols, Modbus, DNP3, and IEC 60870-5-104 (aka IEC 104) are the most used SCADA protocols. These protocols are developed to work over IP to enable the SCADA systems communication through the internet connectivity. As these protocols enable SCADA system communication from any remote location with the use of internet, it also opens the door to expose its existence and invites SCADA specific cyber-attacks. Several traffic filtering based security solutions are designed for SCADA systems, but Linux iptables based open-source firewall approach is one of the best among all. This paper presents an overview of SCADA Systems, and major three SCADA protocols with their architecture. Furthermore various SCADA specific attacks are discussed and iptables firewall is analyzed against those attacks.

Keywords: SCADA systems, SCADA security, network security, open source, firewalls, IEC 60870-5-104, Modbus, DNP3, Linux IPT ables.

1 INTRODUCTION

Mostly all the supervising, controlling, and monitoring needs of any critical infrastructure are managed by SCADA system, and therefore protecting it from any type of threat is critically important. Traditional SCADA systems has 3 major components, (A) Human Machine Interface (HMI), (B) Master Terminal Unit (MTU), (C) Remote Terminal Units (RTUs) or Programmable Logic Controllers (PLCs). Controlling and

monitoring is handled by a SCADA operator using HMI. PLCs or RTUs collect the data from physical end point devices such as sensors and actuators and send it to MTU. MTU is the heart of the system to manage core functions like communication, data collecting, processing, storing and representing.

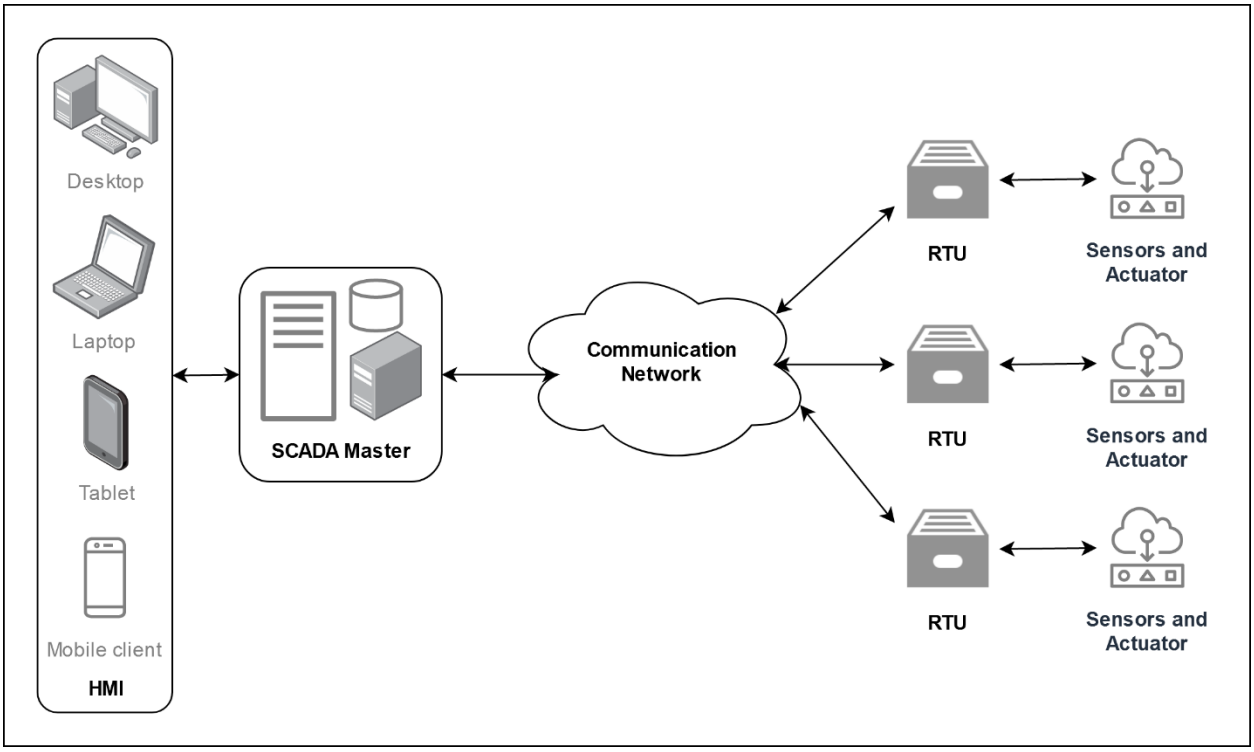
In recent decades, computing and communications have undergone considerable amount of changes. Computation is preferred on the go with a plenteous demand of mobility support in communicating [27], [28]. Due to the increasing users in wireless environment, communication paradigm also have shifted to the concept of Cognitive Radio Networks [25], [26] for better utilization of wireless spectrum. Needless to say, the advancement in handheld equipment and tremendous popularity of mobile application leads to necessity of timely analysis and security provisioning of communication environment. In specific to SCADA systems, SCADA protocols are designed to enable communication between all components of SCADA system. It transfers data and control commands between MTU and other components. Modbus, DNP3 and IEC 60870-5-104 are the three majorly used protocols in SCADA systems. Most of the protocols were initially designed to fulfill the operational requirements only. Over the time these protocols are extended to work over the internet but, it also invites various threat with this extension. Several cyber-attack incidents on SCADA are discussed in [14].

To fill this gap of security, traffic filtering-based detection system is better way to detect and prevent any cyber-attack. Linux Iptables is good option to use as firewall in SCADA system. Several researches have explored and examined its capabilities against SCADA attacks. In this paper, we provide the study of SCADA systems, most used three protocols, various attacks on those protocols, and analysis of iptables rules against those attacks.

Specifically the rest of the paper is sorted out as follows. Section II gives the SCADA system and its security overview. Section III introduces major three SCADA protocols with its architecture. Section IV provides the details of various firewall and IDS security solution based researches. Section V represents common attacks on major three protocols and analyzes whether iptables rule is defined for that particular attack or not. Section VI discusses the summary of whole works. Finally, Section VII concludes this paper and giving the new direction of research in this field.

2 SCADA SYSTEM AND SECURITY OVERVIEW

Figure 1 Generic SCADA Network Architecture



Supervisory Control and Data Acquisition (SCADA) system is a control and monitoring system architecture used in modern industrial control systems and critical infrastructures (e.g. food and beverage industries, power generation plants, petroleum industries, energy sector, transportation systems, sewage plants, manufacturing industries, recycling plants, and many more). Main objectives of SCADA system are: monitor, measure, data acquisition, data communication, controlling and automation. SCADA systems consist of software and hardware units such as Master Terminal Unit (MTU), Human Machine Interface (HMI), Remote Terminal Units (RTUs), Programmable Logic Controllers (PLCs), Sensors and Actuators, and Communication Network Infrastructure. MTU is a core part of SCADA system which manages communication, representing on interfaces, data collection, data processing, and data storing. RTU collects the data from connected sensors and actuators and further sends the collected data to MTU. RTUs are facilitated with storage, so it transmits the data to MTU on received command. HMI is used for monitoring and controlling the SCADA system with the help of an interface. Communication network is a link between all components of SCADA and it can be wired or wireless. Nowadays HMIs are extended to support many devices such as desktops, laptops, tablets, mobile phones, and screens.

SCADA systems are now more vulnerable to many threats [1] as modern SCADA systems are extended from local network to public network with an increased connections. Several studies discovers many vulnerabilities and attacks on SCADA systems. In [3], the authors have used attack tree methodology to discover security vulnerabilities in SCADA systems and have identified eleven attacks. In [5], the authors have classified various SCADA systems based cyber-attacks, such as attacks based on hardware and software, and communication stack based attacks. In [8], the authors provided detailed information about four major type of attacks against SCADA system.

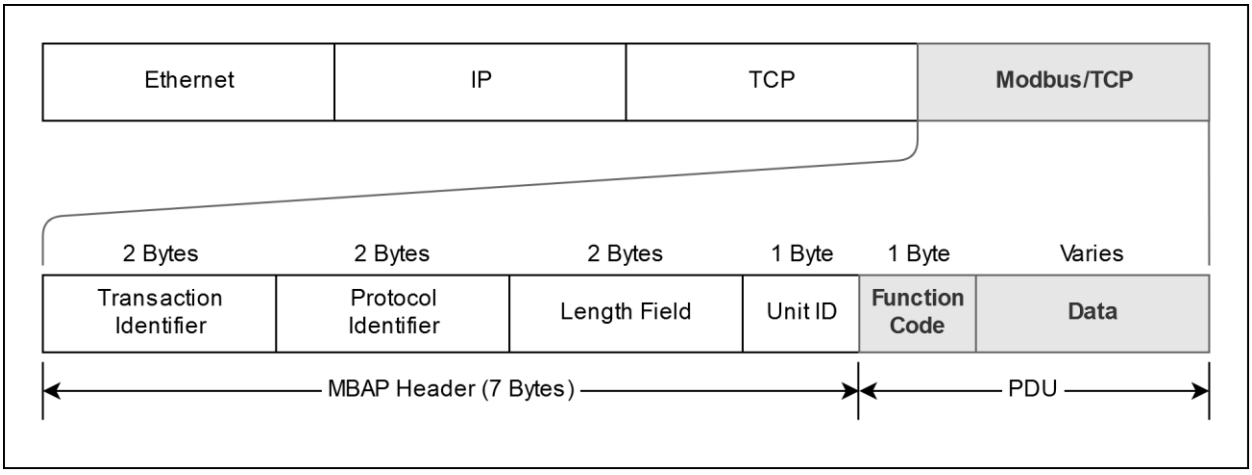
3 SCADA COMMUNICATION PROTOCOLS

SCADA communications protocols are designed to transfer data and control messages on industrial communication networks. Many SCADA protocols have been designed in recent decades, but most of these were initially designed where network security was not considered as a problem [3]. Because of it, many SCADA protocols are lacking when it comes to security, which leads to make the critical infrastructure vulnerable to threats.

Technical details of three major SCADA protocols are provided in the following subsections. This information enables the readers to understand the protocol overview, its architecture, various commands, and vulnerabilities/attacks on it.

3.1 Modbus

Figure 2 Modbus/TCP Protocol Architecture



Modbus/TCP is designed for Ethernet communication. It is an extension of Modbus/RTU protocol, which is a serial communication protocol designed by Modicon to use with PLCs of it. It uses request-response communication model where a device known as Modbus master is requesting or writing the information

and devices known as Modbus slaves supplies the information or acknowledge the execution state. There is one master and up to 247 slaves in one standard Modbus network. Each slave is uniquely assigned with slave address from 1 to 247.

A Modbus/TCP packet contains Modbus Application Protocol (MBAP) header of 7 bytes and Protocol Data Unit (PDU) with variable size. MBAP consists transaction and protocol identifier along with the length of packet, and slave identifier. While PDU consists two fields Function Code (FC) and Data Field which contains the actual Modbus command. FC is the 1 byte information which instruct the slave device which task to perform. Data field contains a detailed information of respective FC defined in 1st byte of PDU. This information could be Read/Write access method, data type, number of registers/coils, starting and ending address of registers/coils, data to write, sub-function code, device states, and etc.

Some Modbus function codes are publically standardized, which are [21]:

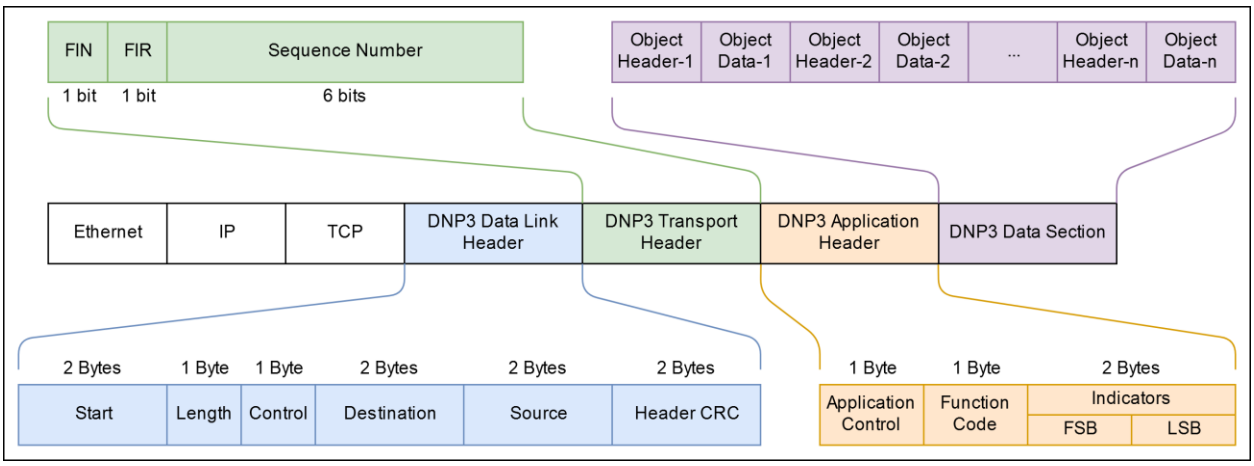
Table: 1 Standard Modbus Function Codes

Function Code	Hex Value	Action
01	0x01	Read Coils
02	0x02	Read Discrete Inputs
03	0x03	Read Holding Registers
04	0x04	Read Input Registers
05	0x05	Write Single Coil
06	0x06	Write Single Register
07	0x07	Read Exception Status
08	0x08	Diagnostics
11	0x0B	Get Communication Event Counter
12	0x0C	Get Communication Event Log
15	0x0F	Write Multiple Coils
16	0x10	Write Multiple registers
17	0x11	Report Slave ID
20	0x14	Read File Record
21	0x15	Write File Record
22	0x16	Mask Write Register
23	0x17	Read/Write Multiple registers
24	0x18	Read FIFO Queue
43	0x2B	Encapsulated Interface Transport
43/13	0x2B/0x0D	CANopen General Reference Request and Response PDU
43/14	0x2B/0x0E	Read Device Identification
65-72, 100-110	-	Reserved for User Defined Function Codes

3.2 DNP3

DNP3 is a group of telecommunications protocols that defines communication between SCADA components such as Master unit, RTUs, Intelligent Electronic Devices (IEDs) and other outstation devices. It is an open source protocol with many important features which makes it interoperable, robust, and one of the most efficient protocol in SCADA systems. It transmits data reliably in sequence of relatively small packets. It supports 4 types of communication mode, one-to-one, multi-slave, multi-master, and hierarchical [22]. In one-to-one, only one master station manage one slave. In multi-slave, one master station manages multiple slaves. In multi-master, one slave has been managed by multiple masters. In hierarchical, master station manages a slave master station as well along with other slaves.

Figure 3 DNP3 Protocol Architecture



A DNP3 message is divided into 4 main parts, (A) Data Link Header is of 10 bytes, which consists starting address (2 Bytes), length of message (1 Byte), a control field which contains data to manage flow of message (1 Byte), destination address where message needs to reach (2 Bytes), source address from where the message was originated (2 Bytes), and cyclic redundancy check code (2 Bytes). (B) Transport Header is of 1 byte, which consists FIR and FIN bits of 1 bit to indicate start and end of a sequence of frames, and sequence number (6 bits) denotes the frame sequence number. It can be any from 0 to 63 for initial frame and increments for each frame comes after initial and number rollover from 63 to 0. (C) Application Header is of 4 Bytes, which consists application control (1 Byte) to control flow of communication, function code (1 Byte) indicates the action to be performed, and indicators (2 Bytes) are used in reply message to pass useful information from outstation device to master station. Reply message can be confirmation, response, or an unsolicited response. (D) Data Section is of variable size and contains data objects with their header.

Some well-known public function codes of DNP3 are as below [22]:

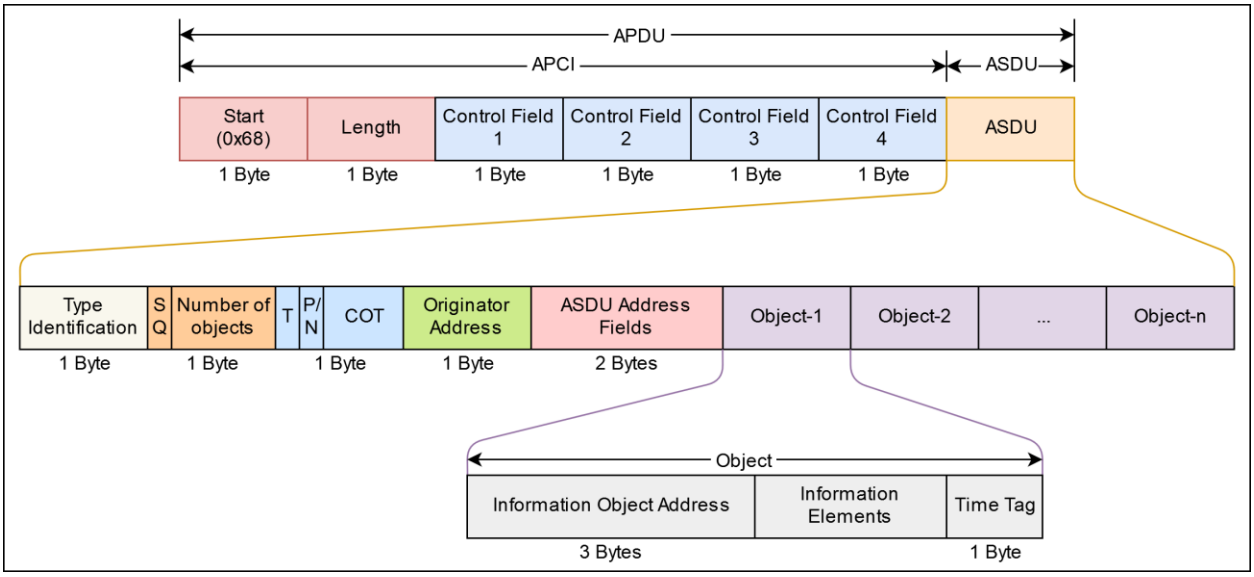
Table: 2 DNP3 Function Codes

Function Code	Hex Value	Action
01	0x01	Read
02	0x02	Write
03	0x03	Select
04	0x04	Operate
05	0x05	Direct Operate
06	0x06	Direct Operate, No Ack
07	0x07	Immediate Freeze
08	0x08	Immediate Freeze, No Ack
09	0x09	Freeze and Clear
10	0x0A	Freeze and Clear, No Ack
13	0x0D	Cold Restart
14	0x0E	Warm Restart
20	0x14	Enable Unsolicited Messages
21	0x15	Disable Unsolicited Messages
22	0x16	Assign Class
23	0x17	Delay Measurement
129	0x81	Response
130	0x82	Unsolicited Response

3.3 IEC 104 (IEC 60870-5-104)

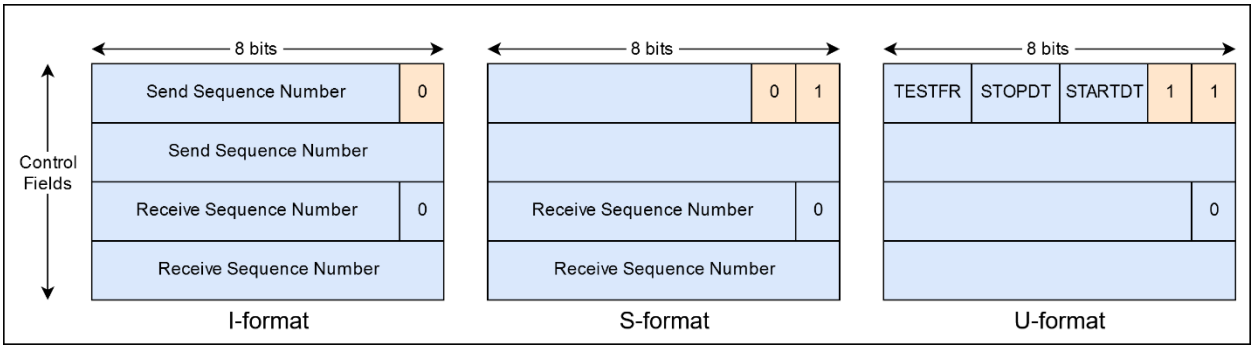
IEC 60870 standards are defined by the International Electrotechnical Commission (IEC) for SCADA systems in electrical and power systems. Part 5 of these standards consist transmission protocols for transmitting telecontrol messages between master station and outstation over standard TCP/IP network. IEC 60870-5-104 (IEC 104) was developed in 2000 and facilitate IEC 60870-5-101 with network access using standard transport profiles. It is a standard for SCADA systems with TCP/IP based communication network for monitoring and controlling geographically pervasive processes.

Figure 4 IEC 104 Protocol Architecture



IEC 104 can be of fixed length and variable length. Fixed length just contains APCI (Application Protocol Control Information) in APDU (Application Protocol Data Unit), while variable length have APCI and ASDU (Application Service Data Unit) in APDU. APCI starts with Start field (1 Byte) with fixed value 0x68 followed by length of APDU (1 Byte), and four CF (control fields) (1 Byte each). There are 3 types of APCI frame (A) I-format (information transfer format) where last bit of CF1 is 0, (B) S-format (numbered supervisory functions) where last bits of CF1 are 01, (C) U-format (unnumbered control functions) where last bits of CF1 are 11. Control fields are elaborated in below figure 5. ASDU contains type identification field of 1 Byte, Structure Qualifier (SQ) bit specifies the addressing of information objects or elements, number of objects defines the number of objects or elements ASDU contains, T bit indicates ASDU is generated for test conditions, P/N bit is used for positive or negative confirmation, cause of transmission (COT) is six-bit code that control the message routing and interpretation of information when it reach the destination, originator address (ORG) of 1 Byte is used to identify controlling station in case of more than one else there is no originator address, ASDU address of 2 Bytes is also called as common address which is associated with the information objects in ASDU. Each information object contains information object address (IOA) which act as a destination address when it is used in a control direction and as a source address when it is used in monitor direction.

Figure 5 IEC 104 Protocol APCI Frames



Some common command types of IEC 104 are [22]:

Table: 3 IEC 104 Common Command Types

Command Type	Reference	Description
45	C_SC_NA_1	Single command
46	C_DC_NA_1	Double command
47	C_RC_NA_1	Regulating step command
58	C_SC_TA_1	Single command with time tag CP56Time2a
59	C_DC_TA_1	Double command with time tag CP56Time2a
60	C_RC_TA_1	Regulating step command with time tag CP56Time2a
48	C_SE_NA_1	Setpoint command, normalized value
49	C_SE_NB_1	Setpoint command, scaled value
50	C_SE_NC_1	Setpoint command, short floating point value
61	C_SE_TA_1	Setpoint command, normalized value with time tag CP56Time2a
62	C_SE_TB_1	Setpoint command, scaled value with time tag CP56Time2a
63	C_SE_TC_1	Setpoint command, short floating point value with time tag CP56Time2a
103	C_CS_NA_1	Clock synchronization command
105	C_RP_NC_1	Reset process command
107	C_TS_TA_1	Test command with time tag CP56Time2a
101	C_CI_NA_1	Counter interrogation command
102	C_RD_NA_1	Read command

4 FIREWALL/IDS FOR SCADA SYSTEMS

In this section, we discussed various researches based on filtering solutions for all three major protocols of SCADA systems. Several work uses Linux iptables while some other uses different approaches. It includes the information about the work and their limitations.

In [16], critical state-based filtering system, the authors have introduced an innovative state analysis based filtering system for SCADA systems. They designed a firewall architecture for the Modbus protocol and DNP3 protocol based SCADA systems with aim to detect off-sequenced command of complex process and block it. This filtering mechanism can secure the SCADA systems only against specifically crafted attack which uses set of commands to disturb the process. While all other classes of attacks can still affect the SCADA systems. Early warning system for the critical state is really helpful, but it cannot be used as solo firewall. However this approach very helpful for enhancing the SCADA firewalls.

In [17], [14] and [15], the authors have identified the potential of the open source Linux iptables based firewall solution for network security and SCADA system security. Some of the common network based attacks were simulated by authors in [17] and tested to examine the capabilities of iptables. Many open source firewall solutions are being used for network security, but use of it in SCADA system were not properly investigated. So, in other two researches, the authors used iptables as a firewall solution in the SCADA systems. For dynamic packet inspection of data, the authors have created iptables rules by utilizing the advance features of iptables. Rules have been defined, tested and validated for its ability to detect various simulated attacks only on Modbus protocol, and DNP3 protocol based SCADA systems. However, rules represented in these papers are for only few attacks, while some more rules needs to be developed for other common attacks on Modbus and DNP3 protocols. Furthermore no work has been accomplished to determine the capabilities of iptables against IEC 104 protocol based SCADA systems.

In [13], SCADAWall model is developed and presented by the authors. SCADAWall consists 3 algorithms, (A) CPI (Comprehensive Packet Inspection), (B) PIPEA (Proprietary Industrial Protocol Extension Algorithm), and (C) OSDA (Out of Sequence Detection Algorithm). A CPI uses the iptables, but extends the dynamic packet inspection technique. It checks the data field as well along with the header to ensure that only trusted payload and packets accepted. A PIPEA enables the SCADAWall users to add any new proprietary protocol and create rules for it. An OSDA is defined to resolve the issue of off-sequenced command like we discussed above for [16]. This model is specifically developed and tested against Modbus protocol based SCADA system.

In [18], [19], and [20], the authors have presented various approaches such as anomaly detection, rule-based IDS and stateful IDS with the use of DPI (Deep Packet Inspection). Anomaly detection based approach is

built on Bro platform with capability of detecting any kind of malicious threats, even a zero-day threats. Authors have tested this approach on IEC 104 SCADA protocol with just three different attacks and represented the results of it. There are many other attacks which needs to be tested with this approach. Also authors have used Bro tool to build the proposed IDS system, but additional efforts are needed in writing parser to convert the network data into Bro compatible format. A rule-based IDS approach is implemented using snort rules, with the use of a DPI (Deep Packet Inspection) method. It uses signature-based approach to detect the known attacks, and model-based approach to detect the unknown attacks. Several attacks were tailored specifically for IEC 104 protocol based SCADA system, tested against both rule-based approaches and detection, and the result is represented by the authors. According to our analysis, this approach is the best security solution among all three different approaches. The stateful IDS approach also uses the DPI method and specifically designed, implemented, and validated for IEC 104 based SCADA systems. However the proposed approach is limited to 8 different alarm states, mainly representing timer overtime state. Furthermore, network based or protocol based attacks cannot be detected or prevented using this approach. From all these three IDS approaches, no one investigated the use of open source Linux iptables rules to prevent the attacks on SCADA systems.

In [24], the authors have studied and analyzed various firewall systems for Smart Grid (SG) paradigm. Authors provided overview of seven different firewall solutions and concluded that most of the paper examined Modbus and DNP3 protocols only, while SCADA protocols like IEC 61850 and IEC 60870 still need more work.

From all these different solutions, our analysis determines that open source Linux iptables is really good approach for SCADA security. However till now, only Modbus and DNP3 protocols based only few attacks are examined. While capability of iptables against IEC 104 protocol based attacks is totally unexplored.

5 COMMON ATTACKS AND IPTABLES RULES

As SCADA systems are controlling critical infrastructures, an attacks on SCADA systems can damage the system or disrupt the critical operations. Further it can lead to hazardous damages to the environment, monetary losses, and most dangerous is human losses. In this section, we discussed attacks identified on Modbus, DNP3, and IEC 104 SCADA protocols and their corresponding iptables rules.

