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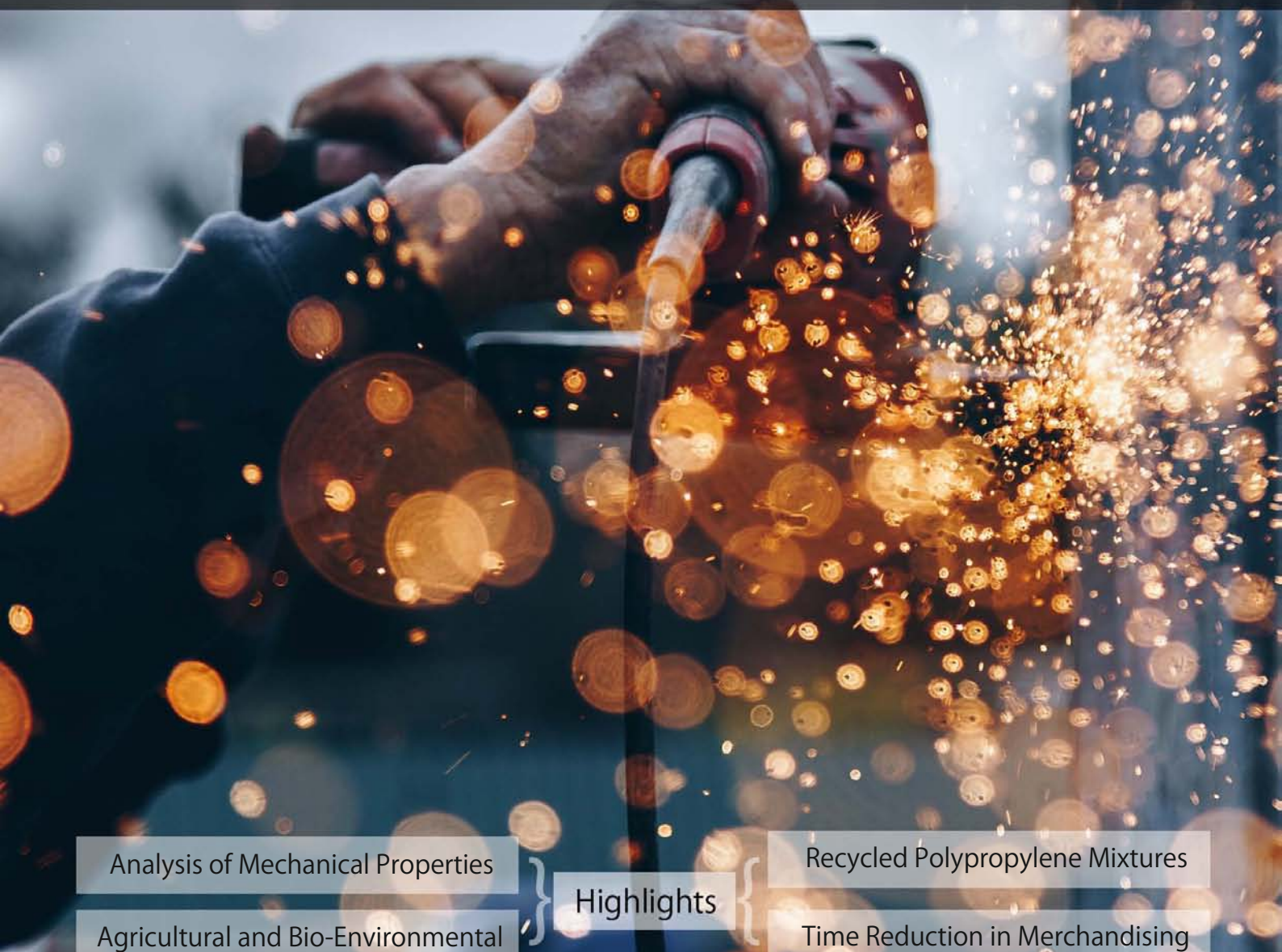

Highlights

Analysis of Mechanical Properties

Agricultural and Bio-Environmental

Recycled Polypropylene Mixtures

Time Reduction in Merchandising

Discovering Thoughts, Inventing Future

VOLUME 20 ISSUE 5 VERSION 1.0

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Production Decline Prediction of Shale Gas using Hybrid Models