5.1 Attacks on Modbus Protocol [2], [3], [5], [6], [14]

Table: 4 Attacks on Modbus Protocol

No.	Attack Goal	Methodology	IPTables Rule Defined?
(M1)	**Gain SCADA system access**	Access to wireless PCN, Third party access, Access to remote field sites, or Use of SCADA transmission media.	No
(M2)	**Identify Modbus device**	FC (Function Code) 43, and Sub FC 14 is used for reading device identification.	Yes
(M3)	**Disrupt master-slave communication**	Accepting communication/command from an unauthorized IPs.	No
(M4)	**Disable/Compromise Master/Slave**	Accepting operation commands from an unauthorized IPs.	No
(M5)	**Unauthorized read/write data**	Accepting read/write commands from an unauthorized IPs.	Yes
(M6)	**Clear counters and diagnostic registers**	FC 08, and Sub FC 10 is used for clearing counters and diagnostic registers.	Yes
(M7)	**Remote restart**	FC 08, and Sub FC 01 is used for restarting the Modbus device remotely.	Yes
(M8)	**Force PLC into listen-only mode**	FC 08, and Sub FC 04 is used to put PLC into listen-only mode.	Yes
(M9)	**Report server information**	Attacker can use FC 17 to enumerate PLCs.	Yes
(M10)	**Clear overrun counters and diagnostic flags**	FC 08, and Sub FC 20 is used for clearing overrun counters and diagnostic flags.	No
(M11)	**Broadcast message spoofing**	Attacker sends faked broadcast messages.	No
(M12)	**Direct slave control**	By identity spoofing, attacker access the slave device.	No
(M13)	**Passive reconnaissance**	Passively sniffing network traffic.	No
(M14)	**Response delay**	Delaying the response from slave devices to the master.	No
(M15)	**Man in the middle attack**	Access to SCADA network and put device between master and outstation device to sniff and modify the messages.	No

5.2 Attacks on DNP3 protocol [2], [4], [15]

Table: 5 Attacks on DNP3 Protocol

No.	Attack Goal	Methodology	IPTables Rule Defined?
(D1)	**Gain SCADA system access**	Access to wireless PCN, Third party access, Access to remote field sites, or Use of SCADA transmission media.	No
(D2)	**Passive reconnaissance**	Passively sniffing network traffic.	No
(D3)	**Baseline response replay**	Attacker sends spoofed message as a response to master and as a command to an outstation devices.	No
(D4)	**Man in the middle attack**	Access to SCADA network and put device between master and an outstation device to sniff and modify the messages.	No
(D5)	**Transport sequence modification**	Attacker sends spoofed message in fragmented message sequence.	No
(D6)	**Outstation write attack**	FC 2 is used to writes data on an outstation device.	No
(D7)	**Clear objects attack**	FC 9, and 10 are used to freeze and clear the data objects.	Yes
(D8)	**Outstation data reset**	FC 15 is used to reinitialize the data objects on outstation.	No
(D9)	**Configuration capture attack**	Fifth bit in second byte of the IIN is set in the message informs master to resend the configuration file again to an outstation.	No
(D10)	**Length overflow attack**	Incorrect value is set in the length field.	No
(D11)	**DFC flag attack**	Attacker sets DFC flag to indicate an outstation as busy.	No
(D12)	**Reset function attack**	FC 1 is used to reset the user process on the outstation device.	No
(D13)	**Unavailable function attack**	FC 14 or 15 is used to make the outstation device unavailable to the master.	No
(D14)	**Destination address alteration**	Attacker alter the destination address field to affect the communication.	No
(D15)	**Fragmented message interruption**	FIR and FIN flags are set in wrong fragmented message to disrupt communication.	No
(D16)	**Outstation application termination attack**	FC 18 is used by attacker to terminate the applications running on an outstation.	Yes

(D17)	**Disable unsolicited responses attack**	FC 21 is used by attacker to stop unsolicited response update from an outstation to master.	Yes
(D18)	**Warm restart attack**	FC 14 is used to restart the communication in the outstation. Continuous stream of this attack can lead to DoS attack as well.	Yes
(D19)	**Cold restart attack**	FC 13 is used to restart the outstation device.	Yes
(D20)	**Broadcast message spoofing**	Attacker sends faked broadcast messages.	Yes

5.3 Attacks on IEC 104 protocol [19], [18], [7], [9], [23]

Table: 6 Attacks on IEC 104 Protocol

No.	Attack Goal	Methodology	IPTables Rule Defined?
(I1)	**Gain SCADA system access**	Access to wireless PCN, Third party access, Access to remote field sites, or Use of SCADA transmission media.	No
(I2)	**IEC/104 port communication**	Establish spoofed connection or hijack the established connection between client and server.	No
(I3)	**Spontaneous messages storm**	Attacker sends huge amount of false spontaneous messages.	No
(I4)	**Unauthorized read command**	Unauthorized client sends command to read the field device.	No
(I5)	**Unauthorized interrogation commands**	Unauthorized client sends interrogation command against server.	No
(I6)	**Remote control commands or remote adjustment commands**	Unauthorized client sends control or adjustment command.	No
(I7)	**Reset process command**	Unauthorized client sends command with type identification 69H to reset the process of server.	No
(I8)	**Broadcast request**	Attacker sends faked broadcast messages.	No
(I9)	**Buffer overflow**	Incorrect packet length.	No
(I10)	**Network reconnaissance**	Port scanning from known and unknown hosts	No
(I11)	**Man in the middle attack**	Access to SCADA network and put device between master and an outstation device to sniff and modify the messages.	No

(I12)	**Single command attack**	Unauthorized client sends a single command to execute.	No
(I13)	**Modification and injection attack**	Command is modified or injected in SCADA system using MiTM.	No

6 DISCUSSION

Several papers have examined the SCADA security issues with detailed information of major protocols used in SCADA systems, attacks on those protocols, attack impacts, and use of different methodology as a countermeasure. In [1] the authors provide technical details of various SCADA protocols along with their corresponding packet structure. Among all those protocols, Modbus, DNP3 and IEC 60870-5-104 (aka IEC 104) are the most widely used protocols in SCADA systems. Different vulnerabilities and attacks on above three major protocols have been identified by the authors in [2], [3], [4], [5], [6], [7], [8], [9], and [10]. Moreover, in [11] the authors have implemented a secure Modbus protocol with the help of cryptography, in [12] the authors have presented a security framework for DNP3 protocol. In [16], [18], [19] and [20] the authors have presents various firewall/intrusion detection system (IDS) solutions with different approaches. In [17], the authors have used iptables as a firewall for network based attacks. Furthermore in [13], [14], and [15] the authors implements Linux iptables as a firewall for SCADA systems. Although lot of research work has been accomplished in direction of firewall/IDS for SCADA System, but most of them are for Modbus protocol and DNP3 protocol and only few for IEC 104 protocol. Also we did not find any paper that examines or evaluates Linux iptables on IEC 104 protocol.

7 CONCLUSION AND FUTURE PLANS

This paper presented the review of SCADA systems and three major protocols used in SCADA network communication. We have analyzed various traffic filtering based security solutions and found open-source Linux iptables are good and effective solution to secure SCADA systems. We have analyzed several attacks on all these three protocols and determined whether an iptables based rules are defined for those attacks or not. Our evaluation shows that for Modbus and DNP3 protocols, iptables rules are defined for only few attacks and lacking for many of the attacks. For IEC 104 protocol, iptables based approach is totally unexplored and no rule is defined for any of the attacks.

In the future plans,

- We will investigate iptables based firewall system against SCADA systems which uses IEC 104 protocol.
- We will develop rules for attacks of Modbus and DNP3 protocols where it is lacking.

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OPEN-SOURCE IPTABLES BASED FIREWALL SOLUTION FOR VARIOUS CYBER-ATTACKS ON ICS/SCADA SYSTEMS

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ABSTRACT

There are very limited commercial firewalls are available in the market for SCADA network. In which open-source IPTables based firewall solution is an identical approach to protect against various attacks. Till now IPTables based firewall solutions were only experimented against either protocol specific SCADA attacks, or small number of network based attacks. In this paper, we proposed a script to easily setup the IPTables rules without much efforts. It provides protections against wide range of SCADA network attacks including attacks on Modbus, DNP3, and IEC 60870-5-104 SCADA protocols, many network attacks, and DoS attacks. Proposed solution uses advance features of IPTables and developed in such a way that packets are only allowed if it passes through all chains of the firewall.

Keywords: SCADA systems; SCADA firewall; SCADA security; network security; open source; firewalls; IEC 60870-5-104; Modbus; DNP3; network attacks; SCADA attacks; DoS attacks; Linux IPTables.

1 INTRODUCTION

SCADA systems are assigned with crucial duties of monitoring and controlling a critical infrastructures. In every SCADA systems, Mater Terminal Unit is the core of the system which manages the communication, and operations both. Human Machine Interfaces (HMIs) are used by the operators to monitor and control the infrastructure. Before few decades, all these components were at one place within closed internal network. But with time, technologies evolves and SCADA protocols were developed/upgraded to handle the SCADA system over external network as well (mainly internet), which provides facilities to monitor and operate the infrastructure from almost anywhere in the world. This was able to achieve with the use of Internet Protocol (IP). However such advancement also invites wide range of attacks as the closed internal SCADA networks are now exposed to internet. The top 3 majorly used protocols in SCADA system are Modbus, DNP3, and IEC 60870-5-104. These are TCP/IP based protocols enabling SCADA systems to communicate over the Internet. Various protocol specific attacks are discussed by the authors in [1]. SCADA network are also facing various network based attacks and DoS attacks which are discussed in later part of the paper.

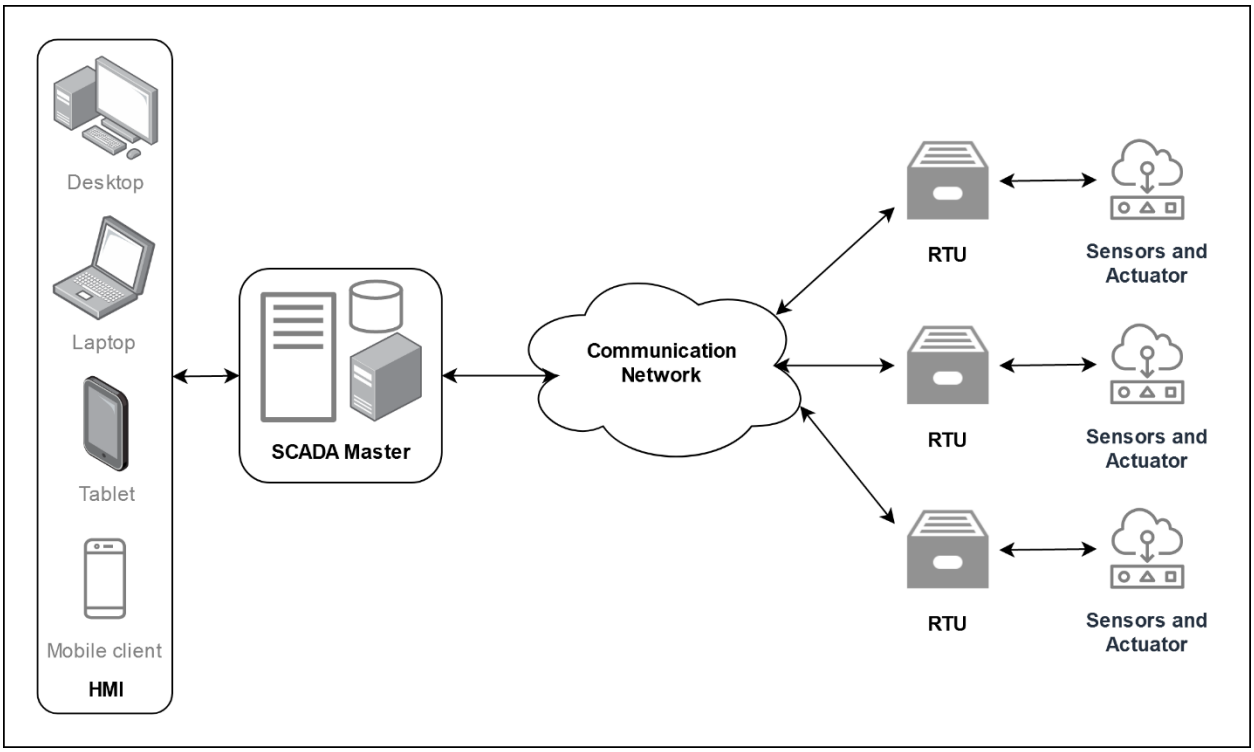
Several researchers have proposed different methodologies to protect the SCADA network from these attacks. Namely whitelisting based approach, anomaly-based approach, IPTables based firewall and etc. which are discussed already discussed by the authors in [1]. While most of the existing firewall solutions used in industry for SCADA systems are proprietary, various researchers proposed open-source IPTables based firewall solution for SCADA network. In our survey [1], we recognized that those works are very limited in number for SCADA protocol specific attacks, and some network based attacks. Which creates huge gap to secure SCADA network system in real-time environment. Also implementing IPTables rules in proper sequence seeking highly technical knowledge and accuracy in order to make it work properly. To fill these gap authors take a step ahead in the work accomplished till now and initiated a complete SCADA firewall solution in terms of bash script. This script is developed with objective of easy deployment of IPTables firewall rules. With minimum efforts anyone can deploy over 45+ rules to protect the SCADA network from 50+ SCADA attacks. The script is developed to setup the rules in such a way that it protects against attacks in hierarchy. Which is in descending as follow, DoS attacks, network based attacks, protocol specific attacks. Proposed solution only allows a packet if it pass though all these hierarchical rules in order to ensure the optimum security in timely manner.

In this paper our main objectives are to develop an open-source firewall solution for SCADA system which can be used in real-time SCADA network environment and is also super easy to deploy and maintain by administrator with almost no knowledge of rule creation thought IPTables. And to achieve these objectives we proposed a script where just few things are needed to enter, such as legitimate IPs and device physical addresses and rest of the hard work is fully automated.

Specifically the rest of the paper is sorted out as follows. Section 2 gives the overview of SCADA systems and major 3 protocols. Section 3 provides details of various network attacks and DoS attacks. Section 4 provides the details of proposed method. Section 5 and 6 represents implementation and experimentation. Section 7 discusses related works. Finally, Section 8 concludes this paper.

2 BACKGROUND

Image 1: Generic SCADA Architecture



In critical infrastructures, huge number of parallel industrial processes are running. Due to this monitoring and controlling of these processes are very difficult because of different types of input and output for each process. The Supervisory Control and Data Acquisition (SCADA) system is a centralized control and monitoring system used to manage these complex industrial processes. It collects the data from sensors, actuators, or instruments, then the collected data is being processed and represented. SCADA systems are extremely important and widely used in modern industrial control systems and critical infrastructures (e.g. food and beverage industries, power generation plants, petroleum industries, energy sector, transportation systems, sewage plants, manufacturing industries, recycling plants, and many more). [1]. It is a software application that is implanted on the hardware devices to enable SCADA operators to manage industrial processes. SCADA systems are very crucial as industries are using it for maintaining the plant efficiency, processes the data for quick and efficient decisions, and reduce the downtime of the industrial process. Human Machine Interfaces (HMIs), Master Terminal Unit (MTU), Remote Terminal Units (RTUs), Programmable Logic Controllers (PLCs), Sensors and Actuators, and Communication Network Infrastructure are the main components of SCADA system. RTUs and PLCs are used to collect the data from end-point sensors or actuators, store it and forward it to the MTU on the request. MTU is the brain of the SCADA system which is responsible for collecting, storing, processing, distributing and displaying the

data along with managing communication. SCADA operators can monitor and control whole SCADA system with the help of HMIs. Main objectives of the SCADA systems are monitor, measuring, data acquisition, communication, process controlling and automation.

In order to fulfill above objectives, the SCADA systems needs a protocols for communication. Protocols are like language or terminology which enables the SCADA components to communication with each other and transmit the data. Various SCADA protocols are Modbus, DNP3, IEC-60870-5-104, IEC 61850, Ethernet/IP, Profibus, Conitel, ICCP, OPC, EtherCAT, OSGP, and etc. Overview of only major protocols are given below.

Modbus/TCP is designed with the basic point-to-point concept for Ethernet communication. Modicon designed it by extending the Modbus/RTU protocol, for communication with Modicon PLCs. In Modbus protocol based SCADA systems, there is one master and multiple slaves, all the end devices or equipment serves as a slave. As it uses request-response communication model, all the slaves only respond to the command ordered by the master device. Each slave is assigned with unique slave address from 1 to 247. A detailed technical information about Modbus protocol with its architecture and function codes is provided by the authors in [1].

The DNP3 (Distributed Network Protocol 3) is combination of communications protocols in one set. These protocols are used for inter SCADA components communication. Its interoperability, robust structure, and reliably transmitting data in small sequenced packets increases the SCADA system efficiency. It is mostly used in water and electric utilities but it has capabilities to use in other industries as well. DNP3 supports 4 different modes of communication, one master-one slave, one master-multiple slaves, multiple masters-one slave, and a master-slave/s or master/s. A detailed technical information about DNP3 protocol with its architecture and function codes is provided by the authors in [1].

IEC 60870-5-104 (a.k.a. IEC 104) is an enhanced version of IEC 60870-5-101 with TCP/IP based communication network access. Where IEC 60870 are standards designed by IEC (International Electrotechnical Commission) exclusively for SCADA systems in power and electrical systems. A detailed technical information about IEC 60870-5-104 protocol with its architecture and function codes is provided by the authors in [1].

3 SCADA ATTACKS

In this section we summaries various attacks on SCADA system for following domains. A. Network based attacks, B. DoS attacks, C. Modbus protocol based attacks, D. DNP3 protocol based attacks, E. IEC 60870-5-104 protocol based attacks, and F. IEC 61850 protocol based attacks.

3.1 Network based attacks

Below described attacks are the most common network based attacks.

3.1.1 Gain unauthorized SCADA access:

Normally, an unauthorized user gain the access to the SCADA network and establish the communication. And attacker can perform any malicious activity on the network to damage the SCADA system processes.

3.1.2 Invalid packet request attack:

In this attack, an attacker sends an invalid packets the SCADA network. For ex. TCP packets with all TCP flags unset.

3.1.3 Non-established/Unrelated packet attack:

In this attack, an attacker sends packets to the SCADA network in which communication is not established or the packets are unrelated to the SCADA system.

3.1.4 Invalid SYN packet attack:

In this attack, an attacker sends packets to the SCADA network with invalid SYN request. For ex. packet has SYN and RST flags are set together, or SYN and FIN flags are set together, or SYN, FIN, RST, and ACK flags are set together.

3.1.5 New connection request with wrong flag attack:

In this attack, an attacker sends request packet to establish new connection to the SCADA network with wrong flags set apart from SYN flag.

3.1.6 Malformed XMAS attack

In this attack, an attacker sends packets to the SCADA network with all TCP flags set.

3.1.7 Malformed NULL attack

In this attack, an attacker sends packets to the SCADA network with all TCP flags unset.

3.1.8 Network reconnaissance

In this attack, an attacker engages with the SCADA network in order to gather information about the network. TCP packets are used where either URG flag is set, or PSH flag is set, or FIN flag is set, or FIN, and RST flags are set, or ACK, RST, SYN, FIN, and URG flags are set, or SYN, and ACK flags are set with new communication request.

3.1.9 Man in The Middle (MiTM) attack

In this attack, an attacker intercepts the communication between two nodes inside the SCADA network. Further the intercepted communication can be used to understand the internals of SCADA system and generate a comprehensive attack.

3.2 DoS attacks [2] [3]

3.2.1 TCP SYN flood attack

In this attack, an attacker sends a huge amount of TCP packets with SYN flag set to flood the target system.

3.2.2 ICMP flooding attack / Ping flood attack / Smurf attack

In this attack, an attacker sends a huge amount of ICMP packets to flood the target system.

3.2.3 UDP flood attack

In this attack, an attacker sends a huge amount of UDP packets to flood the target system.

3.2.4 TCP RST flood attack

In this attack, an attacker sends a huge amount of TCP packets with RST flag set to flood the target system.

3.2.5 TCP FIN flood attack

In this attack, an attacker sends a huge amount of TCP packets with FIN flag set to flood the target system.

3.2.6 TCP ACK flood attack

In this attack, an attacker sends a huge amount of TCP packets with ACK flag set to flood the target system.

3.2.7 Ping of death attack

In this attack, an attacker sends a huge amount of fragmented ICMP packets, or sends IP packets with size more than 65536 bytes to flood the target system.

3.2.8 Slowloris attack

In this attack, an attacker overwhelm the SCADA network with simultaneously opening and maintain connections more than the network can handle.

3.3 Modbus protocol based attacks, 3.4 DNP3 protocol based attacks, and 3.5 IEC 60870-5-104 protocol based attacks

Below listed all attacks based on Modbus, DNP3, and IEC 60870-5-104 protocols are already described by the authors in [1]

Table 1: Protocol based attacks

Index	Modbus	DNP3	IEC 60870-5-104
1	Identify Modbus device	Outstation write attack	Spontaneous message storm
2	Disable/Compromise master/slave attack	Clear object attack	Unauthorized read command attack
3	Disrupt master-slave communication	Destination address alteration address (MiTM)	Unauthorized Interrogation command attack
4	Data read attack	Transport sequence modification attack (MiTM)	Remote control/Remote adjustment command attack
5	Data write attack	DFC flag attack	Reset process attack
6	Clear counters and diagnostic registers attacks	Outstation application termination attack	Modification and injection attack (MiTM)
7	Remote restart attack	Disable unsolicited response attack	Unauthorized single command attack
8	Force PLC to listen-only mode attack	Warm restart attack	Broadcast message spoofing attack
9	Report server information attack	Cold restart attack	Invalid ASDU address field attack
10	Broadcast message spoofing attack	Broadcast message spoofing attack	Buffer overflow attack
11	Direct slave control attack (MiTM)	Baseline response reply attack (MiTM)	Command injection attack
12	-	Configuration capture attack	-
13	-	Outstation data reset attack	-
14	-	Reset function attack	-
15	-	Unavailable function attack	-
16	-	Length overflow attack	-

4 RELATED WORK

In [2], and [3], the authors uses Linux IPTables to develop rules for mitigate only few types of DoS/DDoS attacks. Several classification of firewalls and details of DoS/DDoS attacks are discussed. Those attacks are simulated and tested for analyzing the IPTables based firewall.

In [4], [5], and [15], the authors proposed the use of Linux IPTables as a firewall solution for SCADA systems. Rules for some attacks based on Modbus protocol and DNP3 protocol are developed and tested on test-bed. In [4], and [5], rules are created for only few attacks of both protocols, While in [15], the authors proposed a "SCADAWall" model, which is made up of 3 algorithms, A) Comprehensive Packet Inspection (CPI), B) Proprietary Industrial Protocol Extension Algorithm (PIPEA), and C) Out of Sequence Detection Algorithm (OSDA). OSDA is used to determine the off-sequenced process commands in the SCADA system, while PIPEA enables the firewall model to add any proprietary protocols in the model to be used. The CPI algorithm proposed to check the payload data as well along with the function code of Modbus protocol, and insist to develop all rules for whitelisting the legitimate commands and drop everything which is not whitelisted.

5 PROPOSED METHOD

Linux is one of the most popular open-source operating system, and IPTables is a flexible rule based firewall utility program available in all Linux distributions. It is a user space command line interface to the Netfilter systems of Linux kernel. As the Netfilter implements the firewall and routing capabilities within Linux kernel, any Linux machine can be act as a firewall system used for network packet filtering. It has extremely useful features to filter the packets based on protocol, source ip address, destination ip address, mac address, source port number, destination port number, TCP flags, limiting the incoming/outgoing traffic, and etc. We used these features for creating rules for attacks of Network domain and DoS domain. For creating rules for protocol specific attacks, we used the u32 feature of an IPTables to check the payload of the packet and decide whether to allow the packet or not. In [4], and [5], the authors explained the u32 matching feature of the IPTables for Modbus and DNP3 SCADA protocols.

By default IPTables has 5 types of categories or tables as described below, for our script we will use default filter table along with the custom chains for the attacks:

Table 2: Tables in IPTables

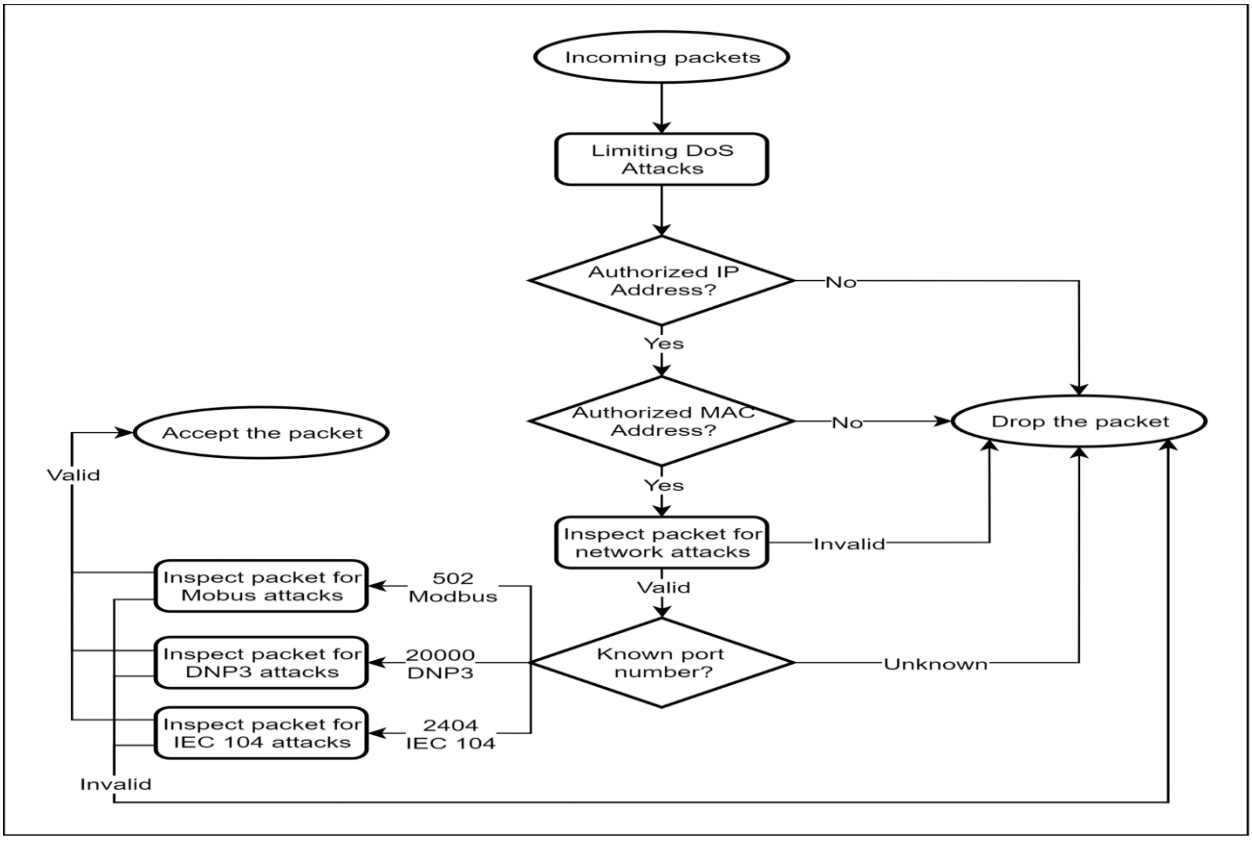
Table Name	Usage	Inbuilt Chains
Filter (Default)	Packet filtering	INPUT, OUTPUT, FORWARD
NAT	Network Address Translation	PREROUTING, POSTROUTING
Mangle	Packet alteration	PREROUTING, OUTPUT
Raw	Packet ordering	PREROUTING, OUTPUT
Security	Mandatory Access Control	-

Below table describes all the default chains, but user can also create a custom chain in the IPTables:

Table 3: Chains in IPTables

Chain Name	Description
INPUT	For packets desired to receive on local machine
FORWARD	For packets routed from the local machine
OUTPUT	For packets generated from local machine desired to send outside.
PREROUTING	For packet modification on arrival
POSTROUTING	For packet modification on sending

In this paper, we propose a script to setup the 47 IPTables rules for all the attacks described in previous section. The script is designed to set and check for all rules in hierarchical approach first by chains and then by rules for each domain to drop all malicious packets used to attack the SCADA system network. Image 2: Script flowchart



Working flow of the rules is represented in step-by-step flowchart below.

1) Limiting the incoming packets for mitigating DoS attacks.
2) Check for authorized sender identity by source IP address.

3) Check for authorized sender identity by source MAC address.
4) Check packet destination port to filter the packet for protocol specific rules.
5) If the packet is of Modbus protocol, it will be pass through Modbus specific rules and if it is valid then IPTables will accept the packer or drop the packet.
6) If the packet is of DNP3 protocol, it will be pass through DNP3 specific rules and if it is valid then IPTables will accept the packer or drop the packet.
7) If the packet is of IEC 104 protocol, it will be pass through IEC 104 specific rules and if it is valid then IPTables will accept the packer or drop the packet.

So at the first the script will set the rules to mitigate the DoS/DDoS attacks on SCADA system, then rules to verify the sender of packets based on IP address and MAC address both, after that packet will be checked against rules for common network based attacks. If packet is legitimate then it will be further checked for protocol specific attacks and if it pass those rules then only the firewall will accept the packet.

6 IMPLEMENTATION

A proposed script contains 47 chains for logs and 5 chains for the attack domains. Each LOG chain is assigned with unique postfix digits according to the rule number. This logging chain mainly consist “log message” which is set with limit to 5 logs per minute, --log-level 1 define the alert message, and “action” to either accept or drop the packet.

Image 3: Log Rule Example

```
#Logging - Unauthorized Interrogation Command Request
iptables -N LOG_40
iptables -A LOG_40 -m limit --limit 5/min -j LOG --log-prefix
"DROPPED: SCADA IEC 60870-5-104 - Unauthorized Interrogation
Command Request: " --log-level 1
iptables -A LOG_40 -j DROP
```

Many times when the network is under DoS/DDoS attacks, the firewall or IDS blocks the legitimate requests as well. To resolve this issue, we used “hashlimit” module of IPTables. It uses hash buckets to determine the rate limit match each connection. So for example an attacker is flooding SCADA system from 5 different connections (nodes), then the rules will match the rate limit for each node separately and will drop the packets when crosses the limit. So legitimate request can be processed properly. In our proposed script we set the hashlimit to 1 packet per second, -burst 20 defines maximum 20 initial number of packet can match, -mode srcip defines rule to match based on source address, -srcmask 32 is used to group all encountered source addresses. All rules of DoS attacks are added to “DOS_RULES” chain.

Image 4: DoS Attack Rule Example

```
#Logging – SYN Flood Attack
iptables -N LOG_9
iptables -A LOG_9 -m limit --limit 5/min -j LOG --log-prefix
"DROPPED: SCADA DoS – SYN Flood Attack: " --log-level 1
iptables -A LOG_9 -j ACCEPT

#Rule – SYN Flood Attack
iptables -A DOS_RULES -p tcp --syn -m hashlimit --hashlimit
1/s --hashlimit-burst 20 --hashlimit-mode srcip --hashlimit-
srcmask 32 --hashlimit-name synattack -j LOG_9
iptables -A DOS_RULES -p tcp --syn -j DROP
```

For filtering packets from trusted/authorized users two chains are created “IP_RULES” and “MAC_RULES” in which the script reads the trusted IP addresses and MAC addresses from the file and accept packets only from them.

Image 5: IP Address filtering Rule Example

```
#Adding all trusted IP addresses to the chain
for var_ip in `cat trusted_ip_list`
do
      iptables -A IP_RULES -s "$var_ip" -j ACCEPT
done

#Logging and dropping the request from unauthorized IP address
iptables -A IP_RULES -m limit --limit 5/min -j LOG --log-prefix
"SCADA Network – Unauthorized IP Communication Request: " --log-
level 1
iptables -A IP_RULES -j DROP
```

For Network attacks, Modbus, DNP3, and IEC104 protocol based attacks, “NETWORK_RULES”, “MODBUS_RULES”, “DNP3_RULES”, “IEC_104_RULES” chains are is created respectively. Example rule of each chain is represented below.

Image 6: Network Based Attack Rule Example

```
#Logging – Invalid SYN Packet Attack Request
iptables -N LOG_4
iptables -A LOG_4 -m limit --limit 5/min -j LOG --log-prefix
"DROPPED: SCADA Network – Invalid SYN Packet Attack Request:
" --log-level 1
iptables -A LOG_4 -j DROP

#Rule – Invalid SYN Packet Attack Request
iptables -A NETWORK_RULES -p tcp --tcp-flags ALL
ACK,RST,SYN,FIN -j LOG_4
iptables -A NETWORK_RULES -p tcp --tcp-flags SYN,FIN SYN,FIN -j
LOG_4
iptables -A NETWORK_RULES -p tcp --tcp-flags SYN,RST SYN,RST -j
LOG_4
```

For SCADA protocol based attacks we enhanced each rule to allow only specific device to send any command packet. For example we have 10 trusted devices in SCADA network but only specified device can send write data command to the slave devices. These rules uses the concept of binary shifting and masking as u32 matching module of IPTables checks 32 bits (4 Bytes) at once. So if the portion of packet which needs to check is less than 32 bits then the targeted portion should be shifted and masked in order to get the desired value. The "0>>22&0x3C@" defines that 4 bytes to match will start from byte '0' of the packet and right shift it for 22 times, after shifting these bits are being masked with binary conversion of hex value '3C'. '@' sign is used to instruct the IPTables pointer to move at the position which is result of the shifting and masking. In our case "0>>22&0x3C@" is used to check the length of IP and move to the start of TCP packet, "12>>26&0x3C@" is used to check the length of the TCP and move to the start of SCADA protocol. '=' sign is used to check the value is equal or not.

Image 7: Modbus Protocol Based Attack Rule Example

```
#Logging - Unauthorized Clear Counters and Diagnostic Registers
Request
iptables -N LOG_19
iptables -A LOG_19 -m limit --limit 5/min -j LOG --log-prefix
"DROPPED: SCADA Modbus - Unauthorized Clear Counters and
Diagnostic Registers Request: " --log-level 1
iptables -A LOG_19 -j DROP

#Rule - Unauthorized Clear Counters and Diagnostic Registers
Request
iptables -A MODBUS_RULES ! -s $var_ip_modbus_master -p tcp --
dport 502 -m u32 --u32 "0>>22&0x3C@ 12>>26&0x3C@ 7>>8&0xFFFFFF=
0x08000A" -j LOG_19
```

Image 8: DNP3 Protocol Based Attack Rule Example

```
#Logging - Unauthorized Outstation Write Request
iptables -N LOG_25
iptables -A LOG_25 -m limit --limit 5/min -j LOG --log-prefix
"DROPPED: SCADA DNP3 - Unauthorized Outstation Write Request:
" --log-level 1
iptables -A LOG_25 -j DROP

#Rule - Unauthorized Outstation Write Request
iptables -A DNP3_RULES ! -s $var_ip_dnp_master -p tcp --dport
20000 -m u32 --u32 "0>>22&0x3C@ 12>>26&0x3C@ 10>>30&0x01=0x01 &&
0>>22&0x3C@ 12>>26&0x3C@ 9&0xFF=0x02" -j LOG_25
```

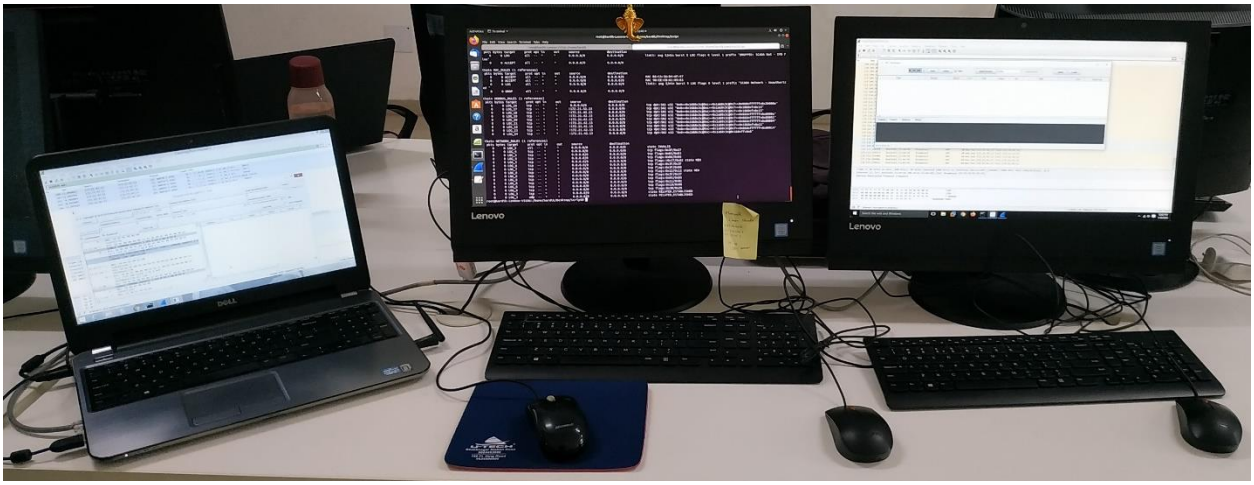
Image 9: IEC 104 Protocol Based Attack Rule Example

```
#Logging - Unauthorized Read Command Request
iptables -N LOG_39
iptables -A LOG_39 -m limit --limit 5/min -j LOG --log-prefix
"DROPPED: SCADA IEC 60870-5-104 - Unauthorized Read Command
Request: " --log-level 1
iptables -A LOG_39 -j DROP

#Rule - Unauthorized Read Command Request
iptables -A IEC_104_RULES ! -s $var_ip_iec104_master -p tcp --
dport 2404 -m u32 --u32 "0>>22&0x3C@ 12>>26&0x3C@ 3&0xFF=0x66" -
j LOG_39
```

7 EXPERIMENTATION

Image 10: Test-bed Setup



For experimenting the proposed script of SCADA firewall rules were tested on test bed. Test bed contains 2 all-in-one PCs as a firewall machine and target machine, and 1 laptop as an attacker machine. Configuration of these machines are: Firewall: Lenevo V310z, Unubtu 18.04.3 LTS (64 bit), 8GB RAM, Intel Core i5-7400 3.00GHz, Target: Lenevo V310z, Windows 10 Enterprise (64 bit), 8GB RAM, Intel Core i5-7400 3.00GHz, Dell Inspiron 5521, Windows 8.1 (64 bit), 4 GB RAM, Intel Core i5-<3700> 1.80GHz. All three machines were connected using Ethernet cables, a SMACC HLF1081A (USB to Ethernet) adapter was used on firewall machine as an additional network interface. We used Wireshark [6] to analyze the network traffic, which was generate, pass through, and received on attacker, firewall, and target machines respectively. In VMWare Workstation [8], Kali linux 2019.4 [7] was installed on attacker machine to generate DoS attacks using “hping3” [9] tool. We used colasoft packet builder [10], for building/customizing a packet to generate various attacks. For testing SCADA protocol specific rules, we

used “Modbus Poll” and “Modbus Slave” simulators [11], DNP3 server and client simulators [12], IEC Server [13], and QTester [14].

A bridge was created on firewall machine to establish inter-connection from the attacker machine to the target machine. This bridge add both network interfaces (built in network interface + USB to Ethernet interface) for connection. Steps to create a bridge network are as follow:

Image 11: Bridge Network Setup Steps

```
#List the interfaces and copy names of default network interface
and USB-to-Ethernet interface (i.e. enp2s0, enx00e04c534458)
ip link

# Install Bridge Utils
sudo apt-get install bridge-utils

#Create bridge and add both interfaces
brctl addbr br0
brctl addif br0 enp2s0 <change enp2s0 with your interface name>
brctl addif br0 enx00e04c534458<change enx00e04c534458 with your
interface name>

#Add configuration text to interfaces file
nano /etc/network/interfaces
      "auto br0
       iface br0 inet static
       bridge_ports enp2s0, enx00e04c534458
       address 172.21.42.12
       netmask 255.255.254.0
       gateway 172.21.42.1"

#Restart network service
/etc/init.d/networking restart

#Set bridge network UP and verify
ip link set dev br0 up
ip a
```

Image 12: Bridge Network Setup

```
hardik@hardik-Lenovo-V310z:~$ ip a
1: lo: <LOOPBACK,UP,LOWER_UP> mtu 65536 qdisc noqueue state UNKNOWN group default qlen 1000
    link/loopback 00:00:00:00:00:00 brd 00:00:00:00:00:00
    inet 127.0.0.1/8 scope host lo
       valid_lft forever preferred_lft forever
    inet6 ::1/128 scope host
       valid_lft forever preferred_lft forever
2: enp2s0: <BROADCAST,MULTICAST,UP,LOWER_UP> mtu 1500 qdisc fq_codel master br0 state UP group default qlen 1000
    link/ether 98:ee:cb:61:89:5f brd ff:ff:ff:ff:ff:ff
    inet 172.21.42.14/23 brd 172.21.43.255 scope global noprefixroute enp2s0
       valid_lft forever preferred_lft forever
    inet6 fe80::a2da:35d5:fb15:a73e/64 scope link
       valid_lft forever preferred_lft forever
3: wlp3s0: <BROADCAST,MULTICAST> mtu 1500 qdisc noop state DOWN group default qlen 1000
    link/ether a0:af:bd:6f:bb:9d brd ff:ff:ff:ff:ff:ff
4: enx00e04c534458: <BROADCAST,MULTICAST,UP,LOWER_UP> mtu 1500 qdisc fq_codel master br0 state UP group default qlen 1000
    link/ether 00:e0:4c:53:44:58 brd ff:ff:ff:ff:ff:ff
    inet6 fe80::2e0:4cff:fe53:4458/64 scope link
       valid_lft forever preferred_lft forever
5: br0: <BROADCAST,MULTICAST,UP,LOWER_UP> mtu 1500 qdisc noqueue state UP group default qlen 1000
    link/ether 00:e0:4c:53:44:58 brd ff:ff:ff:ff:ff:ff
    inet 172.21.42.12/23 brd 172.21.43.255 scope global br0
       valid_lft forever preferred_lft forever
    inet6 fe80::2e0:4cff:fe53:4458/64 scope link
       valid_lft forever preferred_lft forever
hardik@hardik-Lenovo-V310z:~$
```

After establishing inter-communication between all three machines, all listed attacks were performed and IPTables rules were analyzed against it. We determined that IPTables based SCADA firewall was successfully blocking the attacks.

Image 13: Invalid SYN Packet Attack Generation from Attacker Machine

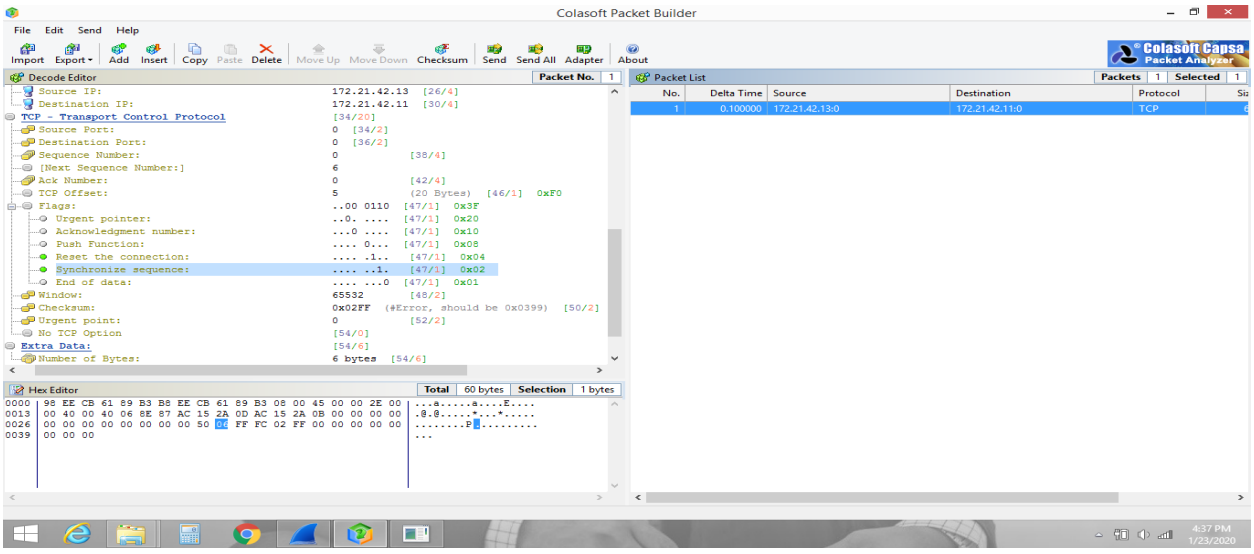


Image 14: Invalid SYN Packet Attack Traffic on Firewall Machine

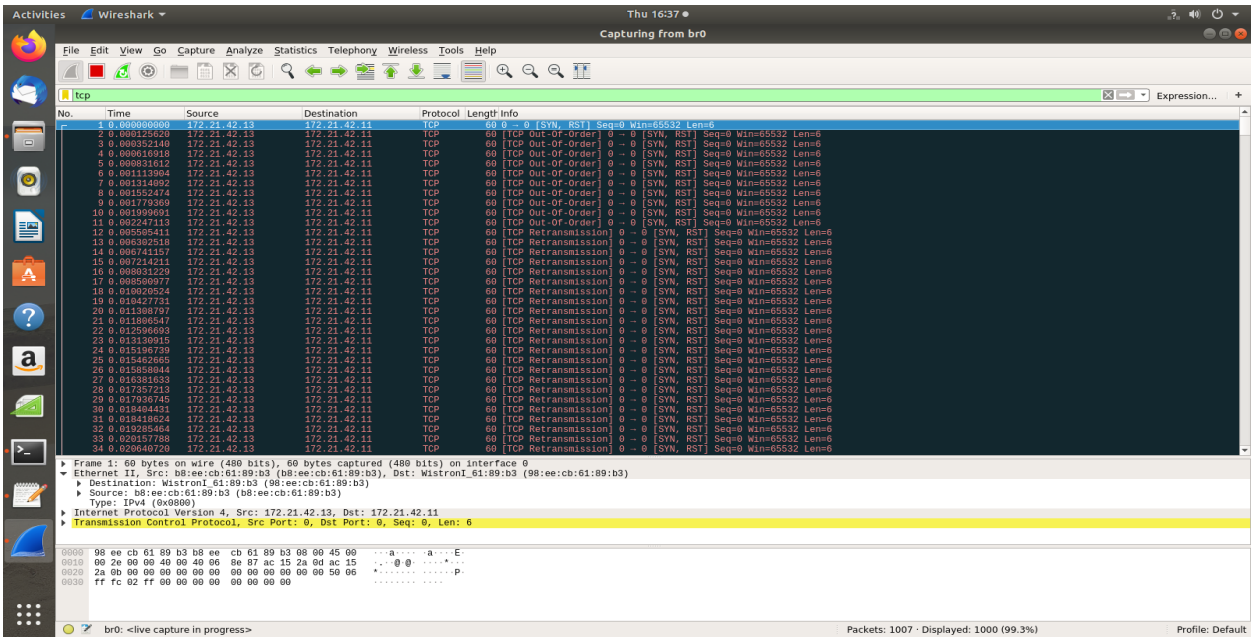
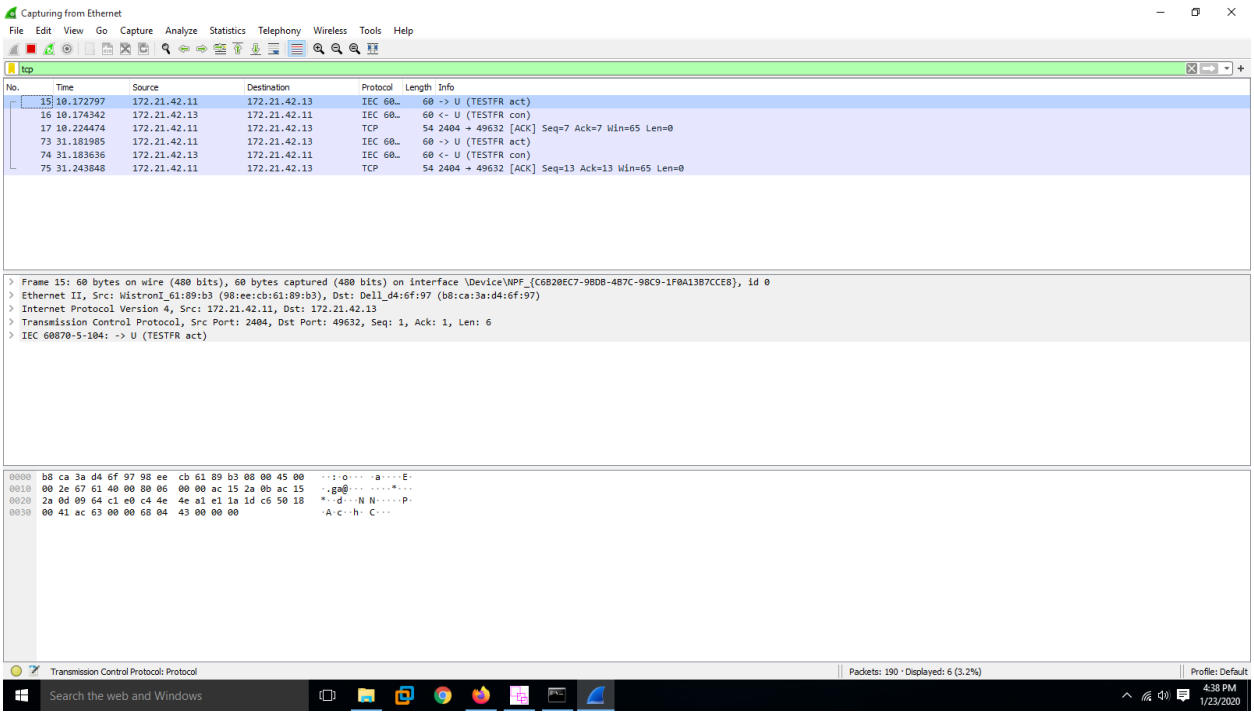


Image 15: Traffic on Target Machine from Invalid SYN Packet Attack



For IEC below screenshots shows that single command was accepted when there were no IPTables rules deployed and after deployment the same command was dropped by IPTables firewall.

Image 16: Unauthorized Single Command Attack Generation from Attacker Machine

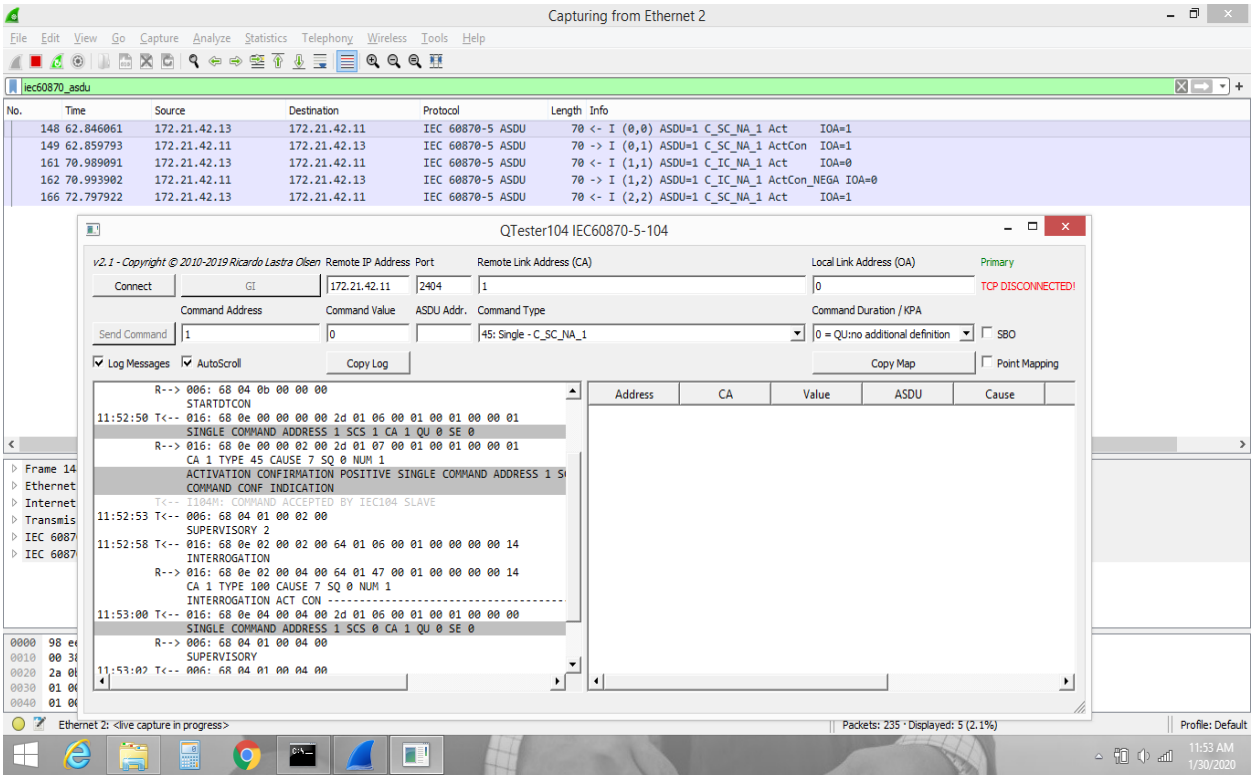


Image 17: Unauthorized Single Command Attack Traffic on Firewall Machine

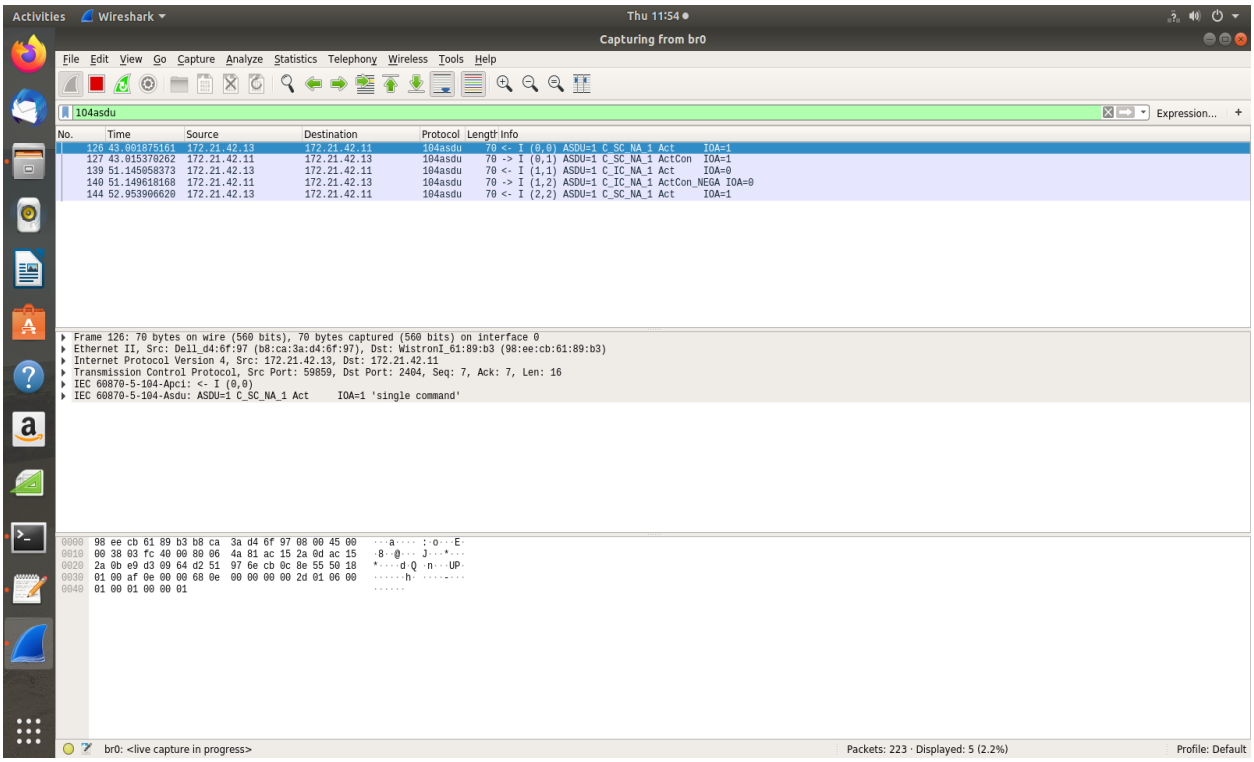
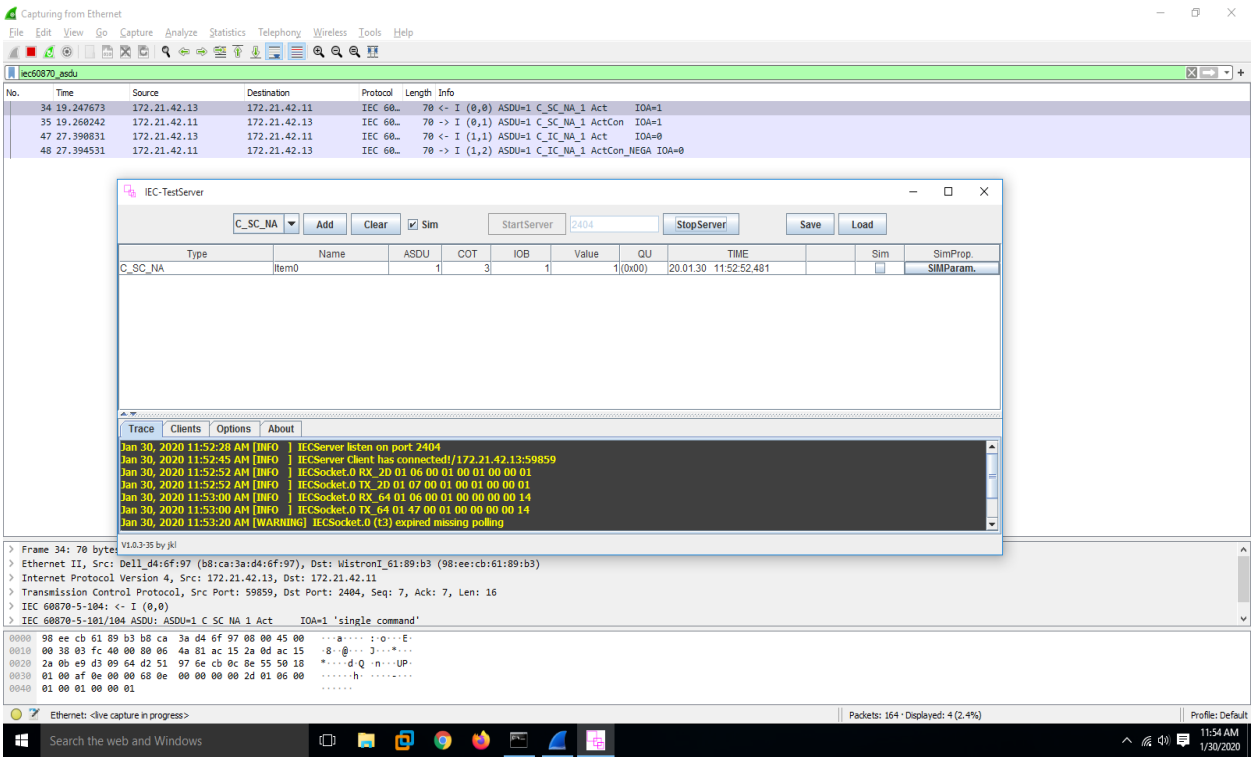


Image 18: No Effects of Unauthorized Single Command Attack on Target Machine



8 CONCLUSION

This paper extended the use of open source IPTables based firewall solution for SCADA systems. Till now the use of IPTables were limited to either protocol specific attacks or only some of the network based attacks. In this paper, we have developed a script to easily setup firewall rules specific to SCADA networks and protect it against wide range of attacks. These includes Modbus, DNP3, IEC 104 protocols based attacks, as well as many network based attacks, and DoS attacks. Result of experiments shows that our script is successfully blocking 50+ different attacks on SCADA network. Methodology to develop the rule is described, also few regions of the script are presented in this paper. The proposed script has been tested and validated on test bed at the Cyber Security Laboratory at Marwadi University.