By P. Manda & D.B. Nkazi

Abstract- Hybrid models have frequently been used for shale gas production decline prediction by manipulating the unique strength of each of the known decline models. The use of a combination of models provides a more precise predicting model for forecasting time series data as compared to an individual model. In this study, the forecasting performance of decline curve hybrid models and ANN-ARIMA hybrid models are evaluated and compared with Arps', Duong's, the Power Law Exponential Decline, Autoregressive Integrated Moving Average (ARIMA) and Artificial Neutral Network (ANN) models, respectively. The variable used to assess the models was the respective flow rate, q(t) monitored over a period of time (T). The results have shown that the single model approach can outperform hybrid models. The average deviation of the two best models indicates a central tendency of the production data around the mean. Subsequently, the spread in the data between the actual and predicted values is found to be less. It can thus be concluded that the ARIMA and ANN models have the best forecasting accuracy for production decline in shale gas compared to the other models.

Keywords: shale gas decline forecasting, Arps' decline model, Duong's decline model, PLE decline model; ARIMA, ANN and hybrid models.

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Production Decline Prediction of Shale Gas using Hybrid Models

P. Manda[α] & D.B. Nkazi[σ]

Abstract- Hybrid models have frequently been used for shale gas production decline prediction by manipulating the unique strength of each of the known decline models. The use of a combination of models provides a more precise predicting model for forecasting time series data as compared to an individual model. In this study, the forecasting performance of decline curve hybrid models and ANN-ARIMA hybrid models are evaluated and compared with Arps', Duong's, the Power Law Exponential Decline, Autoregressive Integrated Moving Average (ARIMA) and Artificial Neutral Network (ANN) models, respectively. The variable used to assess the models was the respective flow rate, q(t) monitored over a period of time (T). The results have shown that the single model approach can outperform hybrid models. The average deviation of the two best models indicates a central tendency of the production data around the mean. Subsequently, the spread in the data between the actual and predicted values is found to be less. It can thus be concluded that the ARIMA and ANN models have the best forecasting accuracy for production decline in shale gas compared to the other models.

Keywords: shale gas decline forecasting, Arps' decline model, Duong's decline model, PLE decline model; ARIMA, ANN and hybrid models.

I. Introduction

Rate-time decline curve extrapolation is one of the oldest and most commonly used tools by a petroleum engineer. Results obtained for a well are subject to a wide range of alternate interpretations, mostly as a function of the experience and objectives of the evaluator. Recent efforts in the area of decline curve analysis (DCA) have been directed towards a purely computerised statistical approach, its basic objective being to arrive at a unique "unbiased" interpretation [1]. In the past few decades, several DCA models have been proposed and benchmarked with commercial reservoir simulators or shale gas production data before being applied to more shale gas reservoirs (SGRs) [2].

Numerous studies have highlighted the importance of DCA models, however, there are limitations with these models. Analysis conducted using these techniques for the prediction and estimation of reservoirs in shale well production have highlighted shortcomings in the models [3]. These shortcomings include underestimation, finite and overestimation of the estimated ultimate recovery (EUR) of reserves. Taking these facts into consideration, the scope exists for developing improved models which address these shortcomings.

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a) Production Decline Models

The Arps decline model is inaccurate within the transient flow regime (TFR) and the Duong model is inaccurate within the boundary dominated flow (BDF). Although the Power Law Exponential (PLE) model incorporates both these flow regimes and was specifically developed for SGRs, the model has its own shortcomings. Hence, the scope to develop a new decline model or a new method to predict more accurately the recovery of SGRs. Accordingly, the approach would be to combine the above-mentioned methods i.e. to evaluate the hybrid decline curve models. As the PLE and Duong's models model the transient flow well and because the Arps model is widely used for BDF, the new approach combines the methods to achieve the objectives and eliminate the shortcomings of the stand-alone models. In this paper, the combination of different models, or hybrid models as they are commonly known, will be investigated.

Hybrid models have frequently been used for prediction by manipulating the unique strength of each of the models [4]. The use of a combination of models provides a more precise predicting model for forecasting time series data as compared to an individual model [5]. The results from studies have indicated that hybrid models have higher prediction accuracy for one-step and multi-step forward forecasts and various hybrid models have been used for obtaining accurate prediction [5; 6].