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COMPRESSIVE STRENGTH STUDY OF GREEN CONCRETE BY USING FERROCK

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ABSTRACT:

As a part of development, rate of building construction is also high, so it means there is lots of use of concrete. It has been observed that 0.9 tons of CO_2 is produced per ton of cement production. Thus, by the use of green concrete it is possible to reduce the CO_2 emission in atmosphere towards eco-friendly construction. In this project there is replacement of cement with the percentage of ferrock. Ferrock is a waste material of steel and having a tensile property. In this M20 Grade concrete is used and for that the mix design was done having the different composition of cement, Fine Aggregate, Coarse Aggregate, Ferrock and Water. The cubes are tested after the curing duration of 7 days, 28 days, and 56 days. In this research work, there was replacement of the cement with the ferrock having a percentage variation 5%, 10 %, 15%, 20%. With the replacement of cement with ferrock it was found that compressive strength of the green concrete was increased, and durability of the concrete was also increased. Also, it was economical as ferrock is a waste material which is available free of cost, so it reduced the overall cost of the work. Also, the Ferrock has a property to absorb the Carbon dioxide from the environment so it is also reducing the air pollution.

Keywords: Green Concrete, Concrete Mix Design, Ferrock, Carbon Dioxide, Compressive Strength.

1. INTRODUCTION

India is a developing country and due to this reason various construction work is going on. The main material which is used as construction work in India is Cement. Cement is responsible for the huge production of carbon dioxide in the environment. This huge production of carbon dioxide in the environment leads to the environment problems such as air pollution, skin disease, respiratory problems, global warming, climate change etc. Green concrete does not have any relation with the green colour. Green concrete means to protect the environment by using the waste product in a constructive way. Ferrock is created from waste steel dust (which would normally be thrown out) and silica from ground up glass, which when poured and upon reaction with carbon dioxide creates iron carbonate which binds carbon dioxide from the atmosphere into the Ferrock. Ferrock are tensile in nature which leads to increase in the compressive strength and durability of the green concrete.

2. OBJECTIVES

Following are the objectives of this research work:

- To study the effect of Ferrock on the Environment.
- To study the effectiveness of concrete by the partial replacement of the cement with ferrock.
- To determine the compressive strength of new mix design of grade M 20.
- To determine the test result for the compressive strength of green concrete.
- To determine the optimum percentage of ferrock in cement so that we can achieve maximum compressive strength.

3. RESEARCH METHODOLOGY

To fulfil the above objectives following research methodology is applied:

- To do the literature review on the green concrete.
- To do the deep study of the different ingredients of the green concrete.
- To do the Mix Design for M 20 Concrete as per the Indian Codal Provisions.
- To cast cubes by using different ingredients as per the Indian Standards.
- To test the casted cubes for strength after 7, 28 and 56 days of curing respectively by performing compressive strength test.
- To compare between conventional concrete and green concrete based on various parameters.

4. LITERATURE REVIEW

Some of the research papers literature review are mentioned here. In this different researchers used the different material for the casting of green concrete in different proportions which is mentioned below and also shown the research gap (future work scope).

Table 1: Literature Review

Sr. No.	Paper Name	Literature Review	Research Gap
1.	High Volume Fly Ash Mixed Green Concrete For Civil Engineering Purposes[21].	Class F Fly ash is used for replacing the cement and M 30 grade of Concrete is used having a two different proportions of water i.e. 0.42 and 0.40 as per Indian Codal Provision. As per the Codal provision 25% of the cement content was replaced by Fly Ash. The samples are tested	In initial phase the compressive strength of green concrete is less as compare to the normal concrete and its flexural strength is also less.

		for a compressive strength at a duration of 28 days, 56 days, and 90 days. High volume fly ash added with green concrete was having higher strength and durability as compare to normal concrete.	
2.	Experimental Study on Green Concrete[20].	Addition of micro silica in cement reduces the air pollution. The optimum replacement of cement with silica 5 % to 15 % leads to increase in strength whereas 20 % replacement leads to the decrease in the strength. It gains more strength in less time as silica fume particle size is very small as compare to the cement. By replacing the fine aggregate with demolished brick will not lead to increase in strength of concrete but overall cost of the project will be reduced about 20 %.	Compressive strength of concrete is decreasing after the 15 % replacement of cement with silica. Silica is also the product which is responsible for the air pollution.
3.	Green Concrete: An Innovative Approach to Sustainable Development[8].	This paper deals with the usage of different by products such as fly ash, pozzocrete, used foundry sand etc. It also deals with finding out the compressive strength of the concrete when the cement is replaced by Pozzocrete P60 as 30 % by weight of cement and fine aggregate are replaced by foundry sand 10 %, 25 % and 50 % by weight of cement. This paper concludes that the use of Pozzocrete P 60 and foundry	The study on the impact of long-term properties of concrete such as creep, deflection, and shrinkage etc.

		sand in the form of partial replacement of cement and fine aggregate is quite feasible for strength.	
4.	A Review on the Study of Green Concrete[18].	It includes the convenience of the usage of various by products such as dust, fly ash, marble, plastic waste, marble granules, silica fumes, blast furnance slag etc. Use of such materials approximately 20 % of cement. Green concrete has greater strength and durability as compare to the conventional concrete.	The drawback of this work is it has less flexural strength, high water absorption, higher shrinkage, and creep.
5.	Green Concrete for Better Sustainable Development[19].	Waste material has a significant potential on green concrete. To manufacture economical and environment friendly concrete , the replacement of traditional ingredients of concrete by waste materials and by products plays a very important role . It gives opportunity to produce environment friendly concrete .	Did not considered the by-products effect on strength of the concrete.

5. MATERIAL USED

5.1 Cement

In this project work, 53 grade of Ordinary Portland Cement is used. As per the Indian Standard the different tests are done for the accuracy such as Fineness Test, Soundness Test, Consistency Test & Initial and Final Setting time. Apart from this the other things regarding cement are monitored such as color test, presence of lumps, adulteration test, temperature test, float tests, strength test and date of packaging. After the testing it was found that this cement can be used for the practical purpose.

5.2 Aggregate

Aggregate is one of the most important ingredient of the concrete which is responsible to provide the strength to the structure. To get the better result we used the angular aggregate and as per the Indian Codal Provisions we did the test such as crushing test, Abrasion test, Impact test, Soundness test, Shape test, Specific Gravity and Water Abosrption Test. In these test the sample is passed as per the Indian Codal Norms.

5.3 Ferrock

Ferrock is created from waste steel dust (which would normally be thrown out) and silica from ground up glass, which when poured and upon reaction with carbon dioxide creates iron carbonate which binds carbon dioxide from the atmosphere into the Ferrock. Compared to Portland cement (made from chalk and clay and resembling Portland stone in colour), which is one of the leading types in use throughout the world today, ferrock is actually five times stronger. It can withstand more compression before breaking and is far more flexible, meaning it could potentially resist the earth moment cause by seismic activity or industrial processes. One of the unique properties of ferrock is that it becomes even stronger in saltwater environments, making it ideal for marine base construction projects. And rather than emitting large amounts of CO2 as it dries, ferrock actually absorbs and binds it! These results in carbon-negative process that actually helps to trap greenhouse gases.

6. INDIAN CODAL PROVISIONS FOR CONCRETE MIX DESIGN

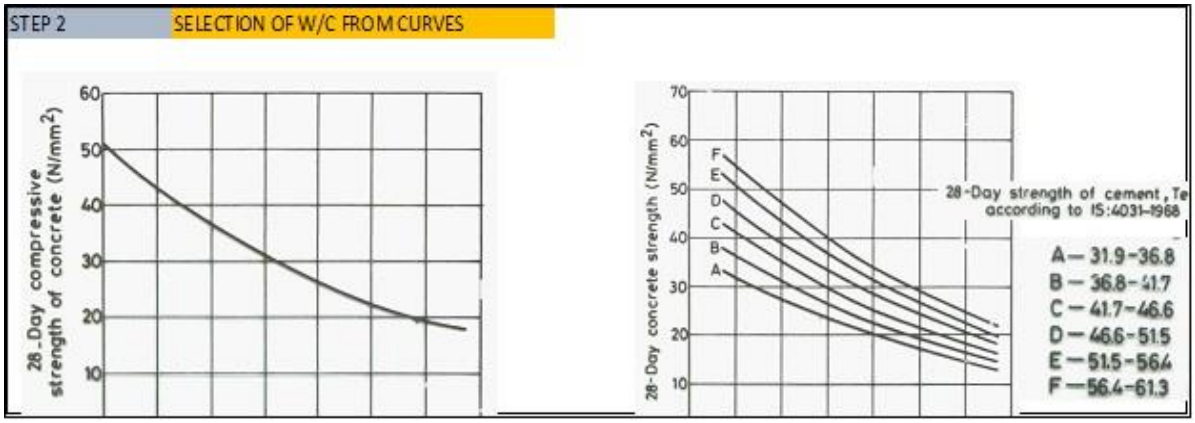
6.1 Step 1 : To Find the Standard Deviation as per Indian Standards

Table 2: Standard Deviation Value for M20 Grade Concrete

Step 1	f m = fck + 1.65s	
THE STANDARD DEVIATIONS ARE		
GRADE	**VALUE**	**UNIT**
M20-M25	4	MPA

6.2 Step 2: To Determine the W/C from Curves Provided in Indian Standards

Graph 1: Selection of W/C from Curves



6.3 Step 3: Water Content and Sand Contents for Concrete Grade up to M35

Table 3: Water Content and Sand Contents

M.S.A (MM)	W (KG/M3)	p = Fagg Vol. (% of total)
20	186	35

As per the Indian Standard for Concrete Mix:

- Fine Aggregate Zone = 2
- W/C = 0.6 upto M35
- W/C = 0.35 > M35
- Compaction Factor = 0.8

→ Estimate water content & sand content for concrete grades up to M35/ above M35 (Adjustments)

→ For change in values in water cement ratio, compaction factor and sand belonging to zone 3 the following adjustment required.

Table 4: Percentage of Sand in Total Aggregates

Change in Condition	Water Content	Percentage of sand in total aggregates
For decrease in water cement ratio	0	-2
(0.6 – 0.5) that is 0.1		
0.1/0.05*1 = 2.0		
For increase in compaction factor	3	0
(0.9 – 0.8) = 0.1		
For sand compacting to zone 3	3	-3.5

6.4 Step 4 : To Calculate the Cement Content and Aggregate Content as per IS

Calculate cement content, aggregate contents,

- w/c = Min (W/C_{curve} , $W/C_{durability}$)
- C = Max (W/w/c* , $C_{durability}$)

$$V = [W + C/S_C + 1/p \times F_{agg} / S_{Fagg}] \times 1/1000$$

$$V = [W + C / S_C + 1 / (1-p) \times C_{agg} / S_{Cagg}] \times 1/1000$$

Table 5: IS Requirements for RCC

IS requirement (RCC)			
Exposure	Min C	Max w/c	Min Grade
Mild	300	0.55	20

Where,

- MSA (MM) = 20
- Content (%) = 2

7. MIX DESIGN FOR M 20 GRADE CONCRETE AS PER INDIAN STANDARDS

7.1 Given Data

- Grade of concrete = M20
- Grade of cement = 53 N/mm^2
- Moderate exposure zone 3 sand
- Degree of workability = 0.9 C.F
- Max. size of aggregate = 20 mm
- Angular aggregate
- Degree of quality control = good
- Type of exposure = mild

7.2 Material Testing Data

- PPC 53 grade cement is used, with 28 days strength 51N/mm^2
- Specific gravity of cement = 3.15
- Bulk density = 1450 kg/m^3

Table 6: Properties of fine and Coarse aggregate

Aggregate	Fine aggregate	Coarse aggregate
S.G	2.66	2.75
Bulk density	1700	1800
Water absorption	1	0.5
Free moisture	2	NIL

7.3 To Find the Target Mean Strength for M 20 Concrete

Target mean strength (Fm) = fck + 1.65s

Fm = 26.6 N/mm^2 (MPA)

7.4 Selection of W/C from Curve

W/C = 0.5

7.5 Estimate Water Content and Sand Contents for M 20 Grade Concrete

For maximum size of aggregate of 20 mm, the air content is taken as = 2

Water = 186 kg/m^3

- Sand = 35 % of total aggregate by absolute volume
- Required water content = 191.58 lit / m^3
- Required sand content = 31.5 %

7.6 Determination of Cement Content

- Water cement ratio = 0.5
- Water = 191.58 lit. or kg
- Cement = 383.16 kg/m^3 > 300 kg/m^3 , therefore O.K.

7.6.1 IS Method

Calculate cement content, aggregate contents,

- w/c = Min (W/C_{curve} , $W/C_{durability}$)
- C = Max ($W/w/c^*$, $C_{durability}$)

$$V= [W+ C/S_C + 1/ p\times F_{agg} / S_{Fagg}] \times 1/1000$$

$$V = [W + C / S_C + 1 / (1-p)\times C_{agg} / S_{Cagg}] \times 1/1000$$

7.7 Determination of Fine Aggregate and Coarse Aggregate

- Consider volume of concrete = $1m^3$
- Entrapped air in wet concrete = 2%
- Volume of fresh concrete (V) = $0.98m^3$

With the quantities of water & cement per unit volume of concrete & the ratio of fine to total aggregate already determined, the total aggregate content per unit volume of concrete may be calculated from the following equations.

7.7.1 For Fine Aggregates

- Fine aggregate = 558.6966 kg mass of F.A.
- Coarse aggregate = 1256.05 kg mass of C.A.

Table 7: Quantity of Different Materials used for the Concrete

Name of the Material	Quantity in kg
Cement	383.16
Fine Aggregate	558.70
Coarse Aggregate	1256.05

Table 8 : Variation in the Quantity of Cement when it is Replaced with Ferrock

WHEN ADDED FERROCK (%) IN CEMENT (IT IS FOR 1 M3)					IT IS FOR =		0.003375	M3
% OF FERROCK	CEMENT (KG)	FERROCK (KG)	F.A. (KG)	C.A. (KG)	CEMENT (KG)	FERRPCK (KG)	F.A. (KG)	C.A. (KG)
0	383.16	0	558.7	1256.05	1.293	0	1.886	4.239
5	364.02	19.16	558.7	1256.05	1.229	0.065	1.886	4.239
10	344.84	38.32	558.7	1256.05	1.164	0.129	1.886	4.239
15	325.68	57.47	558.7	1256.05	1.099	0.194	1.886	4.239
20	306.52	76.63	558.7	1256.05	1.035	0.259	1.886	4.239
25	287.37	95.79	558.7	1256.05	0.97	0.323	1.886	4.239
30	268.21	114.95	558.7	1256.05	0.905	0.388	1.886	4.239
35	249.05	134.11	558.7	1256.05	0.841	0.453	1.886	4.239
40	229.89	153.26	558.7	1256.05	0.776	0.517	1.886	4.239
45	210.73	172.42	558.7	1256.05	0.711	0.582	1.886	4.239
50	191.58	191.58	558.7	1256.05	0.647	0.647	1.886	4.239
TOTAL	3161.05	1053.69	6145.7	13816.55	10.67	3.557	20.746	46.629

7.8 Proportion of Material as per the Mix Design for M20 Grade Concrete

Table 9: Proportions of Material

WATER	CEMENT	F.A.	C.A.	UNIT
0.28	1	1.458129	3.278136	KG

Table 10: Total Estimate of Quantity of Material used for the Making of Green Concrete Cubes

WATER (kg)	FERROCK (%)	CEMENT (KG)	FERROCK (KG)	F.A. (KG)	C.A. (KG)	NO. OF CUBES	TOTAL WEIGHT (kg)
12.49668	0	7.780498286	0	11.34497019	25.50553153	6	44.631
12.49668	1	7.702693303	0.077804983	11.34497019	25.50553153	6	44.631
12.49668	2	7.62488832	0.155609966	11.34497019	25.50553153	6	44.631
12.49668	3	7.547083337	0.233414949	11.34497019	25.50553153	6	44.631
12.49668	4	7.469278354	0.311219931	11.34497019	25.50553153	6	44.631
12.49668	5	7.391473372	0.389024914	11.34497019	25.50553153	6	44.631
12.49668	6	7.313668389	0.466829897	11.34497019	25.50553153	6	44.631
12.49668	7	7.235863406	0.544634888	11.34497019	25.50553153	6	44.631
12.49668	8	7.158058423	0.622439863	11.34497019	25.50553153	6	44.631
12.49668	9	7.08025344	0.700244846	11.34497019	25.50553153	6	44.631
12.49668	10	7.002448457	0.778049829	11.34497019	25.50553153	6	44.631
12.49668	15	6.613423543	1.167074743	11.34497019	25.50553153	6	44.631

12.49668	20	6.224398629	1.556099657	11.34497019	25.50553153	6	44.631
12.49668	25	5.835373714	1.945124571	11.34497019	25.50553153	6	44.631
12.49668	30	5.4463488	2.334149486	11.34497019	25.50553153	6	44.631
12.49668	35	5.057323886	2.7231744	11.34497019	25.50553153	6	44.631
12.49668	40	4.668298972	3.112199314	11.34497019	25.50553153	6	44.631
12.49668	45	4.279274057	3.501224229	11.34497019	25.50553153	6	44.631
12.49668	50	3.890249143	3.890249143	11.34497019	25.50553153	6	44.631
237.43692	GRAND TOTAL	123.3208978	24.5085696	215.5544335	484.6050991	114	

Table 11: Data of Green Concrete Cube

SIZE OF ONE CUBE	0.15	M^3
NUMBER OF CUBES	6	NOS.
WET VOLUME OF CUBE	0.03078	M^3
DENSITY OF CEMENT	1450	KG/M^3
WET MATERIAL	0.52	
DRY VOLUME OF CUBE	0.02025	
WATER CONTENT	0.28	

8. COMPRESSIVE STRENGTH TEST RESULT OF CUBES

Table 12: Compressive Strength of Cubes

SR. NO.	CUBE NO.	DAYS	STRENGTH (N/MM^2)	AVERAGE STRENGTH	FERROCK (%)
1	1	3	6.82	7.57	**0%**
	2		8.06		
	3		7.85		
	4	28	18.98	20.64	
	5		20.74		
	6		22.2		

	7	56	21.03	22.69	
	8		22.03		
	9		24.99		
2	1	7	15.44	15.07	**1%**
	2		14.65		
	3		15.13		
	4	28	20.15	20.76	
	5		21.53		
	6		20.62		
	7	56	26.43	27.19	
	8		25.25		
	9		29.91		
3	1	7	17.56	17.34	**2%**
	2		16.62		
	3		17.86		
	4	28	22.32	21.92	
	5		20.28		
	6		23.15		
	7	56	26.55	28.59	
	8		34.3		
	9		24.93		
4	1	7	18.27	19.92	**3%**
	2		18.92		
	3		22.58		
	4	28	21.97	22.09	
	5		22.56		
	6		21.75		
	7	56	24.8	27.13	
	8		28.91		
	9		27.7		
5	1	7	18.94	20.58	**4%**
	2		17.92		
	3		24.89		
	4	28	21.38	22.77	
	5		23.46		
	6		23.47		
	7	56	25.98	27.83	
	8		27.87		
	9		29.65		
6	1	7	19.02	21.09	**5%**
	2		20.29		
	3		23.98		
	4	28	22.56	23.47	
	5		22.98		

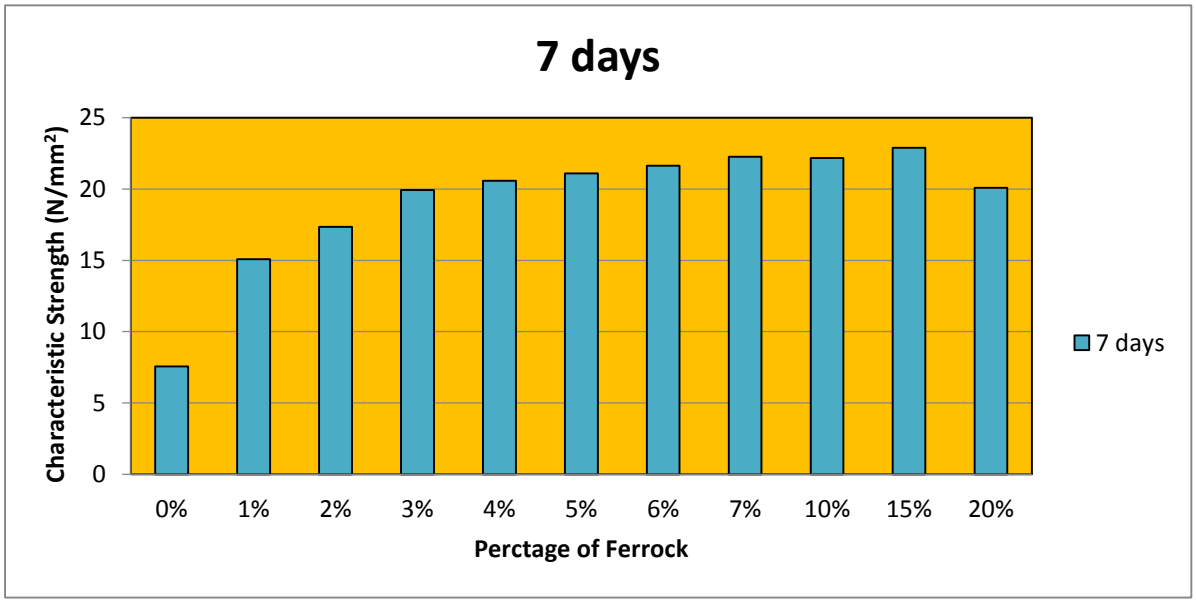
	6		24.89		
	7	56	26.87	28.44	
	8		28.67		
	9		29.78		
7	1	7	19.57	21.64	**6%**
	2		20.24		
	3		25.12		
	4	28	24.23	24.4	
	5		23.56		
	6		25.43		
	7	56	26.97	29.76	
	8		29.78		
	9		32.54		
8	1	7	20.76	21.81	**7%**
	2		22.81		
	3		22.87		
	4	28	25.46	25.62	
	5		24.64		
	6		26.76		
	7	56	28.23	31.24	
	8		30.74		
	9		34.76		
9	1	7	21.63	22.16	**10%**
	2		22.39		
	3		22.48		
	4	28	24.78	25.94	
	5		27.59		
	6		25.46		
	7	56	36.48	36.67	
	8		36.34		
	9		37.2		
10	1	7	22.35	22.88	**15%**
	2		23.54		
	3		22.75		
	4	28	29.33	30.78	
	5		28.56		
	6		34.46		
	7	56	33.16	34.86	
	8		36.53		
	9		34.89		
11	1	7	20.45	20.08	**20%**
	2		20.16		
	3		19.63		
	4	28	30.56	30.67	

	5		30.26		
	6		31.21		
	7		28.12		
	8	56	29.65	29.14	
	9		29.65		

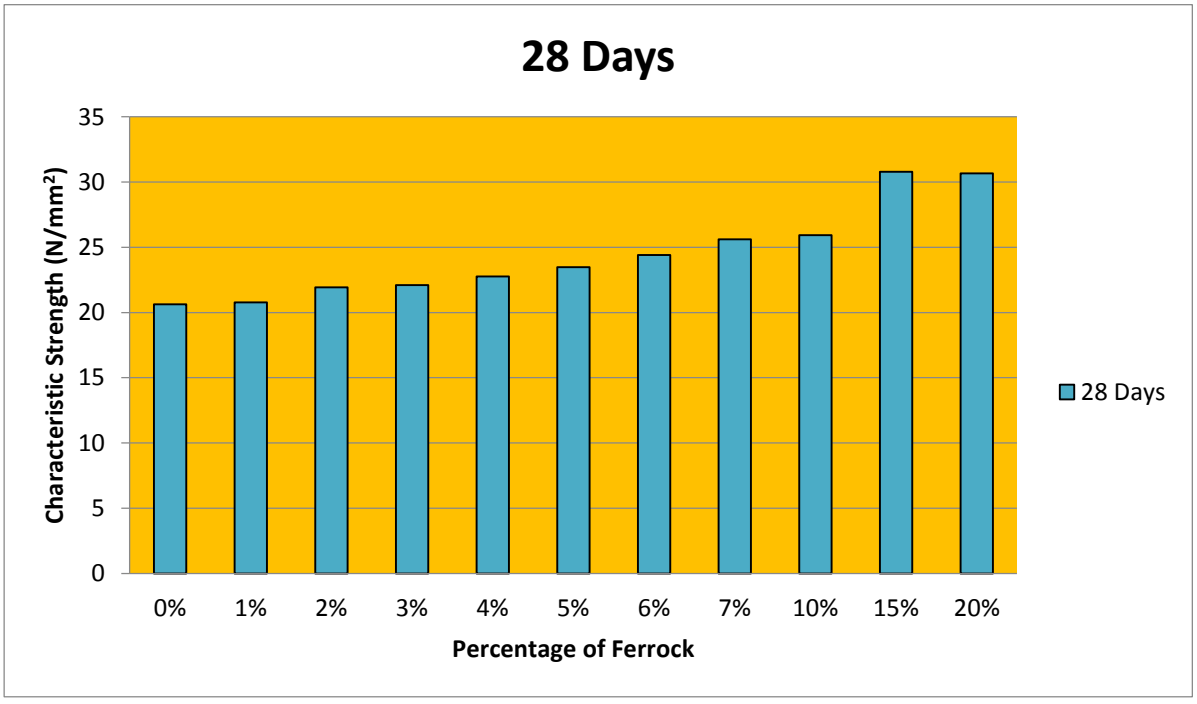
9. ANALYSIS OF THE RESULT

Following are the result analysis at different percentage of replacement of cement with ferrock at the different curing period of 7 days, 28 days, and 58 days.