The evaluation of the forecasting performance of decline curve hybrid models and ARIMA-ANN hybrid models is essential, and these models should be compared with Arps', Duong's, the Power Law Exponential Decline, Autoregressive Integrated Moving Average (ARIMA) and Artificial Neutral Network (ANN) models for accurate prediction of production decline in shale gas.

b) Hybrid Models and ANN-ARIMA Hybrid Models

In the literature, hybrid methods are considered to yield better results [7].The accuracy of time series forecasting is challenging for scientists [7]. Time series data often comprise linear as well as non-linear components [8]. In some cases, linear-based approaches might be more suitable than non-linear approaches due to the data characteristics. The use of hybrid models, which combine DCA models, is a new approach and there is minimal literature covering this

aspect. However, as mentioned, the known approach to the hybrid method is a combination of the ARIMA and ANN method.

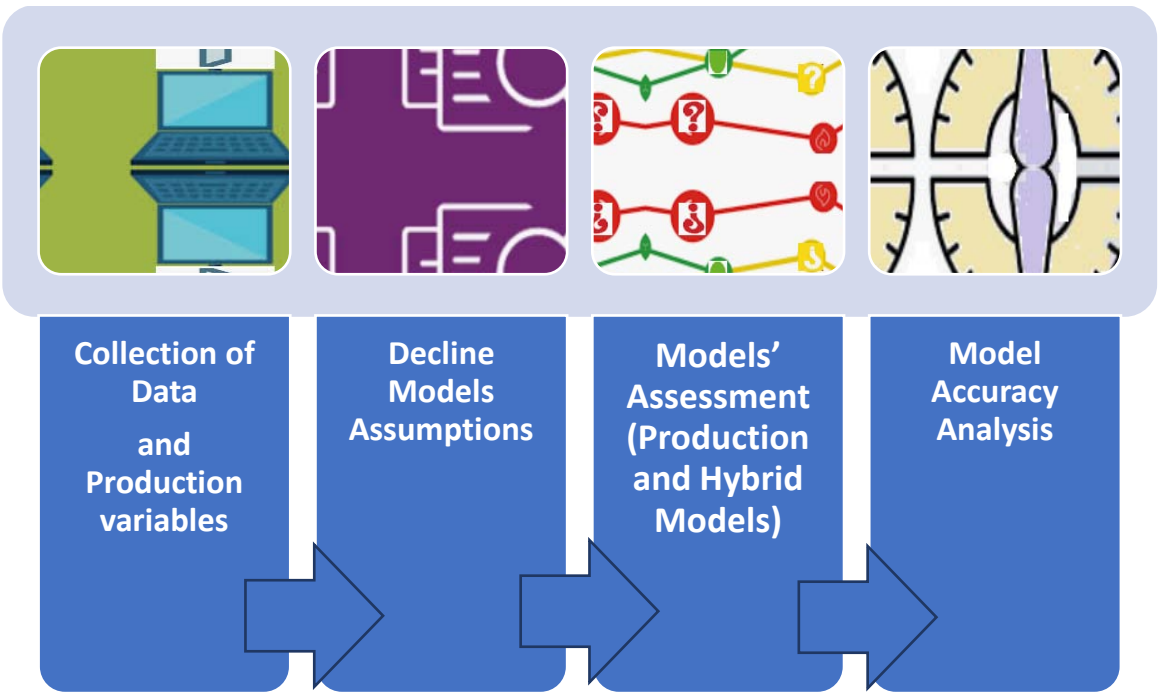
According to Faruk [8], hybrid methods have a higher degree of accuracy than neural networks. ARIMA is able to recognise time-series patterns well except non-linear data patterns. On the other hand, neural networks only handle non-linear data. Therefore, hybrid models combine the advantages of ARIMA with respect to linear modelling and neural networks in terms of non-linear edge modelling [9]. Ayub and Jafri (2020) [10] in their paper highlighted that the combined model has improved forecasting accuracy as compared to when the models are used individually. Notwithstanding this, in some circumstances the single model approach can outperform hybrid models [8]. Babu et al. (2014) [5] explored ARIMA and ANN as a new hybrid model for better prediction of time series. Their results preferred the use of the hybrid model compared to the individual ARIMA and ANN models.