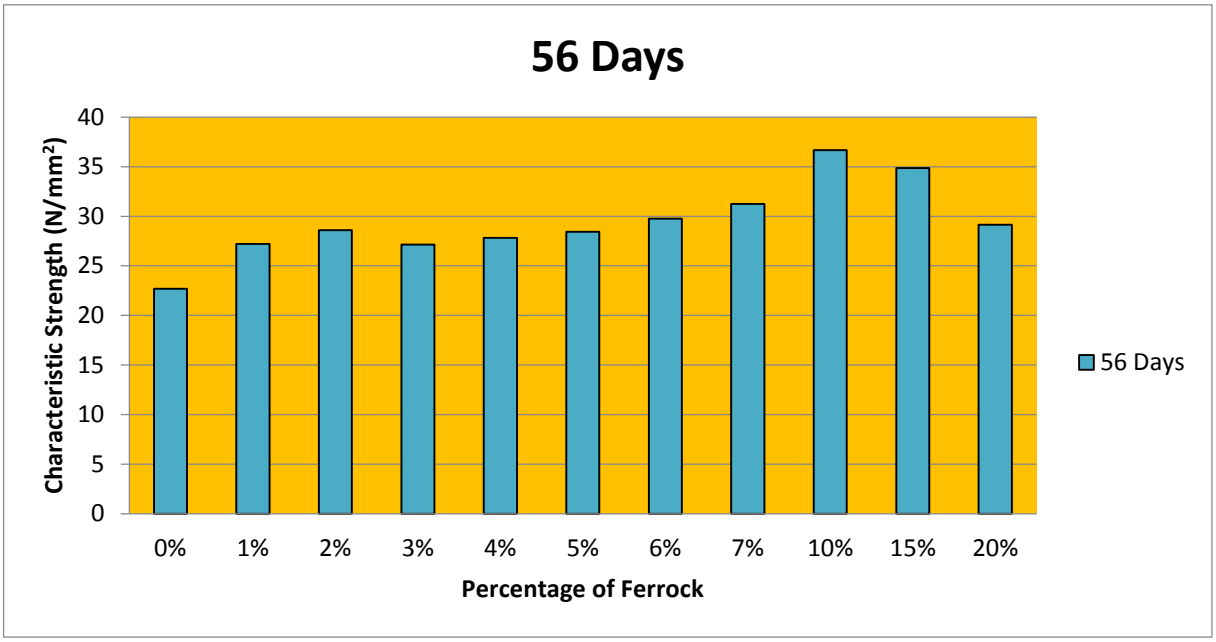
Graph 2: Compressive Strength of Green Concrete after 7 Days of Curing



Graph 3: Compressive Strength of Green Concrete after 28 Days of Curing



Graph 4: Compressive Strength of Green Concrete after 56 Days of Curing



10. CONCLUSION

- From Graph no.2, we get strength of concrete after 7 days:

Table 13: Compressive Strength of Green Concrete after 7 Days of Curing having a Varying % of Ferrock

% of Ferrock	0	1	2	3	4	5	6	7	10	15	20
Strength (N/mm^2)	7.57	15.07	17.34	19.92	20.58	21.09	21.64	22.25	22.16	22.88	20.08

- From Graph no.3, we get strength of concrete after 28 days:

Table 14: Compressive Strength of Green Concrete after 28 Days of Curing having a varying % of Ferrock

% of Ferrock	0	1	2	3	4	5	6	7	10	15	20
Strength (N/mm^2)	20.64	20.77	21.92	22.09	22.77	23.48	24.41	25.62	25.94	30.78	30.67

- From Graph no.4, we get strength of concrete after 56 days:

Table 15: Compressive Strength of Green Concrete after 56 Days of Curing having a Varying % of Ferrock

% of Ferrock	0	1	2	3	4	5	6	7	10	15	20
Strength (N/mm^2)	22.69	27.2	28.59	27.14	27.83	28.44	29.76	31.24	36.67	34.86	32.67

- Green concrete having reduced environmental impact with reduction of the concrete industries CO_2 emission by 30%.
- Green concrete is having good thermal and fire resistant.
- In this concrete recycling use of waste material such as ceramic wastes, aggregates, so increased, so increased concrete industry's use of waste products by 30%.
- Hence green concrete consumes less energy and becomes economical.
- So definitely use of concrete products like green concrete in future will not only reduce the emission of CO_2 in environment and environmental impact but also economical to produce.
- From the result it was concluded that compressive strength and durability of green concrete is more as compare to the conventional concrete up to 15 % replacement of cement with Ferrock and from 20% the compressive strength of concrete is decreasing.

11. FUTURE WORK SCOPE

Following are the future work scope of this work:

1. To do the parametric study based on the flexural strength of the green concrete.
2. To do the analysis with the help of software and to do parametric study based on that.
3. To do more research on ferrock as environment sustainable material.

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Improve Resource Migration Using Virtual Machine in Cloud Computing: A Review

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Abstract:

Cloud computing technology can be widely used depends on the virtualized resource scheduling can timely and reliably assurance user service quality. So efficient and flexible resource scheduling in cloud computing is of great significance. In view of the cloud computing environment, the resource scheduling model based on virtual machine migration. Migration contributes to efficient resource management in cloud computing environment. The core of Cloud computing includes virtualization of hardware resources such as storage, network and memory provided through virtual machines (VM). When the user needs additional resources for virtual machine (VM) than the available resources of datacenter, the whole process will hang and also affects to the other running process in virtual machines of data center**.**

Keyword*: Cloud Computing, Virtual machine, virtualization Migration (VM), Resource Allocation.*

I INTRODUCTION

Cloud computing uses network to make a lot of computer resources unified management and scheduling, forming pools of computing resources, each end user can get powerful computing capability and a variety of information services according to the needs of the business through the Internet Cloud computing is based on open standards and services, on the centre of Internet and provides safe, fast and convenient data storage and network computing service. In Cloud Computing Environment mainly user-based resource allocation. Resource allocation module and monitoring module mainly adopt dynamic resource allocation strategy; implement the adaptive dynamic allocation of resources in order to realize the efficient use of data center resources. The main idea of the resource allocation strategy is to protect user request resources based on SLA, and timely recover completed tasks resources, reduce unnecessary consumption of resources to ensure the smooth operation of the system. [1].

Migration techniques can be classified into non-live migration and live migration.

Non-live migration refers to the process of migrated running VM that is firstly paused and afterward resumes when all the required migration workloads have been completed. Services provided by the VNs

are not accessible during the migration, and open network connections may cause timeout or Disconnection. More advanced live migration mechanisms do not require pause of the VMs.

Live migration mechanisms: migrate as fast and efficient as possible in order to provide dynamic load balance, zero downtime. Live migration provides many benefits such as energy saving, load balancing, and easy maintenance. [2]

Cloud technology is combination of several other technologies such as Virtualization, Service Oriented Architecture (SOA) and web Security limitations in these traditional technologies are also inherited in the overall security of Cloud along with their benefits.

As Cloud infrastructure consists of large scale, distributed, heterogeneous and completely virtualized resources, therefore the traditional security mechanisms are not enough for this environment. Live migration of VM introduces severe security risks in traditional data centers as well as in Cloud environment. The contemporary research on live migration so far is performance oriented and security issues have not received much attention. There are several security risks in live VM migration process provided by Xen, KVM and VMware hypervisors. Live VM migration without security features becomes single point of failure (SPF) for Cloud environment. [3]

.

For better resource utilization, many cloud providers start with static allocation of VMs to physical machines (PMs) using a resource scheduler as shown in Figure 1. However, the resource utilization in the cloud environment decreases as the number of VMs increases in the PMs. This is due to mainly the following two reasons. (1) There are always some unallocated resources left on the PMs. This is due to the unpredictable incoming VM configurations from cloud users. Without accurate historical data, it is difficult to allocate VM properly. (2) Memory balloon and CPU virtualization are widely supported features of virtualization technology. It enables cloud users to configure their VMs memory size and CPU number at operating time, which makes the scheduler work less efficient. These two reasons make the static scheduling approach unfit, and instead, requiring dynamic re-allocation. Therefore, a dynamic VM re-allocation on the PMs is required for improving resource utilization in the cloud environment. [6]

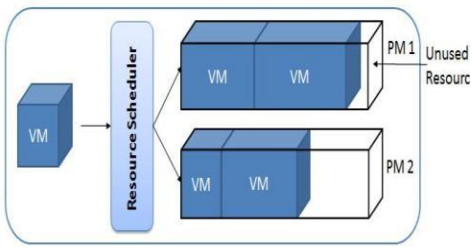

Figure 1. Static VM allocation [6]

II Dynamic Resource Allocation algorithm

Load balancing is achieved by dynamic migration of the overloaded virtual machines. By migrate the virtual machines to available data center dynamically, overloading of datacenter can be avoided. This can be achieved through VM Dynamic resource allocation algorithm and DC balancing algorithm. Thus, overloaded virtual machine under the datacenter is Migrated to available datacenter using their proposed Algorithm. Through this, performance of the datacenter is maximized and results in high user's satisfaction at data centers. [1]

In this Dynamic Resource Allocation Algorithm, the virtual machine under host, will schedule dynamically as per the user's request. Resources will be provided to the user as per the requirement of user. If the user wants to extend the memory, user can request for the additional resource as they need. Dynamically the resource will be given to the requested virtual machine and updated dynamically. In future, we will develop a Dynamic resource allocation algorithm for underutilized VM in datacenter. This algorithm should have criteria for selecting a VM, selecting a node which has sufficient space for underutilized virtual machines. This ensures more Load Balancing in private cloud. [4]

III Auction-Based VM Allocation

They express their needs by submitting bids on the price they would like to spend on the commodities. The proposed auction based VM allocation mechanism works by modeling agents as bidders and VMs as commodities, which is described formally in Algorithm step by step. [5]

1. In this Algorithm, initially, all newly submitted VMs _ are unallocated at each bidding round.

2. Each agent *ai* only bids for the largest unallocated VM that it is capable of hosting.
3. After bidding for the target VM $\theta * ai$, each agent *ai* broadcasts its bid *Bi* to all of the other agents for winner determination.

4. A bid $Bi = <pi, \lambda i/ci>$ consists of the PM identity
pi and its cost-capacity ratio $\lambda i/ci$.

5. After all bids are broadcasted, all of the agents send a winner acknowledgment message <Ack> to the winner agent that has the minimum cost-capacity ratio.

6. In the event of a tie, the agent that has the smallest index is selected as the winner.

7. The agent ai that receives ack from all of the other agents wins the current round bidding. The winner agent ai then is responsible for running its targe

θ * ai and informing all of the other agents that θ * ai has been allocated.

8. This bidding process (steps 2–7) proceeds round by round until all VMs are allocated.

An auction based VM allocation mechanism, which is devised for agents to decide which VM should be allocated to which PM for better resource utilization.

IV Negotiation-Based VM Consolidation

To tackle system dynamics and avoid incurring prohibitive VM migration overhead, a local negotiation based VM consolidation mechanism is devised for agents to exchange their assigned VMs for energy cost savings. The dynamic experimental results demonstrate that the multi agent approach can adapt to system dynamics well by consuming as little energy as the benchmark centralized and distributed global-based resource consolidation approaches, but largely reducing the migration cost, showing its great potential for practical applications. [5]

A negotiation based VM consolidation mechanism, which is designed for agents to exchange their assigned VMs to save energy cost and address system dynamics. A possible reason is that there are only a small number of profitable VM migrations executed in PRO. These advantages make MA approach a preferable choice for cloud computing resource management to reduce energy cost in real time, while consuming tolerable amounts of network traffic.

V Cloud Reconfiguration Algorithms

Researching on cloud reconfiguration algorithms is an active research area of Cloud computing. One problem addressed is trying to minimize number of PMs in the cloud Environment. This is commonly referred as VM Consolidation. The static re- allocation approach is a simple heuristic for the MDBP problem and applies it to minimize the number of PMs required to host a given web traffic. A resource management algorithm to attempts to minimize the number of migrations of VMs while minimizing the number of PMs used. A similar objective is also pursued in and these approaches, however, have focused on how to calculate a new configuration, and have neglected the migration overhead. An algorithm is

proposed to pack VMs according to their CPU needs while minimum the number of migrations will be used. Researchers have also applied a variety of methods to achieve greater resource utilization.

Prediction techniques and queuing theory results are employed to allocate resources efficiently within a single PM serving a web workload. It proposes an optimization algorithm for resource economy that allocates PM resources depending on the expected financial gain for the hosting centre. [6]

By using a probabilistic multivariate model, the algorithm selects suitable PMs for VM re-allocation before a reconfiguration Plan is generated. their evaluation indicates that there is only a minor decrease in resource utilization levels that results from reducing number of PMs for re-allocation. So, the approach leads to a lower number of VMs being reallocated as number of PMs Considered for VM re- allocation decreases.

Cloud reconfiguration algorithms are based on VM reallocation techniques that construct a suitable reconfiguration plan for achieving greater resource utilization in the cloud environment. Existing cloud reconfiguration algorithms [8, 9, 10] aim to solve the problem of low PM resource utilization to allow more VMs to be allocated in the cloud environment

VI Energy Efficient Network-Aware VMs Migration

The destruction of VMs from the PMs gives an opportunity to the service provider to migrate the VMs from the underutilized PMs to the energy efficient PMs, and thus switching-off underutilized/idle PMs and switches at the cloud data center. the objective function for muli-objective VMs migration problem is defined in such a way that VMs are migrated from one PM (source node) to another PM (destination node) such that the maximum number of VMs are migrated to the destination node within their capacity. [7]

Table: - Literature Review

Year/ Publication	Author	Technique/Algorithm	Tools /Technology	Research Gap
2012 (IEEE)	Sijin He, Li Guo, Moustafa Ghanem, Yike Guo	Improve resource utilization	Cloudsim	Author Proposed developing relationship between predefine range and select suitable physical machine to improve migration cost
2014(IEEE)	Divyabairavi Soundararajan, ,Sankari Subbiah	Dynamic resource allocation	Cloudsim	Author Proposed develop dynamic resource allocation in VM datacenter.
2016(IEEE)	Wanyuan Wang, Yichuan Jiang	Multiagent-Based Resource Allocation	Cloudsim	Author Proposed for resource allocation each and every user take full advantage of VM resource as per user request but cloud service provider cost will be increase.
2017(IEEE)	Tian Fu , Zhen Wang	Resource Scheduling Mechanism Based On Virtual Machine Migration	Not mention	Author Proposed resource scheduling model based on virtual machine migration can better achieve the scientific distribution of data center resources and reduce data center load; provide a practical and effective approach to the reasonable

				allocation of resources and guarantee of user service
2018(IEEE)	Neeraj Kumar Sharma, Priyanka Sharma	Energy Efficient Quality of Service Aware Virtual Machine Migration	Cloudsim	Author Proposed that they have not consider network aware VM allocation in cloud data center.

VII Conclusion

In this paper, we surveyed, resource migration using virtual machine in the cloud computing it is very important for cloud providers to manage and assign all the resources in time to cloud consumers as their requirements are changing dynamically. From the comparing above algorithms we conclude that, Cloud Reconfiguration Algorithms is better than the other algorithm reason is In the user-defined view, the imbalance heuristic performs slightly better than the volume heuristic. In the provider-defined view, the volume heuristic performs significantly better than the imbalance heuristic in which it improves resource allocation, utilization, and energy efficiency in the Cloud

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5S IMPLEMENTATION IN CRANE MANUFACTURING INDUSTRY

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ABSTRACT:
The Japanese methodology 5S (Sort, Set in order, Shine, Standardize, Sustain) is a systematic approach towards improvement of the manufacturing facility. The paper exhibits the case study of implementing 5S in a crane industry. Majority of the small-scale industries are ignorant regarding these types of methodologies. The prime motive of implementing 5S in the crane industry was to raise the productivity with keeping in mind the safety precautions, with help of appropriate management. Also, this case study shows that we applied a proper shop floor layout, introduced inventories and bins, and did many changes in order to make the industry perfect. The effective 5S implementation results the enhancement in productivity and efficiency.

Keywords: 5S methodology, 5S system, Continuous improvement.

1. INTRODUCTION

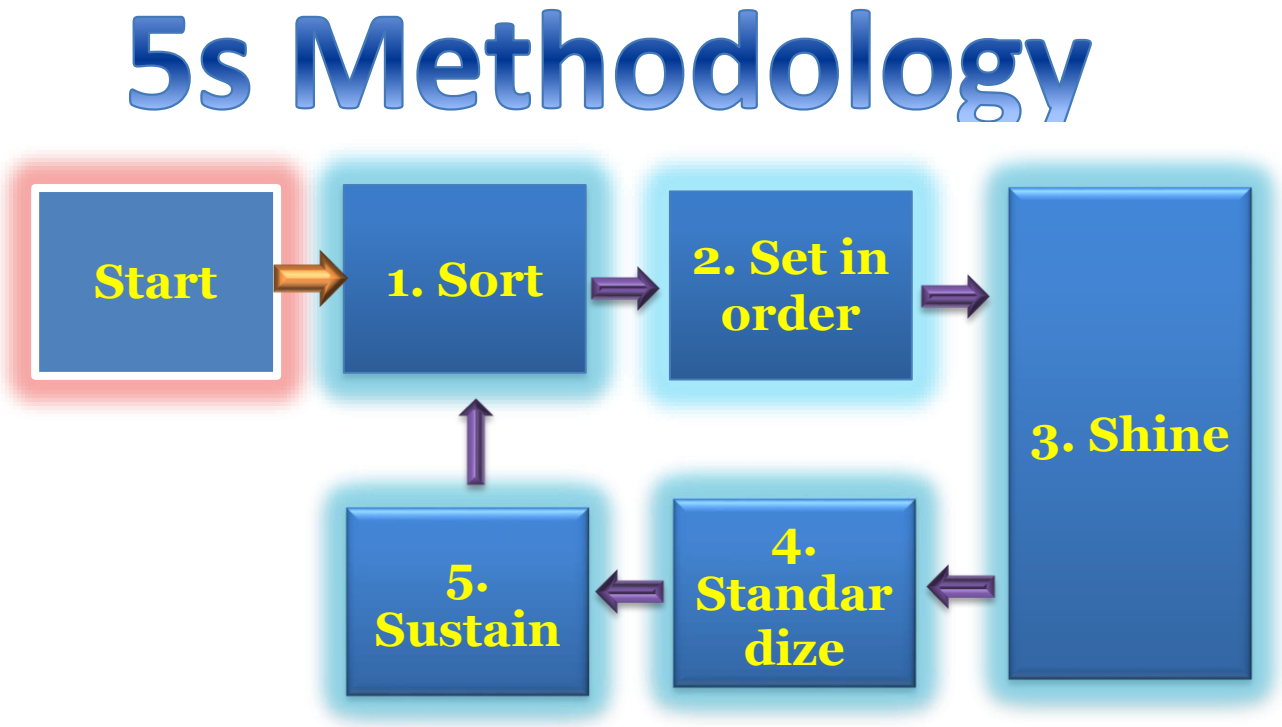
1.1 History of 5S

The methodology was developed in Japan in order to improve the work efficiency, effectiveness, and safety. This systematic technique not only helps to reduce non-value adding time, but also improves productivity and quality [1]. The Japanese methodology 5S is depended on five various pillars: Seiri (Sort), Seiton (Set in order), Seiso (Shine), Seiketsu (Standardize) and Shitsuke (Sustain). In past, 5S was known as the Toyota Production System, which was developed by Taiichi Ohno and Eiji Toyoda with Japanese industrial engineers in 1950 [1]. After some new improvements in old system, Sakichi Toyoda (Father of the Japanese industrial revolution), his son Kiichiro and Taiichi Ohno redesigned "TPS" and named as "5S". Venice shipbuilders used similar type of concept for quality assembly of the ship in 16th century. They completed the process in hours rather than completing in days. By the time, the 5S System has expanded and could be found within Total Productive Maintenance (TPM), Just- In-Time (JIT) process, and the lean

manufacturing [1]. There were two frameworks given for applying 5s methodology. Later on, Total Productive Maintenance (TPM), the Just- In-Time (JIT) process, and the lean manufacturing were founded from the base of the 5S work approach. The second framework of 5S was introduced by Hiroyuki Hirano. Hirano's approach was having only "4s", in which Set in order and Shine were considered as a single aspect; whereas, the former framework, presented by Osada, suggested that keeping discipline in the training and education helps to enhance the quality of work as well as work standards. In 1996 Henry Ford introduced CANDO (Cleaning up, Arranging, Neatness, Discipline and Ongoing improvement), which is also a similar system like 5s methodology.

1.2 Basics of 5S

Figure (1): 5S Methodology



1.2.1 ***Sort (Seiri):*** SORT defines the proper arrangement of everything. The main aim of sort is to organize the working environment [8]. The things should be sorted according to their needs and time frequency of working. Another main objective is to remove all the unwanted or not needed items from the working area.

1.2.2 ***Set in order (Seiton):*** SET IN ORDER is the method by which we arrange the things according to the necessity or the flow of the process [8]. The main objective is to follow the work order. It helps to reduce the searching time and improve the utilization of the time and work.

1.2.3 ***Shine (Seiso):*** SHINE refers the systematic cleaning on the regular basis. Cleanliness means higher visibility, visible results, and the high quality of work [8]. The aim is the items, which are out of place or missing, should be recognized easily as well as the hazards or difficult situations can be understood and accounted easily.

1.2.4 ***Standardize (Seiketsu):*** To create appropriate guidelines for sort, set in order, and shine is called STANDARDIZATION [8]. The purpose of it is to create best practice for members in system along with communicable and easily maintainable standards.

1.2.5 ***Sustain (Shitsuke):*** SUSTAIN comes last because, for implementation of sustain first we have to implement other 4S [8]. The goal of sustain is the members of the system get habituated the implemented system. Sustain teaches the discipline and keeps the process running.

1.3 Organization Introduction

"AKASH ENGINEERING WORKS", which was established in 2002, is one of the reputed crane industries in Gujarat. In the time of beginning, it was a small-scale industry, but now, because of many new customers, they are successfully converted into medium scale industry. The organization is the leading manufacturer of service provider of all the cranes. Also, they provide maintenance as well as distribution of crane spare parts. AEW generally manufactures E.O.T., H.O.T., Crane hoist and Goods lift. The industry has the ground area of 8850 square ft. Moreover, in the organization, they use Production flow layout and for manufacturing of the industrial crane, they use batch production system.

2. PROBLEM STATEMENT

- The biggest issue with the industry was poor control over the inventory. The inventory was not arranged in proper manner, so the time taken for any operation was very high, which was causing the decrement in productivity. Also, the problem of the storage limitation was also one of the major concerns, which affects the work efficiency.
- Secondly, there was no proper Shop Floor Layout in the industry, which was also a big concern. Due to absence of shop floor layout, the handling of material was too poor, which influences the quality control.
- Also, unnecessary materials were spread on the floor area by the workers and these items were not properly put to their respective places by the workers.

- Workers were doing their work without wearing any type of safety equipments. They were not habituated of the safety shoes and safety glasses whenever they do the operations, which might cause the serious accidents.
- Moreover, proper assembly area was not occupied in the layout and the space utilization was also not done in appropriate ways, which were the major causes behind low productivity.

Image (2.1): Unorganized Layout

3. LITERATURE REVIEW

- Mayank Dev Singh et al. (2015) conducted the study at "Sandvik Asia Pvt. Ltd, Mehsana, Gujarat" with the prime aim of reducing the abnormality. Also, the waste of time, motion and improper materials handling were the big difficulties they faced on early stages [3]. In order to solve this query, they implemented 5S methodology and they used manual sorting of material and provided the stopper at fallen down area. Additionally, a specific place was introduced for air gun. After implementing lean manufacturing and 5S, the searching time was reduced to 5-6 minute from 14-16 minutes. They saved 640+ pages per year by providing updated preventive maintenance system. By utilizing standardized operation methods, it is possible to reduce human movements in the shop floor.
- How 5S strategy implemented in any industry, Kaushik Kumar et al. (2012) described the steps for it. With the proper calculations, authors mentioned that lean tool is very beneficiary for the improvement of the productivity in any organization [4]. They mentioned in detail how and when

5S can be implemented. Literature gives the detailed idea about the Sort, Set In order, Shine, Standardize and Sustain. They also stated the various benefits of the system according to industry, so it can be known exactly how and when to apply this methodology.

- The research carried out in a Malaysian Automotive Parts Manufacturing by Nadirah Roslin et al. (2012) described the progress in its early stages of lean manufacturing implementation [5]. The literature suggests that there are few critical success factors such as availabilities of resources, organizational culture and information technology proficiency which impress each dimension of lean manufacturing. The observation of lean success determinants is limited to this case and care should be taken while generalizing the results of this case study to other Malaysian manufacturing organizations. Thus, future studies of multiple case studies can be conducted to get the influence of a variety of success factors for different lean manufacturing tools.
- Gheorghe Dulhai (2008) conducted a study at the manufacturing unit of the auto car exhaust. The aim of the study was to improve manufacturing of the auto car exhaust by various methods like 5S and continuous improvement. They used the questionnaires in order to examine the tasks. After implementation of this 5S strategy, the accidents got reduced. The maximum days they maintained safety [6] till 56 days. Reduction of physical efforts and fewer accidents during the production process were obtained. The results were appeared in short time around couple of weeks.
- In the Hari Bio-Mass Processing Unit, K Ramesh, and team (2014) conducted the study for reducing the waste and removing unwanted activities in the biomass plant. They diagnosed the current flow of the organization in order to implement the transparent process flow. They trained labors and supervisors for minimization of the waste. Document analysis and result reported that after implementation of 5S, the industry achieved the clean work space. Also, they washed the walls to enhance the working environment. As a result, the unwanted activities were reduced, floor layout became neat and clean and approximate 700 kg of excessive scrap got reduced [7].
- By performing the test in the industry, S.R. Dulange (2013) wanted to enhance the textile market in the country with help of cutting-edge management methods in power looms. They did the analysis of the lack of production tools, improper management, and many others. These all things were done by the audit team which was created for the data collection [9]. To sort the items, they utilized the colour coding method and also various tags were used in power looms too. Moreover, the bins were used in order to maintain appropriate material flow. Upcoming 30 weeks were the analysis time after applying this system. Consequently, the improvement in productivity was achieved. That is why the Solapur Textile Sector was upgraded in the matter of management and productivity.

- R.T. Salunkhe et al. carried out the study to cut out the searching time of the spare parts in the industry. In the ABC industry, the lean manufacturing tools such as Kaizen as well as 5S were taken into the action to curb the issues. There were many unwanted items, which were kept in any bins, so the bins did not carry the appropriate objects. They segregated the places of pipe and hoses in variety of racks [10]. By applying 5S methodology the enormous changes came in the searching time because the bins got the colour codes. Where the searching time was somewhere around 13-15 minutes before, now it dropped to 6-8 minutes. Eventually, they gained over the inventory control by maintaining minimum level of self-life items.
- Abhay R. Kobarne, et al. (2016) exhibited one of the major issues in the company. As per their reports, they found that inadequate communication, less contact in the organization. Due to that, the management took some hard commitments [11]. It was told to all that more and more cooperation from all level of laymen is much needed during the implementation period. Finally, by some strict implement, the results started to come satisfactory. Moreover, they found that continuous training is the basic as well as most important aspect in order to change the organization's environment. They also understood that Periodic assessment should focus on the enhancement and development regarding all inputs in the organization. At the end, some fruitful results were obtained.
- Rastogi Vikas et al. (2014) figured out that some of the top organizations have already applied some features of the 5S in their regular activities without total awareness of its pros. However, other investigations are required to implement the 5S as a continuously improving tool in company. They identified that size and structure are the aspects which not only can affect the application of the 5S but also its effectiveness. Moreover, they conceive that this methodology is not new, and they have had it for very long period of time. They also said that they need the 5S at their workplaces as majority of the individuals do their works without thinking and as all know that 5S can be a reflection of the behaviors of people. Hubbard [12] exhibited that orderliness helps to stop three types of waste: searching waste, difficulty-of-use waste, and the waste of returning items to their proper place. Eventually, it was understood that 5S implementation is not possible without appropriate training that make the place standardized. Hence, it is perceived that continuous training is very crucial in order to alter the environment of the company.
- Harsha Lingareddy et al. (2013) carried out their research in metal doors manufacturing industry. They implemented 5S in various stages, where in primary phase they did their research in item selection in production process as the objects were in haphazard manner. They believed that 5S methodology depends on the capacity of constructing and maintaining a well-managed, clean, effective, and high quality work place [13]. Additionally, they worked over shop floor layout too,

in which they created questionnaire for the workers. Eventually, they got amazing outcomes like better use of workplace, no losing of tools, maintenance cost reduction, safety enhancement, reduction in travel time and improved working conditions. They found the rise in efficiency of every aspect in the industry as the workers did their job appropriately.

- Vaibhav Bharambe et al. (2020) (Same authors of this paper) reviewed many research papers of 5S implementation in various organizations [14]. The detailed review of the research papers, from various organizations like manufacturing industry, college, temple and many more, has been done.