The ARIMA processes follow a stochastic behaviour used to analyse time series [11] and is mostly used to predict demand. The application of the ARIMA methodology for the study of time series analysis was developed by Box and Jenkins [11]. The Box–Jenkins methodology includes three iterative steps of model identification, parameter estimation and diagnostic checking [12]. This three-step model building process is typically repeated several times until a satisfactory model is finally selected and can then be used for prediction purposes [12]. In an ARIMA model, the future value of a variable is assumed to be a linear function of several past observations and random errors [11]. During the past decades, researchers have been focusing more on linear models due to their simplicity in comprehension and application [13]. A disadvantage of the classical ARIMA methodology is that it requires a large number of observations to determine the best fit model for a data series [13].

The ANN model, on the other hand, has found increasing consideration in forecasting theory, leading to successful applications in various forecasting domains including economics, business, financial and many more [14]. One advantage of neural networks compared to other non-linear models is their universal model, which is capable of predicting fairly extensive functions with a high degree of accuracy. No assumptions are required for neural networks, thus neural networks conform to the characteristics of the data [15]. However, there are disadvantages associated with this model such as constructing the forecasting model, the selection of the network architecture and the data pre-processing techniques which apply to the time series data [16; 17].

This investigation uses different hybrid models in forecasting production decline and evaluating the hybrid models for improved forecasting accuracy of time series by using the unique strengths of the models. The experimental results used are based on the study of shale gas production data obtained from a previous study done by Paryani et al. [3].

II. Methodology



a) Collection of Data

The variable used in this investigation is flowrate, q(t) in STB/day, monitored over a period of time (T) in days. The estimated data was extracted from the research conducted by Paryani et al. (2018), who obtained the data from the Cannon Well located in Karnes County evaluated over a two-year period. Kappa Citrine and JMP software are used for simulation of the DCA, hybrid DCA, ARIMA, ANN and ANN-ARIMA hybrid models respectively.

b) Production Behaviour

i. *Arps' Decline Curve Model*

Arps' decline curve analysis is the most commonly used method of estimating ultimate recoverable reserves and future performance [18]. Paryani et al. [3] attribute this to reliable history match (even with b > 1) and its simplicity. The model process is based on the following vital assumptions: that past operating conditions will remain unaffected; that a well is produced at or near capacity; and that the well's drainage remains constant and is produced at a constant bottom-hole pressure [19]. Notably, the Arps model is only applicable in pseudo-steady flows when the flow regime transfers from linear flows to boundary-dominated flows (BDF) [20]. This indicates that the Arps equations are not applicable to the production forecasting of the entire decline process of horizontal wells in low-permeability reservoirs [21]. The most commonly employed hyperbolic form of Arps' decline equation [1] is used for shale reservoirs. The hyperbolic decline equation is suitable to use due to the "best fit" that it provides for the long transient linear-flow regime observed in shale gas wells with b values greater than unity [22].

$$q = \frac{q_i}{(1+bD_i t)^{\frac{1}{b}}} \quad (1)$$

Where q is the flow rate in STB/day or Mscf/day, q_i is the initial flow rate in STB/day or Mscf/day, D_i is the initial decline constant, which is measured in days-1, and b is the decline exponent.

Table 1: Summary of the Arps model behaviour, assumptions, condition and parameters

Production Behaviour	Assumptions	Condition	Parameters
Boundary Dominated Flow (BDF)	Decline parameter, b, defines the decline behaviour	0 < b <1	b = 1.10 D_i = 0.12

ii. *Duong's Decline Curve Model*

Doung [23] presented an unconventional rate decline method to evaluate the performance of shale gas wells that does not depend on the fracture types. The model assumes linear or near-linear flow, as indicated by a log–log plot of rate over cumulative production versus time, which yielded a straight-line tendency [24]. The rate is calculated in the model using the following equation [2]:

$$q(t) = q_i t(a,m) + q_\infty \quad (2)$$

Where t (a,m) is the time constant in 1/s, and q_∞ is the production rate at infinite time in m^3/s.