4. IMPLEMENTATION OF 5S

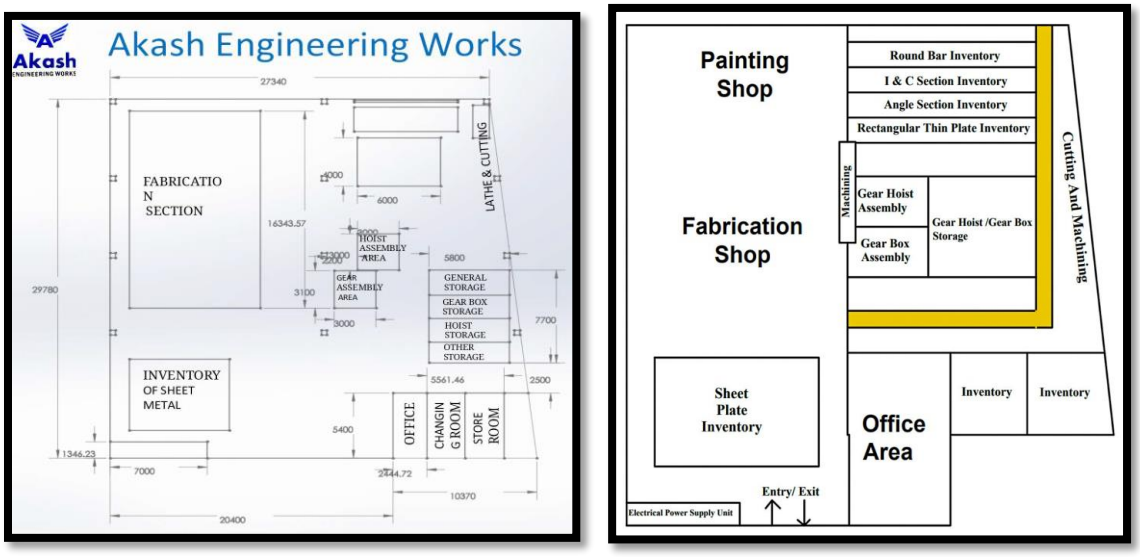
- Inventory control was the biggest problem in the industry. All materials, which were coming for assembly work; the workers were putting them anywhere in the inventory room. There was no specific location decided for systematic arrangements of raw material. We firstly did the analysis of the need of materials and designed the systematic racks accordingly in the industry. In that, we sorted the materials in three different stores. One for Gear hoist assembly, second for Gear box assembly and eventual one for electrical panel equipment stores.

Image (4.1): Improper Arrangement of the Materials

Image (4.2): Proper Arrangement of the Materials

- As per above images, we can see that in the before time the couplings, gears, welding rods boxes were placed on the floor and the things which were placed on the racks were also nasty and not easily indentified. In order to improve all that difficulties, we redesigned the racks in such a way that all the materials get organized in the rack. For easy identification, we used the name plates for each material. Also, in racks, we segregated different TONS of gears in same rack but in ascending order of it. To solve the disarrangement of bearing and keys, we used the bins and segregated them according to the size.

Figure (4.3): Old-New Plant Layout



- As we were in early stages, there was no proper shop floor layout in the organization. Due to that the space related issues in assembly of gear hoist and gear box were occurring. To resolve those issues, we implemented new process layout according to the data included the movements of the workers and traveling flow of the material. During designing new layout, we gave proper space for assembly operations, walkway, and machining area. We constructed walk way in such manner that no worker gets harmed during walking on that path. Industry affected immensely after implementation of new shop floor layout. Now workers and other people can walk fearlessly on the walkway, which enhances the discipline in the company.

Image (4.4): Floor Markings

- We conducted safety awareness sessions for the workers' safety. In these sessions, we showed them the videos and pictures and explained that how the things might become worst if the safely is compromised. Also, we provided them the helmets, gloves, and glasses for their own safety. Additionally, we applied the siren in the shop floor. So, in case of emergency or anything hazard happens, they can press the buttons and all the workers can immediately stop their work and can go to the safe place. For spreading more awareness about 5S and safety, we hanged the posters and various banners, so the visual images can motivate the workers and they become self-aware about safety every day.

Image (4.5): Before & After Providing the Helmets

Image (4.6): 5S Safety Tags

5. RESULT ANALYSIS

5.1 Sort Rating:

Sort is the first step of the 5S methodology. For calculation of sort rating [2], we allotted 5 regions for sort arrangement, and we decided that the system should achieve at least 2.5 out of 5, which shows that the implemented system is 50% active.

Following are the Sort rating criterion.

(1) Material Availability :
Give '1' marks if necessary, material for assembly is available, if not then mark it '0'.

(2) Material Sorting:
Give '1' marks if material for assembly is sorted in its allocated place, if not then mark it '0'.

(3) Gas Cylinder Sorting:

Give '1' marks if empty gas cylinder and filled gas cylinder are sorted in its allocated place, if not then mark it '0'.

(4) Tools Sorting:

Give '1' marks if cutting, measuring, and fitting tools are sorted in its allocated place, if not then mark it '0'.

(5) Waste Elimination:

Let total 'F' number of waste are listed but only 'E' was eliminated the marks of elimination process will be Fraction of waste elimination = [E/F]

Table (5.1): Sort Rating

Sr. no.	**Durations**	**Material Availability**	**Material Sorting**	**Gas cylinder sorting**	**Tools sorting**	**Waste Elimination**	**Total Rating**
		0 or 1	0 or 1	0 or 1	0 or 1	[E/F]	
1	14 Feb 2020	1	0	0	1	0.6	2.6
2	20 Feb 2020	1	1	1	0	0.6	3.6
3	26 Feb 2020	1	1	1	0	0.6	3.6
4	04 Mar 2020	1	0	1	1	0.8	3.8
5	09 Mar 2020	1	1	1	1	0.8	4.8
6	15 Mar 2020	1	1	0	1	0.8	4.8

5.2 Set In Order Rating:

Set in order is the second step of the 5S methodology. It deals with the proper arrangement of the tools, material, and processes [2].

Following are the Set-in order rating criterion.

(1) Inventory material arrangement:

Give '1' marks if all outsource material are arranged in its allocated place, if not then mark it '0'.

(2) Flow path of assembly is followed:

Give '1' marks if suggested assembly flow path is followed, if not then mark it '0'.

(3) Taking material for assembly:

In this process, labor comes to inventory for taking parts, which he will use for assembly. Let total 'B' number of parts is required for assembly. Where 'A' shows that out of total requirements how many parts he took from inventory.

Fraction of material took = [A/B].

(4) Tools sequencing Rating:

This shows that the consistency of the fulfillment of the requirement of the tools. Let 'C' be the numbers of tools irregular arrangement of tools, 'D' proper tool arrangement in sequence.

Fraction of consistency to tool arrangement: [C/D]

(5) Flow process of assembly is followed:

Give '1' marks if suggested assembly process flow is followed, if not then mark it '0'.

Table (5.2): Set In Order Rating

Sr. no.	**Durations**	**Inventory material Arrangement Rating**	**Flow path of assembly follow Rating**	**Taking material for assembly Rating**	**Tools sequencing Rating**	**Flow process of assembly is follow Rating**	**Total Rating**
		0 or 1	0 or 1	[A/B]	[C/D]	0 or 1	
1	14 Feb 2020	1	0	0.55	0.6	1	3.15
2	20 Feb 2020	1	0	0.55	0.6	0	2.15
3	26 Feb 2020	1	1	0.7	0.8	0	3.5
4	04 Mar 2020	1	1	0.7	0.8	1	4.5
5	09 Mar 2020	1	1	0.8	1	1	4.8
6	15 Mar 2020	1	1	0.8	1	1	4.8

5.3 Shine Rating:

Shine is the third step of the 5S methodology. It deals with the working environment of the shop floor with proper cleaning on the work space [2]. For that we allocated the rating in five criterions.

Following are the Set-in order rating criterion.

(1) Machine cleaning rating:

Give '1' marks if machine is cleaned after every set period of timing, if not then mark it '0'.

(2) Walk way cleaning rating:

Give '1' marks if walk way is cleaned during assembly, if not then mark it '0'.

(3) Working Environment:

Give '1' marks if air, water, washroom, lighting conditions are good, if not then mark it '0'.

(4) Cleaning Consistency rating:

Let total 'G' cleaning not on shop floor during every set period of timing. And 'H' for total set period of cleaning required. Fraction of cleaning consistency = [G/H].

(5) Safety from accidents rating:

Let total 'I' accidents occurs during auditing because of safety compromise. And 'J' for total number of safety norms created to require the accidents. Fraction of safety from accidents = [1-{I/J}]

Table (5.3): Shine Rating

Sr. no.	**Durations**	**Machine cleaning rating**	**Walk way cleaning rating**	**Working environ-ment**	**Cleaning Consistency rating**	**Safety from accidents rating**	**Total Rating**
		0 or 1	0 or 1	0 or 1	[G/H]	[1-{I/J}]	
1	14 Feb 2020	0	1	0	0.25	0.2	1.45
2	20 Feb 2020	0	1	0	0.5	0.4	1.9
3	26 Feb 2020	0	1	1	0.5	0.6	3.1
4	04 Mar 2020	1	1	1	0.75	0.6	4.35
5	09 Mar 2020	1	1	1	0.75	0.8	4.55
6	15 Mar 2020	1	1	1	0.75	0.8	4.55

5.4 Standardize Rating:

Standardize rating will be got by calculating the average of previous three 'S', because standards of any system will rise and fall by mean rate depending factors [2].

$$Standarize\ rating = \frac{\text{Sort} + \text{Set in order} + \text{Shine}}{3}$$

Table (5.4): Standardize Rating

Sr. no.	**Durations**	**Total Rating = [{S1 +S2 + S3}/3]**
1	14 Feb 2020	2.4
2	20 Feb 2020	2.55

3	26 Feb 2020	3.4
4	04 Mar 2020	4.21
5	09 Mar 2020	4.71
6	15 Mar 2020	4.71

5.5 Sustain Rating:

Sustain rating depends on the previous four 'S', because without that the regularity will not be maintained. Therefore, Sustain rate will be the average of previous four 'S' ratings [2]. By following the instructions accurately, we can maintain the machine condition at its peak level, which may help for better production and stay away from breakdown.

(1) Removing small faults through the aid of cleaning.

(2) Providing the execution of visual control.

(3) Providing the performance of protective activities.

(4) Granting the responsibility of the machine to the operator.

(5) Formation of a disciplined company.

Table (5.5): Sustain Rating

Sr. no.	**Durations**	**Total Rating = [{S1 +S2 + S3 +S4}/4]**
1	14 Feb 2020	2.4
2	20 Feb 2020	2.55
3	26 Feb 2020	3.4
4	04 Mar 2020	4.21
5	09 Mar 2020	4.71
6	15 Mar 2020	4.71

5.6 5S System Efficiency:

After implementing 5S, the immense changes in the industry have come. In the initial stage the efficiency was very less. However, week by week the numbers of system efficiency were rising gradually. Eventually, we achieved almost near to double efficiency of the initial one. The industry got many benefits after implementation, which clearly shows the successful implementation of 5S in the industry.

Table (5.6): 5s System Efficiency

Sr. no.	Durations	(S1+S2+S3+S4+S5)*100 / 25	Efficiency (%)
1	14 Feb 2020	(2.6+3.15+1.45+2.4+2.4)*100/25	48.00%
2	20 Feb 2020	(3.6+2.15+1.9+2.55+2.55)*100/25	51.00%
3	26 Feb 2020	(3.6+3.5+3.1+3.4+3.4)*100/25	68.00%
4	04 Mar 2020	(3.8+4.5+4.35+4.21+4.21)*100/25	84.28%
5	09 Mar 2020	(4.8+4.8+4.55+4.71+4.71)*100/25	94.28%
6	15 Mar 2020	(4.8+4.8+4.55+4.71+4.71)*100/25	94.28%

6. CONCLUSION

The 5S system implemented in this crane manufacturing industry is found to be adequate due to many benefits such as the wastes, scraps and losses were minimized, over production stocks were controlled with flexible work stations. The 5S is an effective management tool which can improve housekeeping, environmental conditions and health and safety standards.

SORT

- The materials or parts' finding time declined and it helped to make easy the material handling in the industry.
- Also due to sorting of all materials or parts, they are now easy to access and store in the inventory.
- Waste sorting improved the handling of waste material.
- Sorting of assembly processes and workers also improved the plant productivity.

SET IN ORDER

- Sequencing of the raw material/parts in inventory storage helped to minimize the time of decision of the worker.
- Set the order for the assembly operations of the product helped to shorten the unwanted activities.

SHINE

- By introducing Periodic Routine Method, the regular checking of objects is done. Also, the things like colors, containers and other wet things are periodically checked. Hence, the leaking can be avoided, and clean floor area is achieved.
- Now, after removal of the wastes and dust on the floor area, the working environment became positive inside the industry.

STANDARDIZATION

- Standardization of the flow of the assembly of the product is done. Due to that, we saved **27 minutes and 102 meter** travel distance of the gear hoist in total assembly timing and travel distance respectively and for gear box we saved **28 minutes of time and 45 meter** travel distance from total assembly of gear box.
- Siren and face scanners made the workers self-disciplinary. These objects made the workers to be on time and to do their respective work by maintaining the discipline in the industry.

SUSTAIN

- Workers are feeling motivated because of the standardized process and due to safety tags/banners, now they follow the safety rules. We organized the safety awareness programs one to one for workers, so that the workers were got aware about safety.
- Also, we ensured sustaining sorting, storage, and shining activities every day. For monitoring all the systems, we conducted the internal audits and the results are very satisfactory.
- Due to all this 5S practice, discipline in the process has been improved and workers are now also became disciplined.

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MALWARE ANALYSIS AND DETECTION USING MEMORY FORENSIC

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ABSTRACT

Malware harm to system, network, file-malware crime has used in cyber war , isolated malware depends on its symptoms ,and using malware cyber war has happened that depends on malware symptoms. After malware crime we could investigate malware footprint in memory such as advanced malware ,it's malware investigate using memory forensic via live and dead .if we could investigate malware in RAM and cache then live forensic and if we could find malware from hard disk. Then it is called dead forensics. Such a malware apt.rootkit, key- logger it is footprint we can Found Depends os we could find differ malware. There are four techniques of malware analysis: static malware analysis, dynamic malware analysis, advance static malware analysis, and advance dynamic malware analysis. After malware crime using memory but we could investigate malware footprint in memory depend on malware artifacts. Which has found only memory not anywhere in system such as a using file, network, client, server, application.

Keyword: Linux and Parrot OS, RAT Trojan Malware (Linux Malware) latest malware, live and dead forensics of memory.

1. INTRODUCTION

Malicious + Software = Malware, Malware Analysis and Memory forensic Have become a must have skill for fighting advanced malware, targeted attack, and security breaches. But what information has been stolen, how will this hurt to Business and this will only possible by investigation and forensics. A lot these answers might only be found through malware analysis and memory forensics. This forensics is used by security analysis to investigation sophisticated malware such as a root kit. Malware is harm to system, network, server, client, and file. While cyber warfare among countries has focused on Windows operating system so far, modern APT such as an advanced malware also aims at Mac OS X and other os also, Mac OS becomes no longer safe zone. Depends on malware or for symptoms of malware check we can use analysis tools using analysis all four techniques in analysis but after malware crime investigate malware footprint, but we could not found in system ,network and using file. Some advanced malware such as key logger ,apt, advanced persistent threat ,rootkit, we can found such malware footprint in memory if we could found in ram or cache then live forensic and if found

from hard disk then it' call dead forensic using differ OS such as Mac OS, parrot OS, windows, android, iOS, kali, cyber hawk, black-box.

2. OBJECTIVES

While we will do investigate after crime has happened and find malware footprint from memory not analysis only, it means memory forensic live as well dead both. With latest malware 2019 depends on os memory resident malware.

There are several types of malware:

- APT : advanced persistence threat
- key logger : data capture from key board
- rootkit : unauthorized access in kernel or memory and gather information
- adware : from advertisement gather information
- fileless : memory residence Malware
- downloader : from download link malware download and gather information
- spyware : replicate and gather information from victim
- RAT : remote access Trojan

There are four malware techniques to analysis of malware:

- Static analysis: via API calls static analysis has been done via API calls
- Dynamic analysis: via function calls dynamic analysis has been done.
- advanced static malware analysis: disassembler
- advanced dynamic malware analysis : Debugging

3. RESEARCHMETHODOLOGY

Which has malware find in memory it means symptoms of malware I have been take and take differ os parrot and compare between live and dead forensic with latest malware2019.

Which has malware find in memory it means symptoms of malware we will take and take differ os parrot and compare between live and dead forensic with latest malware2019.

Malware analysis using memory forensic, which has malware effect to memory cause all types of malware not effect to memory and we will take differ os parrot os with latest malware either 2019 or 2020. and compare between live and dead forensic using differ tool such as Lime and volatility.

Step 1: install free sweep game and make remote trojan access RAT and generate payload via meta sploit tool.

Step 2: using meta sploit tool and generate payload and spread malware to internet.

Step 3: gather information from victim system.

Step 4: live and dead forensics via time tool, volatility, wireshark.

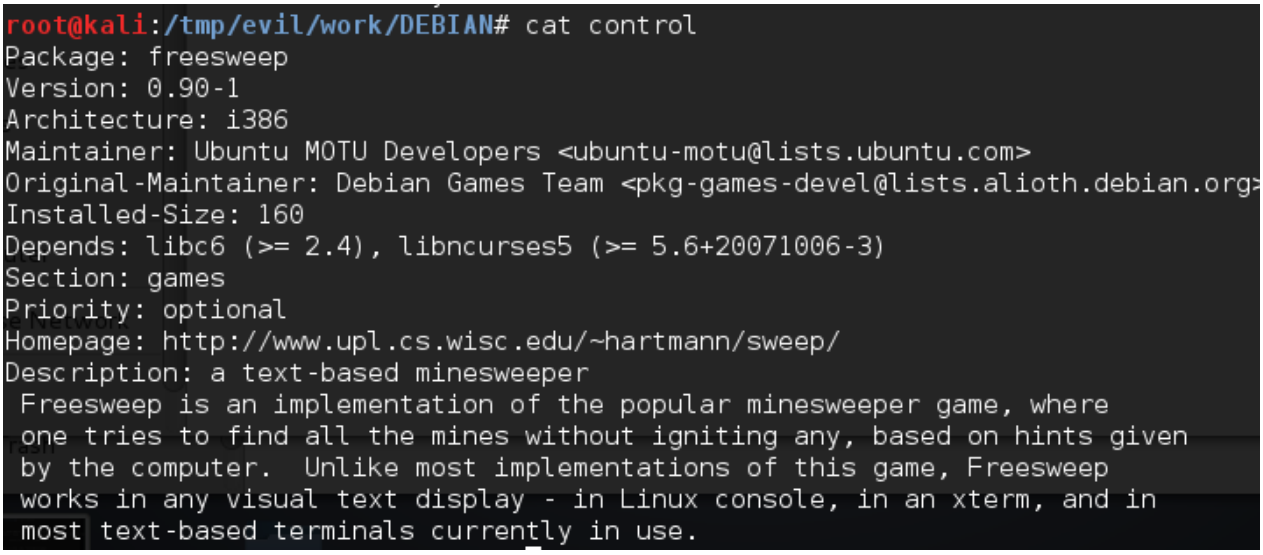

Figure 1: install game

```
root@kali:/tmp/evil/work/DEBIAN# cat postinst
#! /bin/sh
# postinst script for freesweep

set -e

scores=/var/games/sweeptimes
if [ ! -e $scores ] ; then
  touch $scores
  chown root:games $scores
  chmod 0664 $scores
fi

# Automatically added by dh_installmenu
if [ "$1" = "configure" ] && [ -x "`which update-menus 2>/dev/null`" ]; then
        update-menus
fi
# End automatically added section


exit 0
```

Figure 2: Postinst

Figure 3.3: generate payload

```
root@kali:~# msfvenom -a x86 --platform linux -p linux/x86/shell/reverse_tcp LHO
ST=172.21.42.106 LPORT=443 -b "\x00" -f elf -o /tmp/evil/work/usr/games/freeswee
p_scores
Found 10 compatible encoders
Attempting to encode payload with 1 iterations of x86/shikata_ga_nai
x86/shikata_ga_nai succeeded with size 98 (iteration=0)
x86/shikata_ga_nai chosen with final size 98
Payload size: 98 bytes
Saved as: /tmp/evil/work/usr/games/freesweep_scores
```

Figure 3.4: start reverse handler

```
root@kali:/# msfconsole -q -x "use exploit/multi/handler;set payload linux/x86/s
hell/reverse_tcp;set LHOST 172.21.42.106;set LPORT 443;run;exit -y"
[-] Failed to connect to the database: could not connect to server: Connection r
efused
        Is the server running on host "localhost" (::1) and accepting
        TCP/IP connections on port 5432?
could not connect to server: Connection refused
        Is the server running on host "localhost" (127.0.0.1) and accepting
        TCP/IP connections on port 5432?

payload => linux/x86/shell/reverse_tcp
LHOST => 172.21.42.106
LPORT => 443
[*] Started reverse handler on 172.21.42.106:443
[*] Starting the payload handler...
```

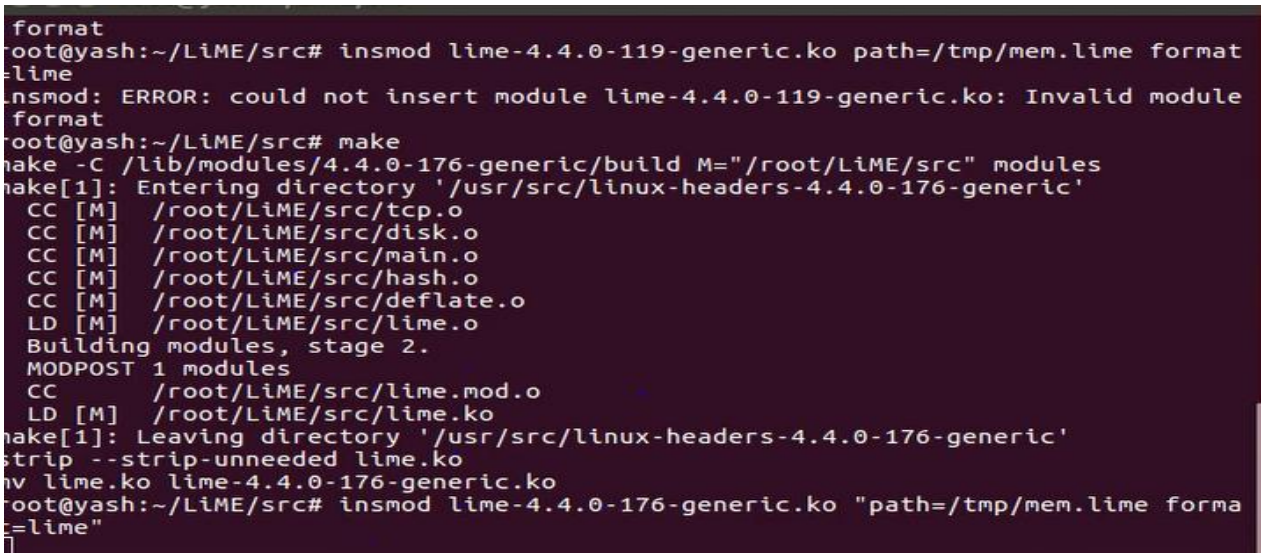

Figure 3.4: Memory Forensics using LiME tool

Malware Forensics:

We could analysis of malware via machine learning, forensics, and four malware analysis techniques.

Here we have did via forensics from memory live and dead forensics. If we have did gather data from RAM or cache, it is live forensics because data temporarily stored in RAM and cache. If we have did gather information from hard disk, then it is dead forensics. Because all the information stored in hard disk. And it is all about called artifacts of memory.

Investigation and find evidence

- Memory forensic: live and dead.
- Live forensic: Cache and RAM
- Dead forensic: Hard disk

Malware enter via source:

- File: exe file,.dll file, .bat file
- application and software: malicious code
- network through: Ransomware, adware downloader
- google forms, google link

4. LITERATUREREVIEW

4.1 Detect mac objective-C malware using memory forensics:

In this Paper forensic tool use Mac OS and detect objective -c malware for Mac OS malware analysis using memory forensic using volatility tool. So, in this they had detected Objective c detective malware. Objective malware is sophisticated malware. Using APIs, they had did active malicious

activity and gather information using sophisticated malware. And using Forensic tool volatility in Mac OS analysis and detect malware and criminal how crime had did that investigate.

4.2 Advanced Malware Analysis through Memory Forensic Technique:

Static analysis method has been complex method. Here in this paper use windows OS Here use static analysis and dynamic analysis and memory forensic all three method use in this paper. They have taken 200 malware samples. They have shown malware 40 malware Out of 200. VM ware, Virtual Box, Cuckoo sandbox, Volatility tool, IDA pro, Wireshark, Virus Total are the required tool for analysis. Some tool volatility for forensic purpose, Ida pro is for static analysis tool use, cuckoo sandbox is use for dynamic analysis. Many malware Trojan, RAT, Ransomware.

4.3 GPU-assisted malware effect using memory forensics:

In this paper GPU effect malware use. Here in this paper GPU-assisted malware detect. GPU assisted malware Symptoms to perform malicious activity and still information. They had used lime tool for forensic. Here window OS used and for forensic anti – forensic techniques use. GPU driver manage the kernel. Here they had never considered either malicious hardware or code JUST modified of the graphics card's Firmware.

4.4 AUMFOR: Automated Memory Forensics for Malware Analysis:

In this paper use AUMFOR is GUI memory forensic tool. Here they had did forensic in volatile memory RAM or cache that is why here used live forensic. AUMFOR tool is used for window and Linux OS. Here they had developed AUMFOR tool based on python language. Volatility tool is for live forensic OS malware memory forensic. This tool has benefit is no need commands. AUMFOR - Automated Memory Forensic tool is use for forensic investigator by performing all work itself.

4.5 Automated malware detection using artefacts in Forensic memory images:

Here in this paper cuckoo sandbox is use for automatic malware analysis. Using registry, APIs call, DLLS. Machine learning also use. Here they have taken memory dump. They have detected malware automatically Using CuckooSandbox.

4.6 Malware Detect using Artifacts of Memory dump and Dynamic Analysis:

Here in this paper for malware analysis using dynamic malware analysis. Using volatility tool and cuckoo sandbox they have detected and analysis of malware with machine learning. Using API call, DLL, Registry feature they have detected Malware. Adware, Ransom ware, Key logger, Downloader and Backdoor such malware found.

4.7 Android Malware Analysis Based On Memory Forensics:

In this paper they have taken android malware dynamic analysis and memory forensic techniques. They have found malicious malware using Trojan application such as backdoor. In this paper APKANALYZER is used for memory forensic tool for android. Ukatemi SHIELD is for analysis purpose of Android application. They are use Lime tool for capture memory images.

4.8 Review of Mobile Malware Forensic:

Here in this paper take mobile device for analysis of malware. Here they have taken mobile device for analysis of malware using forensic. Android and IOS mobile used for mobile forensics. Malware such as backdoor, viruses, worms, Trojans and spyware, botnet. They have taken Open Source Android Forensics (OSAF) tool for mobile forensic. They have OSAF tool for taken malware investigate with android application.

4.9 Rootkit detection using memory forensics:

MASHKA is physical tool used for rootkit detection. Malware Analysis System for Hidden Knotty Anomalies (MASHKA) is used for forensic purpose and this tool is anti-forensics tool. In this paper how to detect kernel level rootkit from the memory and also analysis of anti-root kit tools. Here in this paper they have taken window OS. They have taken Volatile memory dump it means live forensics.

4.10 Malware Analysis survey using Static, Dynamic, Hybrid and Memory Analysis:

Here in this paper they have used static malware analysis, dynamic malware analysis and analysis of memory .They have taken several malware such as virus, worms, Trojan, spyware, root kit, ransom ware, adware, botnet. In this paper they have taken static analysis using API calls, opcode and in dynamic analysis using function call and function parameter. And memory analysis using memory analysis using DLL, Registry key, and network connection. In this paper they have used two type of malware detection method one is the signature-based detection and second is Heuristic-based Detection.

4.11 Smartphone Volatile live Memory forensics:

Here in this paper they have taken mobile device IOS and Android. And they have done live forensic in volatile memory. They had taken This all are parameter such as a Contacts list, emails, messages, downloaded confidential documents from email attachment via malware of mobile android and IOS mobile. They have done comparison between android and IOS Device with raw volatile memory it is live forensic.

4.12 Malware analysis using Memory forensic via virtual machine introspection tool:

In this paper VM Introspection Tool is used for forensics. Using this tool, they had done Forensic. This tool is used for both live forensic and dead forensic of malware. Due to malware cyber-attack Happened therefore they has developed tool for forensic purpose. First, they had run vulnerable software and run malware exploit and write to memory and target to VM. Third task is read to memory VM. And last one is run to tools for observation of Event.

4.13 Detection Automatic Analysis and identify using Malware Processes in Forensics via DLLs.

In This paper they had done forensic using DLL dynamic link Libraries .malware forensic collect evidence and data recovery using Volatility tool. In this paper they had recovered how to restore processes, system registry, network Information and files that all the information Recovered from memory. Cause forensics it means live and dead forensics and investigate, find evidence, recovered data this all are we have to check while we will forensics.