Table 2: Summary of the Duongs model behaviour, assumptions, condition and parameters

Production Behaviour	Assumptions	Condition	Parameters
Transient Flow Regime (TFR)	Very low permeability and long periods of transient flow	b > 1	q_i = 361.24 a = 1.07 m = 1.10

iii. *Power Law Exponential Decline Model (PLE)*

Ilk et al. [25] presented the PLE, which is an extension of the exponential Arps formula for the decline degree in shale reservoirs. This model was developed precisely for SGR and approximates the rate of decline with a power law decline. The PLE model matches production data in both the transient and boundary-dominated regions without being hypersensitive to remaining reserve estimates [26]. Seshadri and Mattar[27] presented that the PLE model can model transient radial and linear flows, while Kanfar and Wattenbarger[28] proved that the model is reliable for linear flow, bilinear flow followed by linear flow, and linear flow followed by BDF, or bilinear flow followed by linear flow and finished with BDF flow. Vanorsdale[29] deduced that when the flow regime changes throughout the initial 10 years of the well, the PLE model will yield a very optimistic recovery. The model characterizes the decline rate by infinite time, $D\infty$ which is defined as a "loss ratio" (which is assumed to be constant from Arp) [30]. The production rate is derived as follows:

$$\frac{q}{dq/dt} = -b \quad (3)$$

$$b = D_\infty + D_i t^{-(1-\hat{n})} \quad (4)$$

Where dq/dt is the slope, D_∞ is the decline rate over a long-term period, and $\hat{n}$ is the time exponent. By substituting the above equations, the production rate is obtained:

$$q(t) = \hat{q}_i e^{[-D_\infty t - \hat{D}_i t^{\hat{n}}]} \quad (5)$$

Table 3: Summary of the PLE model behaviour, assumptions, condition and parameters

Production Behaviour	Assumptions	Condition	Parameters
BDF and TFR	Approximates the rate of decline with a power law decline	b changes with time	n = 0.182 D_i = 0.268

iv. *The Arps'-Duong's-Power Law Models Hybrid Model*

The first proposed method incorporates the three DCA models, namely Arps', Duong's and PLE models. The Arps model only considers BDF while Duong's and PLE models consider TFR. The PLE model also considers BDF and has been specifically developed for SGRs. Hence, by combining the three models the limitations from each is presumed to be minimised or eliminated.The equation is given as:

$$\frac{qt}{qi} = t\,(-D_\infty - D_i\hat{n}) - In\frac{b+1}{b} \quad (6)$$

where q_t is the flow rate in STB/day or Mscf/day, qi is the initial flow rate in STB/day or Mscf/day, t is the time in days, $D\infty$ the decline rate over along-term period, while D_i is the initial decline constant, which are both measured in days $^{-1}$, $\hat{n}$ is the time exponent and b is the decline exponent.

Table 4: Summary of the Arps-Duong-Power Law hybrid model behaviour, assumptions, condition and parameters

Production Behaviour	Assumptions	Condition	Parameters
BDF and TFR	Approximates the rate of decline with anexponential decline	0 > b >1	n = 0.182 D_i = 0.194 b = 1.10

v. *The Arps-Duong Hybrid Model*

The second proposed model incorporates the two developed DCA models. Arps' model only considers BDF while Duong's considers TFR, hence both these flow regimes will be taken into account when combining these two models. The equation is given as:

$$qt = [\frac{qt}{t}][1 + bD_i]^{-\frac{1}{b}} \quad (7)$$

Where qt is the flow rate in STB/day or Mscf/day, t is the time in days, D_i is the initial decline constant, which is measured in days $^{-1}$and b is the decline exponent.

Table 5: Summary of the Arps-Duong hybrid model behaviour, assumptions, condition and parameters

Production Behaviour	Assumptions	Condition	Parameters
BDF and TFR	Approximates the rate of decline with a mechanistic growth decline	0 > b >1	D_i = 0.194 b = 1.10

vi. *The Arps-Power Law Exponential Hybrid Model*

The third proposed model incorporates the Arps and PLE models. These models consider BDF and TFR flows. Since the PLE model was developed specifically for SGRs, it would be advantageous to evaluate these two models combined due to both being simple equations to use. The equation is given as:

$$t[-D_\infty - D_i\hat{n}] = \frac{\frac{1}{b}}{qt} In(1 + bD_i) \quad (8)$$

Where qt is the flow rate in STB/day or Mscf/day, t is the time in days, $D\infty$ the decline rate over a long-term period and D_i the initial decline constant, which are both measured in days^{-1}, $\hat{n}$ is the time exponent and b is the decline exponent.

Table 6: Summary of the Arps-Power Law Exponential hybrid model behaviour, assumptions, condition and parameters

Production Behaviour	Assumptions	Condition	Parameters
BDF and TFR	Approximates the rate of decline with a logistic decline	0 > b >1	n = 0.182 D_i = 0.194 b = 1.10

vii. *The Duong-Power Law Exponential Hybrid Models*

The fourth proposed model incorporates the Duong and PLE models. These models both consider TFR. The equation is given as:

$$\frac{In\ qt}{qm} = t\ [-D_{\infty} - D_i\hat{n}] \quad (9)$$

Where *qt* is the flow rate in STB/day or Mscf/day, t is the time in days, $D\infty$ the decline rate over along-term period and D_i the initial decline constant, which are both measured in days^{-1} and $\hat{n}$is the time exponent. q_m is the flow rate at slope m in m^3/s.

Table 7: Summary of the Duong-Power Law Exponential hybrid model behaviour, assumptions, condition and parameters

Production Behaviour	Assumptions	Condition	Parameters
BDF and TFR	Approximates the rate of decline with a mechanistic growth decline	0 > b >1	n = 0.182 D_i = 0.194 q_m= 7.12

viii. *Autoregressive integrated Moving Average (ARIMA) Model*

As mentioned earlier in the paper, the ARIMA processes follow a stochastic behaviour used to analyse time series [11] and are mostly used to predict production demand. The model is labelled as an ARIMA model (p, d, q), where: -

1. p is the number of autoregressive terms;
2. d is the number of differences; and
3. q is the number of moving averages.

According to Ayub and Jafri (2020) [10], the best ARIMA model is determined according to criteria as follows:

- Relatively small BIC
- Maximum adjusted R^2

a. The Autoregressive Process

This process assumes that Y_t is a linear function of the preceding values and is given by equation (5).

$$Y_t = \propto_1 Y_{t-1} + \varepsilon_t \quad (10)$$

Generally, each observation consists of a random component i.e. a random shock, ε and a linear combination of the previous observations. $\propto_1$ in the equation is the self-regression coefficient.

b. The Integrated Process

The integrated process is the archetype of non-stationary series. A differentiation of order 1 assumes that the difference between two successive values of Y is constant. An integrated process is defined by equation (6).

$$Y_t = Y_{t-1} + \varepsilon_t \quad (11)$$

where the random perturbation ε_t is a white noise.

c. The Moving Average Process

The moving average process is a linear combination of the current disturbance with one or more previous perturbations. The moving average order indicates the number of previous periods embedded in the current value. Thus, a moving average is defined by equation (7).

$$Y_t = \varepsilon_t - \theta_1\varepsilon_{t-1} \quad (12)$$

In order to evaluate the best fit for the ARIMA model, a number of scenarios were evaluated and the ARIMA scenario (2,1,2) was selected to give the best forecast values, due to having the lowest MSE of 4.82, a low BIC of 8,23 and highest adjusted R^2 of 0,979. Table 2 indicates the best results for the ARIMA model, which are highlighted in bold.

Table 8: Statistical results for the different p,d,q for the ARIMA model

ARIMA	BIC	MSE	Adjusted R^2
(0,0,0)	8,63	46.91	0.000
(1,1,1)	6,19	5.86	0.974
(1,2,1)	9.42	5.84	0.958
(1,3,1)	6,69	6.35	0.899
(2,1,1)	8,25	5.08	0.974
(2,1,2)	**8,23**	**4.82**	**0.979**

ix. *Artificial Neutral Network (ANN) Model*

The model consists of three interconnected layers: the input layer, the hidden layer, and the output layer. The basic unit of any ANN is the neuron or node (processor). Each node is able to sum many inputs x1, x2,..., x3 whether these inputs are from a database or from other nodes, with each input modified by an adjustable connection weight [14]. The relationship that occurs in the output and input layers follows equation (8).

$$Y_t = \propto_0 + \sum_{j-1}^{q} \propto_j g\left(\beta_0 j + \sum_{l=1}^{p} \beta_i j Y_t - i\right) + \varepsilon_t \quad (13)$$

where $\propto_j$ (j = 1,2,3, ..., q) and $\beta_i j$ (i= 1,2,3, ..., p; j = 1,2,3, ..., q) are the parameters of the model (often called the weights), p is the number of input points (input nodes), and q is the number of hidden nodes. The activation function used in the hidden layer is the logistic sigmoid function and the linear function is the output layer.