4.14 Detecting Malware and Root kit via Memory Forensics

In this paper they had taken malware and rootkit for detection. That malware is effect to memory. And steal information of victim. They had used VMI Virtual machine introspection. VMI system is used for detecting hidden process.

4.15 Formality: Automated Forensic Malware Analysis using volatility:

Here in this paper they had taken volatility tool for investigate using memory forensic. And they had investigated in RAM memory its live forensic .in this paper for steal information they had inject

ransomware, and botnet. They had taken RAM Dump form RAM Memory that was live forensics.in this paper they had taken 5 various malware samples.

5.ANALYSISPART

Table 1: ANALYSIS

Basic Static analysis	Basic dynamic analysis	Advance static analysis	Advance dynamic analysis	Forensics
API CALLS Opcode	Function call Function parameter Information traces	Disassembler using IDA Analysis of the linked libraries	Debugging Analysis on registry	DLL Registry Network connection.
PEview PEid Md5deep Virus total	COMODO ANUBIS Virtual box	Bintext Ida pro	OlldbgRegshot	Volatility Lime GRR Remnux

6. FINDINGS

Using static and dynamic tool we could not did forensic, for forensic we should be take differ tool such as volatility, Lime tool, GRR for live and dead forensic. And also find latest malware depends on os.cause depends on OS. We could find malware according to malware symptoms. And also check which malware effect to in memory is. And we will find evidence from memory. Here there are some tools for forensics purpose:

- Meta sploit tool

  Here we have used meta-sploit tool to generate payload and spread malware into internet and gather information from victim.

- lime tool

  It is use for live forensics. This tool is use for live forensics.

- volatility tool

  It is use for forensics purpose, but this tool is convert into readable format.

- wireshark tool

  This tool is use for also forensics purpose.

  Two techniques for gather information from kernel and memory via rootkit

There are two techniques of hooking:

- IAT hooking
  Malware harm to system using two techniques (1) IAT hooking and (2) inline hooking.

- Inline hooking:
  They both techniques IAT and inline hooking use gather data from kernel and memory.

Table 6.1: FINDINGS PARAMETERS

Sr. No.	OS	Malware analysis techniques	Techniques for malware detection	Analysis tool	Forensics tool
1	Window	Static malware analysis	machine learning	IDA Pro	Lime
2	MAC	Dynamic malware analysis	forensics	Cuckoo sand box.	Volatility
3	IoS	Dynamic malware analysis	Via four Malware analysis techniques	PEid	Wireshark
4	Android	Static malware analysis		PEview	
5	Linux				
6	Parrot				

6.2 Diagram of Malware Analysis using memory Forensics:

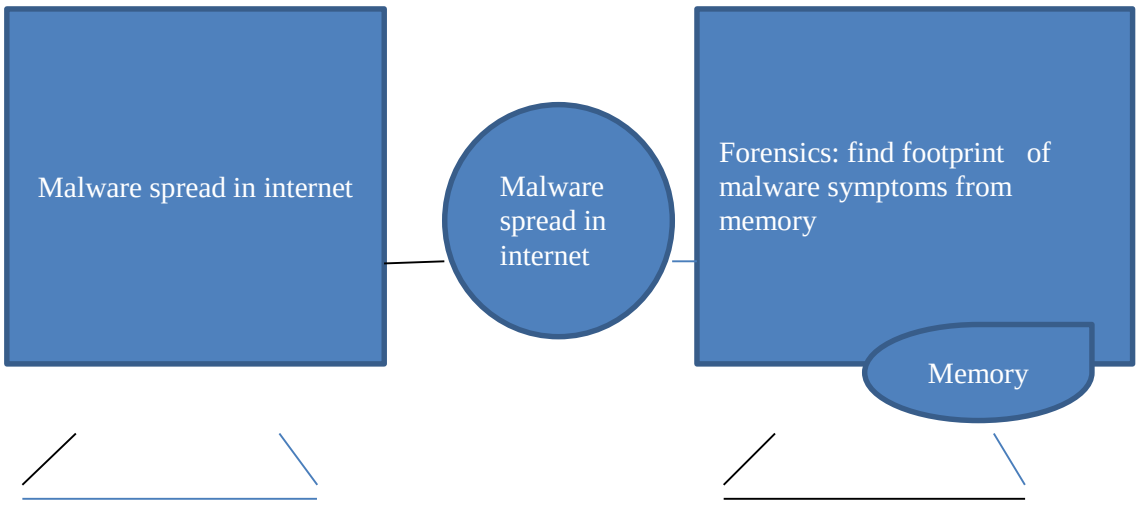

Figure 6.2 : how to malware spread in internet and Forensics via memory

7. CONCLUSION:

We have conclude we can find malware in memory but after attack and crime and we can find malware evidence and footprint in memory-investigation(memory forensic)-via using different method and tool of malware analysis and memory forensic for both and use different os for research work.

Via malware crime it would be not possible to recover the data. So, via malware crime not possible to recovery. May be some time it will possibly find other techniques and find tools .via modern anti -techniques perhaps it will possible to recovery data. And use Apple brand OS such a MAC and IOS OS for further research work. And take latest malware.

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COPARATIVE STUDY OF DIAGRID SYSTEM, HEXAGRID SYSTEM AND SHEAR WALL SYSTEM IN TALL TUBE-TYPE BUILDING

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ABSTRACT

In this paper consistent floor plan of 36 m x 36 m located in seismic zone V for G+49 storey tall building is considered, and all physical members are planned as per IS 456:2000. Earthquake factors are measured from 1893-2002. Dead & live loads are mentioned as per Indian Standards. Here, analysis of diagrid and hexagrid system will be directed by using design software STAAD Pro. Twelve models are modelled in staad.pro collectively of corner shear wall, core shear wall, diagrid system and hexagrid system buildings with regard to variation in their combination of exterior structural system and internal structural system. Both dynamic (Response spectrum analysis) and static analysis of these models have been conceded out to regulate their performance. The model so prepared is been compared to the normal building parameters like Storey displacement, Storey drift, base Shear and bending moment to determine the efficient structure.

Keywords-- Shear wall, diagrid, hexagrid, tall tube building

1 INTRODUCTION

1.1 General

Emporis standards

- Buildings height between 35-100 meter is termed as multi-storey building.
- Buildings higher than 100m is termed as skyscraper building.
- Buildings 300m or higher is termed as super tall building.
- Buildings 600m or taller is termed as mega-tall building.

High rise buildings are more popular in these days due to following reasons

- scarcity of land
- increasing demand for business and residential
- economic growth
- technological advancement
- innovations in structural systems

- desire for aesthetics in urban settings
- cultural significance and prestige
- human aspiration to build higher
- to make denser city and
- to reduce the transmission losses of energy

1.2 Lateral Load Resisting System for Tall Buildings

1.2.1 Introduction

Taller buildings demanded by socio-economic trends, structural engineers were pressed to provide lateral load resisting systems that would cut off cost of structural and reinforcing steel for buildings of greater height to width aspect ratios and different vertical heights.

Structural Engineers may use concepts in order to control building response to lateral loading, which are as follows:-

1. By Increase stiffness of the system
2. By Increase building weight
3. By Increase density of the structure with fill-ins
4. By Use of efficient shapes
5. By Generate additional damping forces (tuned mass dampers)

1.2.2 Classification

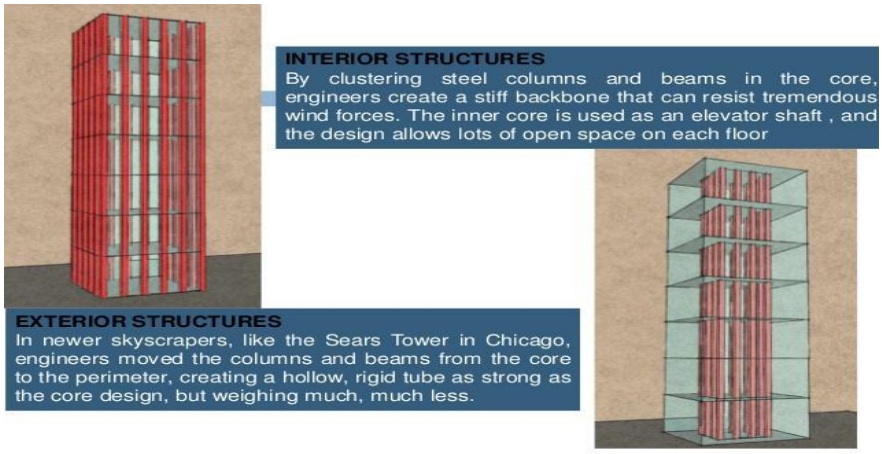
Lateral load resisting system is broadly classified as

(A) Interior Structural Systems

(B) Exterior Structural System

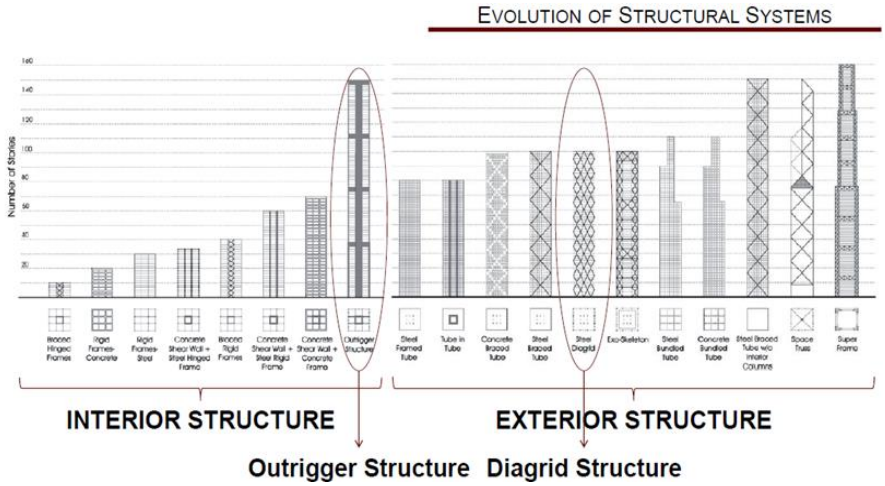
A system is classified as an interior structure in which the major part of the lateral load resisting system is detect in the interior of the building in the same way, if the vital part of the lateral load resisting system is detect at the building perimeter, a system is classified as an exterior structure. In interior structure, components of the lateral load resisting system are at the exterior face of the building perimeter. In exterior structure components of the lateral load resisting system is within the interior of the building to oppose gravitational load

Figure 1 Lateral load resisting systems



Source: from Wikipedia

Figure 2 Evolution of structure system

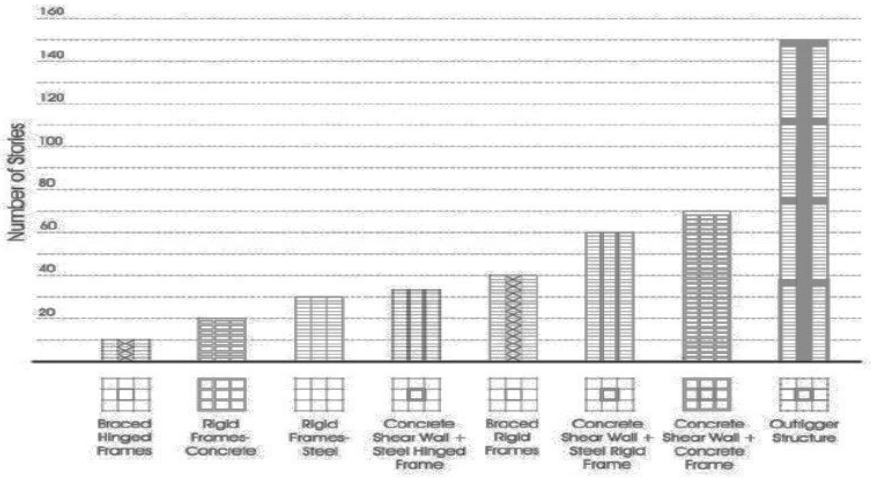


Source: From Wikipedia

1.2.3 Interior Structural System

The two basic types of lateral load-resisting systems are the moment-resisting frames and shear trusses/shear walls. These systems are commonly arranged as planar assemblies in two principal orthogonal directions and may be take on together as a combined system in which they interact. Another very important system in this category is the core supported outrigger structure, which is very extensively used for super tall buildings. The MRFs consists the horizontal and vertical members rigidly connected together in form of a grid. Moment-resisting frames can be located in or around the core, on the exterior, and the across the interior of the building with grid lines.

Figure 3 Interior structure systems

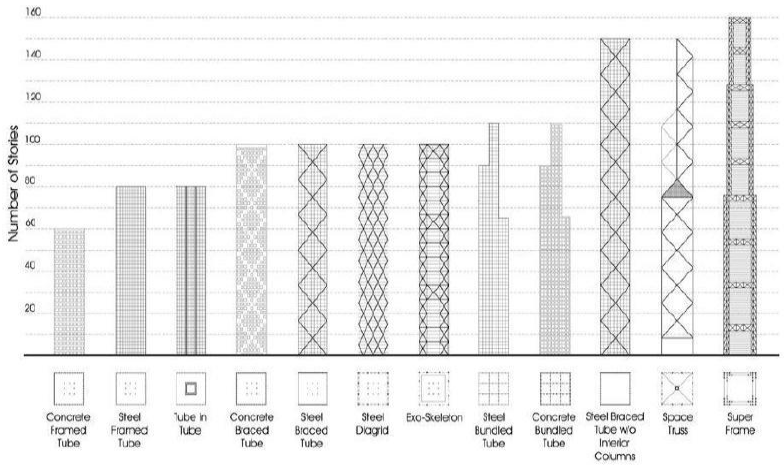


Source: from Wikipedia

1.2.4 Exterior Structure System

The tube structure is one of the most typical exterior structure, which can be defined as a three-dimensional structural system utilizes the perimeter of the entire building to resist lateral loads. The earlier application of the tubular notion is associated to Fazlur Khan, who came up with this concept in 1961, and the first known building was designed as a framed tube. By using this concept world's tallest buildings are the the 110-storey World Trade Centre Towers (destroyed in 2001 by a terrorist attack) in New York and 110-storey Sears Tower. Tubular forms have many types based on the structural efficiency that they can provide of several heights.

Figure-4 Exterior structure systems

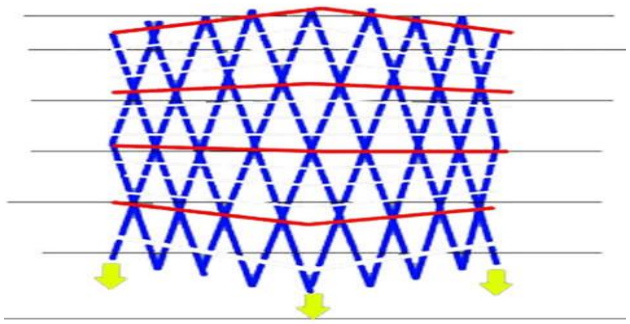


Source: from Wikipedia

1.2.5 Diagrid Structure

Diagrid is a form of space truss. It contains of perimeter grid made up of a chain of triangulated truss system. Diagrid is placid by crisscrossing the diagonal and horizontal members. Diagrid has good look and it is recognizable from far. For less obstruction to the elevation it is necessary to the diagrid system is lessen the number of vertical column as well as horizontal column and rises the diagonal members on the aspect of the buildings. Perimeter "diagrid" system reduce the 20 percent of the structural steel weight related to other structure.

Figure 5 Diagrid system

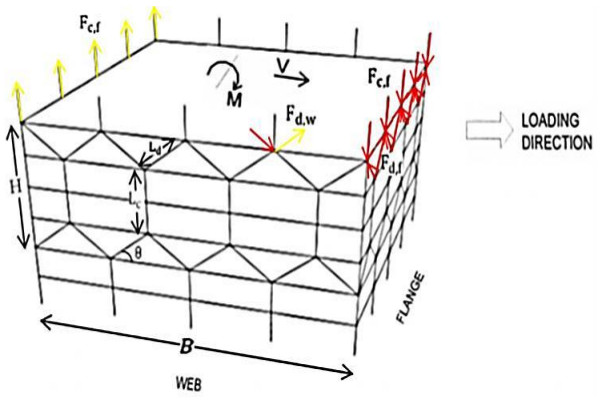


Source: from Wikipedia

1.2.6 Hexagrid Structure

In hexagrid structural system, all the vertical columns are reserved. Hexagrid structural system is mostly of two type vertical hexageid system and horizontal hexagrid system. It will be designed of Hexagon which is a group of hex-angulated truss system. Hexagrid is accumulated by crisscrossing the diagonal and horizontal members.

Figure 6 Hexagrid Structural system



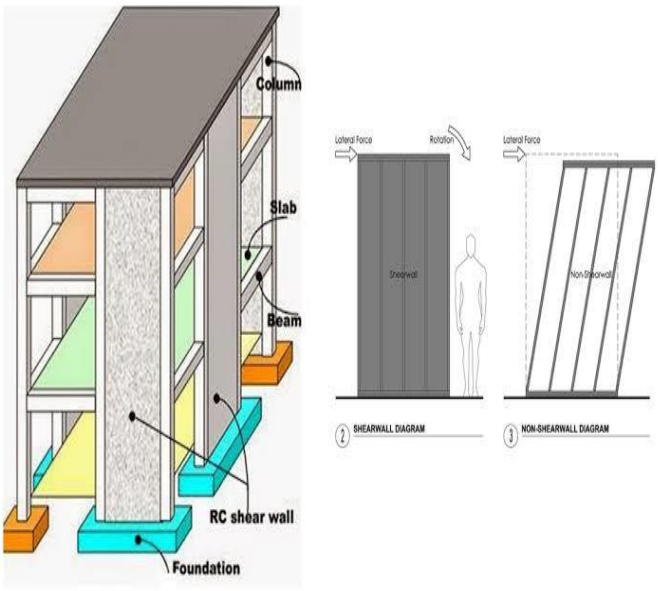
Source: from Wikipedia

1.2.7 Shear Wall Structural System

Shear wall is a structural member which is used against lateral forces i.e. parallel to the plane of the wall. By the Cantilever Action Shear wall resists the loads where the bending deformation is more.

Lateral forces from exterior walls, floors, and roofs to the foundation in a direction parallel to their planes is transfer by rigid vertical diaphragm. I.e. RC wall. Shear walls are plane or flanged in section and core walls are of channel sections. To resist lateral displacements, they also provide enough strength and stiffness.

Figure 7 Shear wall



Source: from Wikipedia

2 OBJECTIVE OF STUDY

- The main objective of this study is to understand the analysis and design methodology of new concept diagrid structural system and hexagrid structural system. .
- Analysis of building frames considering seismic analysis.
- To carry out assessment on a tall tube type structure models with Shear wall, diagrid and hexagrid system for well presentation.
- The performance of the structure is considered based on the storey displacement, storey drift, base shear and bending moment.

3 LITERATURE REVIEW

Lots of research work is carried out in diagrid structure. Some important works are mentioned here such as 1) Introductory design of tall building structures with an exterior structure system, 2) A Study on the Seismic Presentation of exterior structure system Hexagrid System with Diverse Patterns, 3) Relative Study of two exterior structure system Pentagrid and Hexagrid System for Tall Building, 4) Relative Study of Diagrid Constructions over Braced tube Structures. In this above researches comparison of building data of diagrid, hexagrid / pentagrid etc. structural system with different shear wall location are not studied so I do this study. The brief description of these works are described below.

Farhan Danish obtainable Initial design of tall building structures with a hexagrid system by stiffness method. Study and design of 60 storey building has been modelled in MIDAS a commercial finite element software. Hexagrid system is designed for varying size and type. Based on the above design studies, it is suggested that to use a vertical hexagrid system structure for the reason is a vertical hexagrid system was stiffer than a horizontal hexagrid system and hexagrid structural system is more reasonable and provide conflict to lateral forces.

Mobi RIA Mathew presented) A Study on the Seismic Presentation of exterior structure system Hexagrid System with Diverse Patterns. They concluded at the end for 36-storey hexagrid structures, which briefly described below. In this study the building of 1296 sq. m. with storey height 3.6 m. is modelled In ETAB. In hexagrid structural system the angle is 1200. Comparing the performance of hexagrid structural system with different patterns. From calculation results, it is indicated that Storey drift for all structure models are in the permissible limits and decreased hexagrid density increases the storey drift and storey displacement.

Relative Study of two exterior structure system Pentagrid and Hexagrid System for Tall Building: This paper focus on the comparison of pentagrid and hexagrid systems behaviour in tall diagrid Building. Taranath S. D considered for the analysis tall buildings of 40, 50 and 60 floors. From calculation results, it is indicated that Pentagrid system is more efficient than Hexagrid system.

Comparative Study of Diagrid Structures over Braced tube Structures: Arpitha L M presented a paper on the models of diagrid system and braced tube systems ware compared for result like the maximum storey displacement, store drift, base shear, and time period. Analysis result shows that the model braced structures is stiffer than the diagram structures since the columns are provided in periphery. The hexagonal plan structure is stiffer and due to square plan displacement is higher and displacement due to hexagonal plan is less and due to square plan base shear is higher

4 METHODOLOGY OF WORK

4.1 Static Analysis

1. Equivalent static load method

Static analysis is an engineering branch which studies the stress in materials and structures subjected to static or dynamic forces or loads. The objective of the analysis is generally to determine whether the collection of elements, usually referred to as a structure or component, can safely withstand the specified forces and loads.

This is possible when the defined stress from the applied force is less than the yield strength and the material is to be able to withstand. This relationship referred as factor of safety (FOS) and is used as an indicator of success or failure of the analysis.

4.2 Dynamic Analysis

1. Response spectrum method

"Response spectrum is defined as the study of the maximum response of single degree of freedom that have a certain period and damping during seismic ground motion". Response Spectrum analysis should be done to attain the design seismic force. It is required to have a time history record to perform the seismic analysis and design of a structure built at a particular location. Further, as the response of the structure depends on the frequency content of the ground motion and its dynamic properties, the seismic analysis of structures cannot be carried out that depends on the ground acceleration's peak value. To overcome these difficulties, the most popular method is response spectrum in the seismic analysis of structures. In the prediction of displacements and member forces in structural systems, this method has computational advantages in using the response spectrum method for seismic analysis.

4.3 Methodology adopted in Present work

In this present comparative study, the analysis of following structures is been carried out:

1. Normal building.
2. Only core shear wall building.
3. Only corner shear wall building.
4. With core shear wall and with corner shear wall building.
5. Only diagrid system building.
6. With core-with corner shear wall diagrid system building.
7. With core-without corner shear wall diagrid system building.
8. With corner-without core shear wall diagrid system building.
9. Only hexagrid building.
10. With core-with corner shear wall hexagrid system building.
11. With core-without corner shear wall hexagrid system building.
12. With corner-without core shear wall hexagrid system building.

The plan areas of all structures are same through the analysis, also the beam and column dimensions are kept constant.

The value such as beam column size, hexagrid-diagrid size, Density of rcc, Density of masonry, Young's modulus, compressive strength of steel and concrete etc. are kept constant in all buildings.

For same structure data and earthquake data 12 models are analysis by static and dynamic analysis.

The results parameters include the maximum displacement, maximum drift, and maximum storey shear.etc. Which are to be compared.

4.4 Modelling

The research work consists of hypothetical models of tall tube structures. The work consists of 12 models and which includes normal building, diagrid system, hexagrid system, core shear wall and corner shear wall structure.

4.5 Modelling Data

The following data is taken for the research work:

- Number of stories: 50 storey
- Plan: 36m x36m
- Seismic zone: V
- Floor height: 3 m
- Grade of concrete: 30 Mpa
- Grade of steel: Fe 415
- Size of columns: 900 mm x 900 mm
- Size of beams: 450 mm x 800 mm
- Wall thickness:230 mm
- Response reduction factor: 5
- Type of soil: Medium soi
- Depth of slab: 150 mm
- Diagrid:650 mm x 650 mm
- Hexagrid:300 mm x 300 mm
- Dead load: 17.25 KN/m²
- Live load: 3.75 KN/m
- Floor finish: 1 KN/m²
- Angel of diagrid / hexagrid:65
- Zone factor: 0.36
- Importance factor: 1
- Damping ratio: 0.05

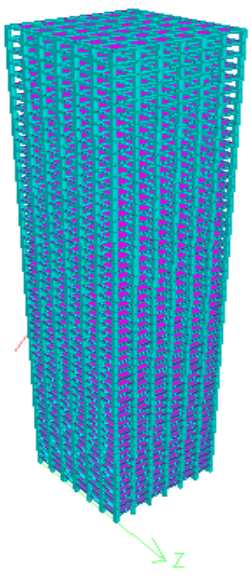
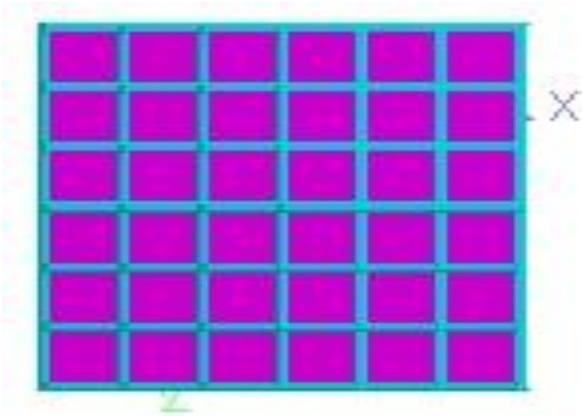


Figure 8 Hypothetical model



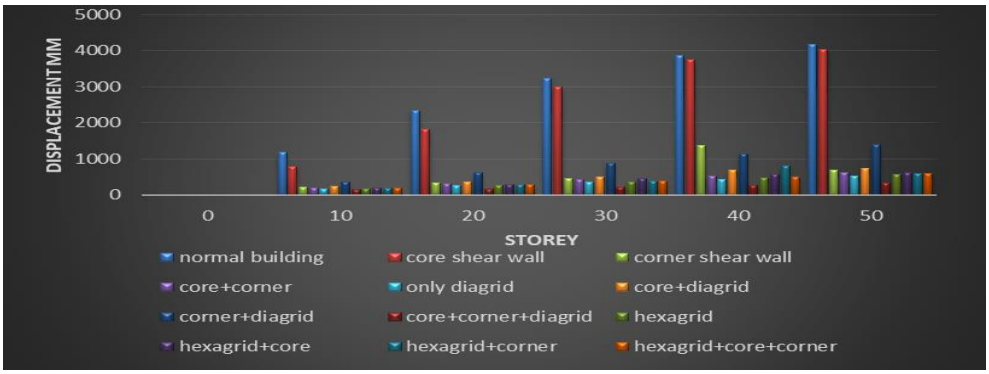
5 ANALYSIS AND RESULTS

Table: 1 Comparison of Displacement Results

Displacement (mm)	**Storey**	0	10	20	30	40	50
	Normal building	0	1182	2340	3240	3858	4178
	Core shear wall	0	790	1830	2990	3750	4041
	Corner shear wall	0	219	337	456	1363	682
	Core +Corner	0	200	308	417	526	624
	Only diagrid	0	166	257	347	437	528
	Core+ Diagrid	0	239	369	499	693	746
	Corner+ Diagrid	0	356	616	876	1136	1396
	Core+ Corner+ Diagrid	0	157	161	218	275	332
	Hexagrid	0	176	272	368	464	560
	Hexagrid+ Core	0	196	289	456	569	607
	Hexagrid+ Corner	0	186	287	388	815	590
	Hexagrid+ Core+ Corner	0	185	286	387	488	589

Source: from the analysis

Graph: 1 Comparison of Displacement



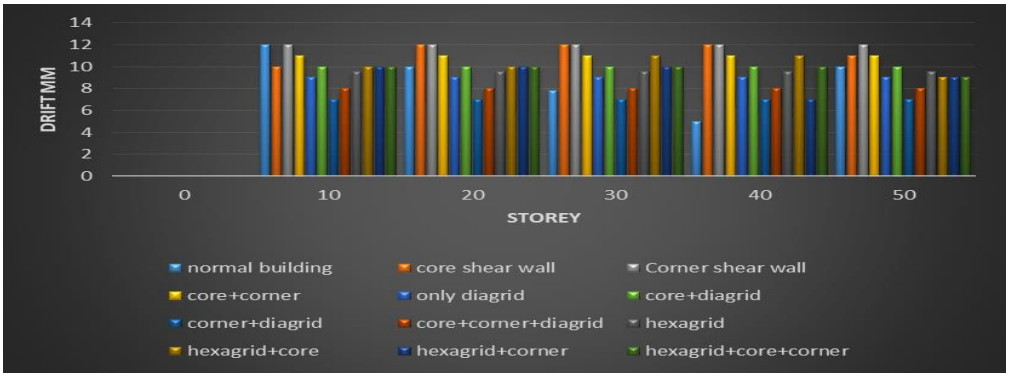
Source: from the analysis

Table: 2 Comparison of Drift Results

	Storey	0	10	20	30	40	50
	Normal building	0	12	10	7.8	5	10
	Core shear wall	0	10	12	12	12	11
	Corner shear wall	0	12	12	12	12	12
	Core +Corner	0	11	11	11	11	11
	Only diagrid	0	9	9	9	9	9
	Core+ Diagrid	0	10	10	10	10	10
	Corner+ Diagrid	0	7	7	7	7	7
	Core+Corner+ Diagrid	0	8	8	8	8	8
	Hexagrid	0	9.5	9.5	9.5	9.5	9.5
Drift (mm)	**Hexagrid+ Core**	0	10	10	11	11	9
	Hexagrid+ Corner	0	10	10	10	7	9
	Hexagrid+Core+Cornr	0	10	10	10	10	9

Source: from the analysis

Graph: 2 Comparison of Storey Drift



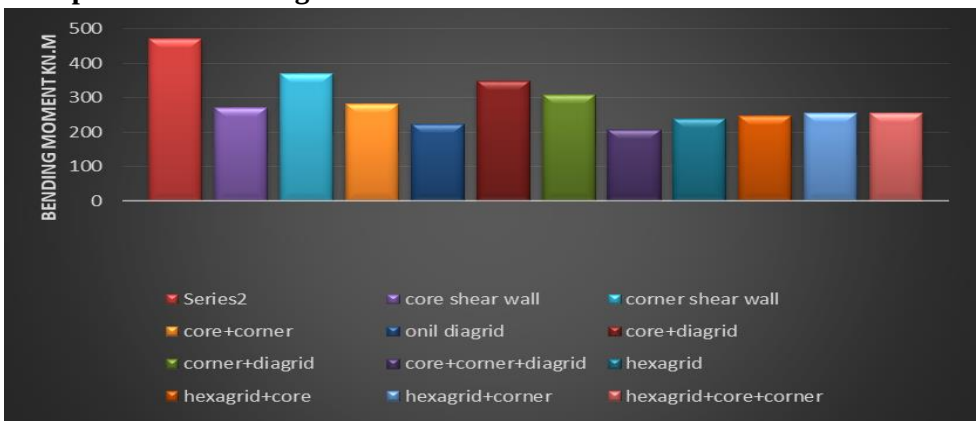
Source: from the analysis

Table: 3 Comparison of Bending Moment Results

Bending moment (KN. m)	
Direction	**X**
Normal building	471
Core shear wall	271
Corner shear wall	371
Core +Corner	281
Only diagrid	224
Core + Diagrid	349
Corner + Diagrid	310
Core+ Corner+ Diagrid	207
Hexagrid	240
Hexagrid+ Core	247
Hexagrid+ Corner	256
Hexagrid+ Core+ Corner	256

Source: from the analysis

Graph: 3 Comparison of Bending Moment



Source: from the analysis

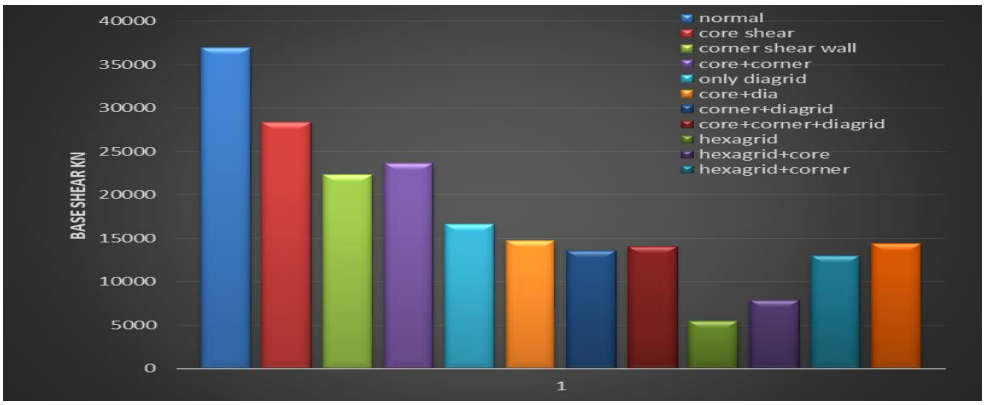
Table: 4 Comparison of Base Shear Results

Base shear (KN)	
Normal building	37000
Core shear wall	28405
Corner shear wall	22317
Core +Corner	23629
Only diagrid	16627

Core+ Diagrid	14783
Corner+ Diagrid	13588
Core+ Corner+ Diagrid	14096
Hexagrid	5498
Hexagrid+ Core	7871
Hexagrid+ Corner	13002
Hexagrid+ Core+ Corner	14448

Source: from the analysis

Graph: 4 Comparison of Base Shear



Source: from the analysis

6 CONCLUSIONS

1) Comparison of storey displacement:

The values from static and response spectrum method analysis displacement for normal building is 92 % more than the core + corner + diagrid model building. In Diagrid and hexagrid model's displacement is less as compare to normal building. So, diagrid and hexagrid system is good in storey displacement.

2) Comparison of storey drift:

The values of storey drift from the analysis in corner shear wall model is 41% more than the corner + diagrid model. Storey drift of Diagrid and hexagrid model is less than the normal building and shear wall buildings model. So, diagrid and hexagrid system is good in storey drift.

3) Comparison of bending moment:

In core + corner +diagrid building bending moment is less and high in normal building. Bending moment is 56 % more in normal building. So, diagrid and hexagrid system is good in bending moment.

4) Comparison of base shear:

Base shear in normal building is 79 % more than the hexagrid building model. Diagrid and hexagrid building model have less base shear so diagrid and hexagrid building modal is good in base shear. So, diagrid and hexagrid system is good in base shear.

- Comparison of diagrid-hexagrid building and normal building are shows that diagrid and hexagrid building has less displacement, less storey drift, less bending moment, and base shear in seismic analysis.
- Diagrid and hexagrid structure comparison to normal building provide more aesthetic look it becomes important for tall structure.
- So, from result comparison with normal building, one can adopt diagrid and hexagrid structure for better lateral and gravitational load resistance.
- So, from the results and conclusions final conclusion is diagrid system and hexagrid system is good for tall tube type RC building.

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DEVELOPMENT AND VALIDATION OF A BIOANALYTICAL METHOD FOR DETERMINATION OF SILYMARIN IN PLASMA

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ABSTRACT

Silymarin is the active component of milk thistle plant which is a standardized extract consisting of silymarin flavonolignans (70-80 %), and a chemically undefined mixture composed of polymeric and oxidized polyphenolic compounds (20-30 %). Various analytical methods have been reported for its determination in plasma. Reported methods involved sample pretreatment using liquid-liquid extraction which makes them more time consuming because of frequent evaporation and reconstitution steps. Present study was aimed to develop a simple High-Performance Liquid Chromatography method with minimum time for sample pretreatment. This method was developed and validated using ultra violet detection for the determination of silymarin in plasma. The method was based on protein precipitation using methanol. Analysis was performed on ACE C18 column (150 × 4.6mm, 5µ) with gradient elution using solutions containing orthophosphoric acid: methanol: water in two different ratios 0.5:35:65 V/V/V and 0.5:50:50 V/V/V, pumped at a rate of 0.8 mL/min. The UV detection was performed at 288 nm. The retention time for the analysed comonents; silycristin, silydianin, silybin A, silybin B, isosilybin A and isosilybin B were found to be 7.97, 9.50, 17.04, 18.40, 22.45 and 23.35 min, respectively. The standard curve was linear over the range of 2 to 40 µg/mL with the regression coefficient >0.99. The intraday and interday precision was less than 3.06 and 6.56%, respectively. The results of analysis have been validated statistically and by recovery studies. The developed method was successfully applied for preclinical pharmacokinetic studies of silymarin in plasma samples of rabbit that were obtained at different time intervals after oral administration of silymarin.

Key Words: Silymarin, bioanalytical method, determination, plasma, pharmacokinetic

1 INTRODUCTION

Silybum marianum is one of the ancient and thoroughly researched plants. It is popularly called as milk thistle as common name. Active component of this plant is silymarin which is a standardized extract composed of approximately 70-80 percent silymarin flavonolignans including silybin A & B, isosilybin A & B, silydianin and silychristin as shown in Figure 1, and flavonoids (taxifolin and quercetin). Remaining 20-30 percentage part is a chemically undefined mixture comprising of polymeric and oxidized polyphenolic compounds. The isomers are collectively known as silymarin [1, 2]. Silymarin is a flavonolignans derived from the plant *Silybum marianum.* It is official in Indian Pharmacopoeia [3], United States Pharmacopoeia [4] and British Pharmacopoeia [5]. As per Indian Pharmacopoeia, it is indicated for hepatoprotective and chemoprotective activities [3]. It exhibits different pharmacological activities, like antioxidant, cardioprotective [6], antiinflammatory, anticancer, and hepatoprotective [7-11]. It has been used for the treatment of liver cirrhosis [12] and viral hepatitis [13]. Effect of Silymarin is due to several activities likes regulation of cell membrane permeability, leukotriene inhibition and reactive oxygen species scavenging properties [14]. Silymarin has an elimination half life of approximately 6-7 h and it is more than 70% bound to plasma proteins [15]. The major constituent of silymarin is silybin (also known as silibinin), a mixture of two diastereomers, silybin A and silybin B, in approximately equimolar ratio [16]. Silymarin is herbal medicine hence collectively all compounds are active and used for the treatment of liver cirrhosis and viral hepatitis [17] hence all the components were analyzed in the present method.

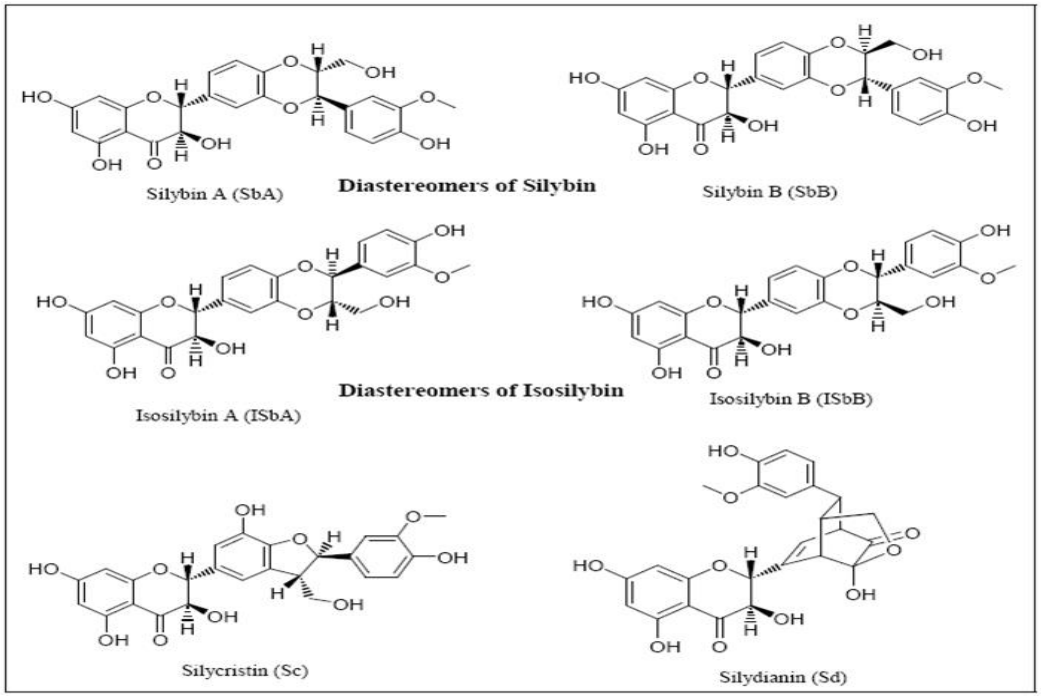

Figure 1: Chemical structure of Silymarin components

Most pharmacopoeial methods for assay of silymarin described HPLC with spectrophotometric detection at 288 nm [18-20]. Some non-pharmacopoeial methods are also reported for analysis of silymarin components in non-biological samples [21-24]. Few methods are reported for analysis of silymarin in biological matrices [25-27]. However, in the reported bioanalytical methods, the sample pretreatment consisted of liquid-liquid extraction. The liquid-liquid extraction protocols, evaporation and reconstitution steps used in such methods makes them more time consuming. Therefore, the present study was aimed to develop a simple HPLC method for determination of silymarin in plasma with minimum sample pretreatment.

2 MATERIALS AND METHODS

2.1 Chemicals

Silymarin was a generous gift from Centaur Pharmaceutical Private Limited (Goa, India). Methanol of HPLC grade and phosphoric acid (85%) of analytical grade were obtained from Finar Chemicals Ltd (Ahmedabad, India). Double distilled water prepared in the laboratory was used during the entire HPLC procedure.

2.2 Apparatus

2.2.1 HPLC system

The chromatographic separation was carried out using integrated Shimadzu HPLC instrument (Model: LC 2010 CHT) equipped with an auto injector and UV Visible detector. A reversed column and gradient elution of a mobile phase were used for chromatographic separation. Spectrophotometric detection was done at 288 nm. The output signal was monitored and processed using LC solution software.

2.2.2 Column

ACE C18, 5 µm, 4.6 x 150 mm analytical column with ODS 5 µm, 4.6 x 100 mm guard column was used for the method development.

2.2.3 Software

LC solution software was used for acquisition, reporting and analysis of data generated in the experimentation.

2.3 HPLC Conditions

Samples were eluted using a mobile phase consisting of solution A containing orthophosphoric acid: methanol: water (0.5:35:65 V/V/V) and solution B containing orthophosphoric acid: methanol: water (0.5:50:50 V/V/V). The mobile phase was filtered through a membrane filter (0.45 µm pore size, 47 mm diameter, Sartorius India Pvt. Ltd., Mumbai, India) and degassed in a sonicator (Enertech Fast Clean, Mumbai, India). Pumping of the mobile phase at a flow rate of 0.8 mL/min was carried out in the gradient mode for the run time of about 51 min. The temperature of column oven was set at 45 °C and UV detector was set at 288 nm. Samples of 10 µL were injected into column using an auto injector.

2.4 Preparation of Standard Solutions

Silymarin primary stock solution was prepared in methanol. For the preparation of solution, an accurately weighed 10 mg of silymarin was transferred to a 10 mL volumetric flask. Then 7 mL of methanol was added to the flask and stirred well to dissolve the drug. The volume was made up to the mark with methanol to yield a concentration of 1 mg/mL. Working standard solutions were prepared by dilution with methanol. Calibration standards were prepared by spiking stock solutions into drug-free plasma to yield concentrations of 2, 4, 8, 20, 32 and 40 µg/mL. External standard method was used to analyze the drug samples.

2.5 Preparation of Samples

The storage of collected plasma samples was done at -20 °C. The stored plasma samples were taken out and allowed to attain a room temperature before further processing. Methanol (2.5 mL) was added to 500 µL plasma and then mixture was vortexed for 30 s. The tube was centrifuged for 5 min at 2000 rpm (Remi, Cooling Centrifuge, Model C- 24BL, Remi Elektrotechnik Limited, Vasai, India) and supernatant was filtered through polyvinylidene difluoride (PVDF) syringe filter (Millipore Millex-HV Hydrophilic, 0.45 µm pore size, 33 mm diameter, Millipore India Pvt. Ltd., Mumbai, India) and transferred into a clean tube. The resulting solution (10 µL) was injected into the chromatographic system for analysis.

2.6 Selectivity

The developed method was investigated for its selectivity of the analytes over the potential interference of endogenous substances by analyzing blank plasma and comparing with LOQ solution samples from at least six sources.

2.7 Calibration Curves

The calibration curve was constructed in the range of 2-40 µg/mL to encompass the expected concentrations in measured samples. The calibration range was selected to cover the expected Cmax (2-6 µg/mL) of silymarin in tested formulation. The calibration curve was obtained by plotting silymarin peak area versus the silymarin concentration. Linear regression of the data was performed to determine correlation.

2.8 Accuracy, Precision and Recovery

The accuracy, precision (within-day and between-day) and recovery values of the method were determined using the quantification of five QC samples with three different concentrations within the calibration range. The food and drug administration (FDA) criterion for acceptability of accuracy and precision is ± 15% deviation from the nominal value, except for the LOQ, which should not exceed 20% [28].

2.9 Stability Study

Short-term, long-term, freeze-thaw and processed sample stability study of silymarin in plasma were carried out. For the purpose of stability study, spiked QC samples of 2 µg/mL (LQC) and 40 µg/mL (HQC) were used. Silymarin QC samples were kept room temperature for 24 h before protein precipitation to perform short-term stability study. For long-term stability study, the plasma QC samples were stored at -20 °C for 16 days before analysis. Freeze-thaw stability study was conducted by cycling of the plasma QC samples for three cycles between -20 °C and room temperature. The plasma sample were analyzed after each cycle. Analysis of freshly prepared plasma QC samples and samples kept in the auto injector for 6 h before injection was carried out for the assessment of processed sample stability.

2.10 Application of Developed Method

Developed method was applied for determination of silymarin in plasma following oral administration of 300 mg/kg dose of silymarin in New Zealand white rabbits (three). The study protocol was approved by Institutional Animal Ethical Committee (IAEC) of Shri Sarvajanik Pharmacy College, Mehsana, Gujarat vide Proposal No.: SSPC/IAEC/17/08/2013 as per the guidance of Committee for the Purpose of Control and Supervision of Experiment on Animals (CPCSEA). Blood samples were taken from a rabbit prior to dosing and at 0.25, 0.5, 0.75, 1, 2, 4, 6, 8, 12 and 24 h after drug administration. The blood samples were centrifuged at 5000 rpm for 10 min, and plasma was collected in polyethylene tubes and stored frozen at -20 °C until analysis.

3 RESULTS AND DISCUSSION

3.1 Selection of Extraction Solvent

Extraction of silymarin isomers from plasma was tried using extracting solvents like methanol, ethanol, ethyl acetate, diethyl ether, acetone, and dichloromethane. The solubility in methanol, ethanol, ethyl acetate, diethyl ether, acetone and dichloromethane were found to be 237.7, 225.3, 198.1, 185.4, 168.5 and 102.9, respectively expressed in mg/mL. From the tested solvents methanol was used due to high solubility of silymarin isomers in it.

3.2 Chromatographic Selectivity

Typical chromatograms of drug-free plasma and spiked plasma of silymarin (2µg/mL) are shown in Figure 2. The method selectivity was demonstrated on six blank plasma samples. Chromatograms were found to be free of interfering peaks. The retention time of silycristin (Sc), silydianin (Sd), silybin A (SbA), silybin B (SbB), isosilybin A (ISbA) and isosilybin B (ISbB) were 7.97, 9.50, 17.04, 18.40, 22.45 and 23.35 min, respectively under the optimized chromatographic conditions.

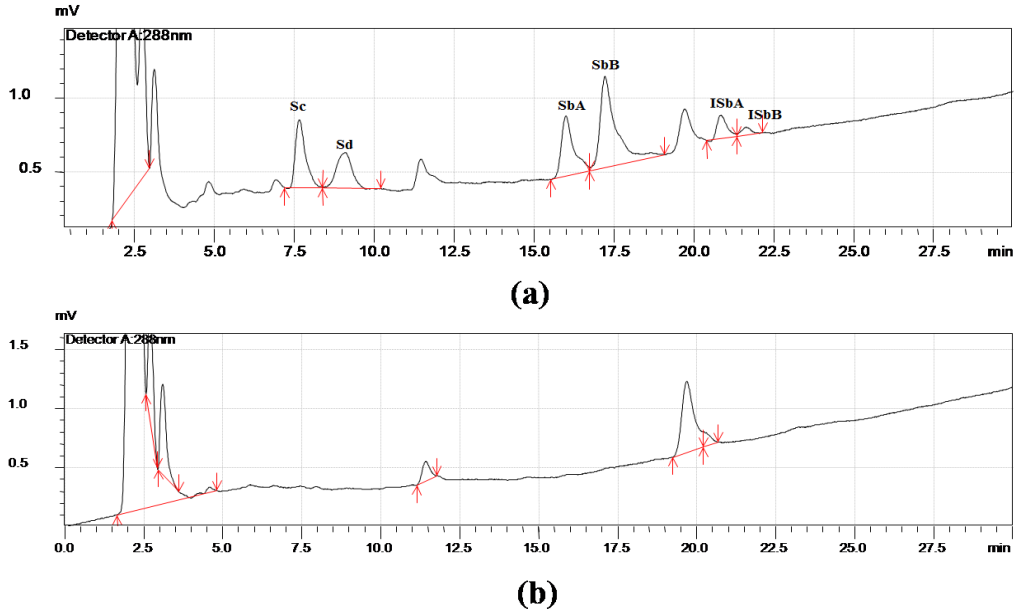

Figure 2: Chromatograms of (a) spiked plasma of Silymarin (2 µg/mL) and (b) a drug-free plasma

3.3 Linearity

The standard curve of silymarin in plasma was linear over the range of 2 to 40 µg/mL as shown in Table 1. The linearity of the calibration data was evaluated using regression coefficient of 0.999 as shown in Table 2.

3.4 Accuracy, Precision and Recovery

Accuracy, intraday and interday precision and recovery were assessed by analyzing the LOQ and QC samples prepared by spiking the plasma with known amount of silymarin. Results of accuracy data and intraday precision are shown in Tables 3 and 4, respectively. The accuracy of the method was higher than 86% for all the concentrations. The mean intraday precision was found to be 3.06%.

Table 1: Calibration Curve of Silymarin in Plasma

Sr. No.	Concentration in spiked plasma (µg/mL)	Concentration of Silymarin Std (µg/mL)	Peak area ± S.D. (n=3)		% Recovery from spiked plasma	% CV
			Silymarin in Spiked plasma	Silymarin Std in Methanol		
1	2	2	29627 ± 1608	31813 ± 1137	93.13	5.42
2	4	4	55873 ± 1534	65029 ± 2154	85.92	2.75
3	8	8	117272 ± 11330	137563 ± 9773	85.25	9.66
4	20	20	302410 ± 10138	320991 ± 13379	94.21	3.35
5	32	32	494199 ± 9859	527288 ± 18154	93.72	1.99
6	40	40	615364 ± 42182	698450 ± 47498	88.10	6.85

Table 2: Linearity Results of Silymarin in Plasma and Methanol

Pearameters	Results	
	Silymarin in Plasma	Silymarin in Methanol
Linearity Range	2-40 µg/mL	2-40 µg/mL
Regression Line Equation	y = 15519x + 5041	y = 17152x + 6165
Correlation Coefficient (R^2)	0.999	0.997

3.5 Stability Study

The stability study was performed as per bioanalytical validation guidelines. From the results of short-term stability study performed at room temperature, it was observed that low and high QC samples were stable for 24 h with assay of 90.63 ± 0.67%. From the results of long-term stability, it was found that silymarin samples stored at -20 °C for 16 days were stable with assay of 95.96 ± 0.95%. The decrease of silymarin concentration in plasma samples detected after exposing samples to three freeze-thaw cycles was insignificant, with mean assay of 95.15 ± 0.53%. The results of stability of processed samples in the autosampler showed that QC samples were stable for at least 6 h at room temperature, without significant loss of silymarin.

Based on the preliminary stability results, it was concluded that the processing and analysis of the plasma samples shall be completed within 16 days after animal experiments. The collected plasma samples were frozen and thawed only once and were processed immediately after thawing. After processing, the samples were kept in the auto sampler for a time not longer than 6 h.

Table 3: Accuracy Data of Silymarin in Plasma Samples

Sr. No.	Concentration in spiked plasma (µg/mL)	Peak area of Silymarin in Spiked plasma	Concentration Recovered from plasma (µg/mL)	Mean Concentration (µg/mL)	% Deviation
1	2	31627	1.71	1.69	15.27
		30422	1.64		
		31245	1.69		
		30945	1.67		
		32456	1.77		
		119272	7.36		
2	8	124585	7.70	7.52	6.03
		122354	7.56		
		118737	7.33		
		123562	7.64		
		302410	19.16		
3	20	295451	18.71	19.07	4.64
		311424	19.74		
		304428	19.29		
		291452	18.46		
		474199	30.23		
4	32	492145	31.39	30.66	4.19
		482542	30.77		
		472962	30.15		
		482456	30.76		

Table 4: Intraday Precision Data of Silymarin in Plasma Samples

Sr. No.	Concentration in spiked plasma (µg/mL)	Average Peak Area (n=5)					S.D.	% CV
1	2	29627	30422	28245	28746	30456	991	3.36
2	8	117272	124585	122354	114737	123562	4275.88	3.55
3	20	302410	295451	315424	304428	291452	9223.30	3.06
4	32	494199	502145	482542	492962	512456	11163	2.25

Results of interday precision and recovery are shown in Tables 5 and 6, respectively. The mean interday precision was found to be 6.56%. To assess the extraction recovery of silymarin from plasma, protein precipitation method was chosen due to simplicity. The mean extraction recovery was 91.24 ± 1.27%.

Table 5: Interday Precision Data of Silymarin in Plasma Samples

Sr. No.	Concentration in spiked plasma (µg/mL)	Average Peak Area (n=5)			S.D.	% CV
		Day 1	Day 2	Day 3		
1	2	29499	27134	30945	1923	6.59
2	8	120502	102452	112145	9033	8.08
3	20	301833	274154	295412	14487	4.98
4	32	496861	435452	462515	30776	6.62

Table 6: Recovery Data of Silymarin in Plasma and Methanol

Sr. No.	Concentration in spiked plasma (µg/mL)	Concentration of Silymarin Std (µg/mL)	Average Peak Area ± S.D. (n=5)		% Recovery
			Silymarin in Spiked plasma	Silymarin Std in Methanol	
1	2	2	28367 ± 990	31564 ± 1265	89.55
2	8	8	127272 ± 11330	137563 ± 9773	92.51
3	20	20	292410 ± 10138	320991 ± 13379	91.09
4	32	32	484199 ± 9859	527288 ± 18154	91.82

3.6 Applicability of Developed Method

Suitability of the developed method was investigated in preclinical pharmacokinetic study of silymarin. Figure 3 shows mean plasma concentration time profile of silymarin after a 300 mg/kg oral dose administration to New Zealand white rabbit (three). Table 7 shows the pharmacokinetics parameters determined by noncompartmental analysis of the plasma drug concentration time profile.

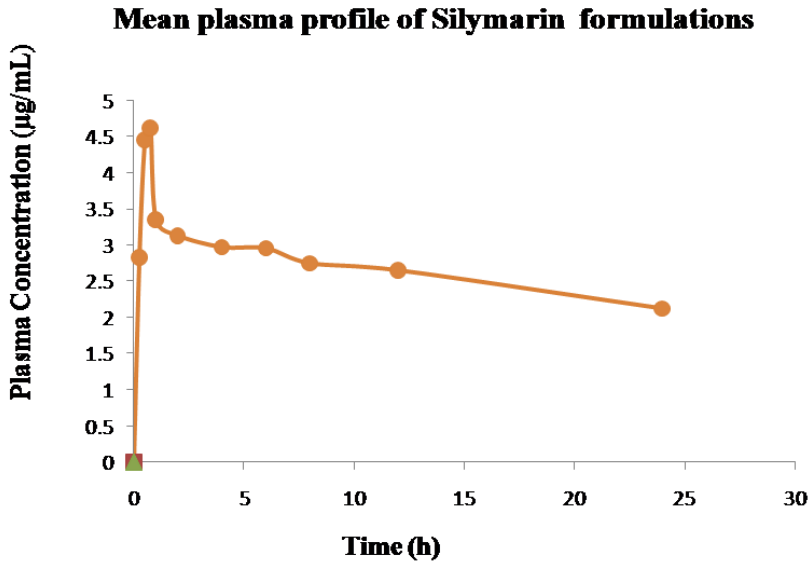

Figure 3: Mean plasma concentration Vs time profile of silymarin following a single dose of 300 mg/kg to rabbit

Table 7: Pharmacokinetic Parameters of Silymarin following a single oral dose of 300 mg/kg to New Zealand White Rabbit

Pharmacokinetic parameters	Average ± SD (n=3)
T_{max}, h	0.75 ± 0.011
C_{max}, µg/mL	4.627 ± 0.058
AUC, µg.h/mL	63.953 ± 1.720

4 CONCLUSION

A simple, sensitive, and reproducible HPLC method that is applicable for preclinical pharmacokinetic study of silymarin in plasma was developed and validated. The stability studies demonstrated that

silymarin was stable during assay procedures and for 16 days in frozen storage conditions. The developed method is selective without any interference of endogenous substances. Developed method require less time for sample pretreatment and cost effective compared to LC-MS method.

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