To choose the best algorithm for the model, the number of hidden nodes and layers are changed. The accuracy can also be increased by increasing the number of nodes and layers [31]. In the case of this study, a univariate input layer and four nodes as shown in Figure 1 gave the best model.

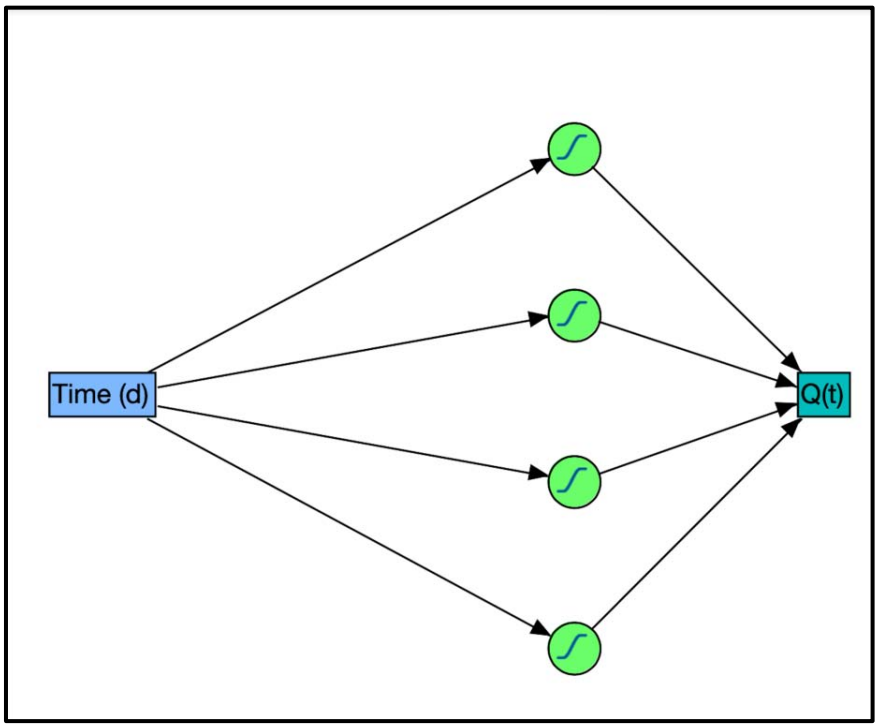


Figure 1: Univariate Artificial Neutral Network obtained from JMP

x. *ANN-ARIMAHybrid Model*

Zhang investigated the concept of the hybrid ANN-ARIMA model to obtain precise results as compared to using both models separately [12]. Numerous techniques, which explored the hybrid approach have been used for many years to take advantage of the unique strengths of each of the various types of models. The objective of merging the models is due to the notion that a single model is able to define all the specifics of time series [32]. Mathematically, time-series data can be expressed as a combination of linear and non-linear components [15]:

$$Y_t = L_t + N_t. \quad (14)$$

Where Y_t shows the time-series data, L_t indicates the linear components, and the non-linear components are represented by N_t.

Mathematically, the neural network model for residual of n input nodes can be expressed as follows:

$$e_t = f(e_{t-1} + e_{t-2}, \ldots, e_{t-n}) \quad (15)$$

Where f is a non-linear function that is specified by the neural network. With regard to the results of the prediction error of N_t, the combination forecast using the hybrid method can be expressed as:

$$\hat{y}_t = \hat{L}_t + \hat{N}_t. \quad (16)$$

N_t is obtained from the predicted values of the ANN model while $\hat{L}_t$ is the forecasted value from ARIMA based on the residual values.

III. Results and Discussion

Kappa Citrine and JMP software were used for the simulation of the models. The experimental results obtained are explained below.

a) Results for the Arps Model

Kappa Citrine software was initially used for determining the parameters for the Arps model. The b and D_i values were found to be 1.10 and 0.12 respectively. Subsequently, JMP software was used to construct the prediction model. The second step was to graph a semi-log plot (log q vs. t) to determine the model forecasting equation and parameters. The forecasting equation is given as follows:

$$y = \frac{c}{1+e^{(-ax^2-b)}} \quad (17)$$

where c is the asymptote, a the growth rate while b is the inflection point. The actual and forecasted flow rate values are shown graphically in Figure 2.

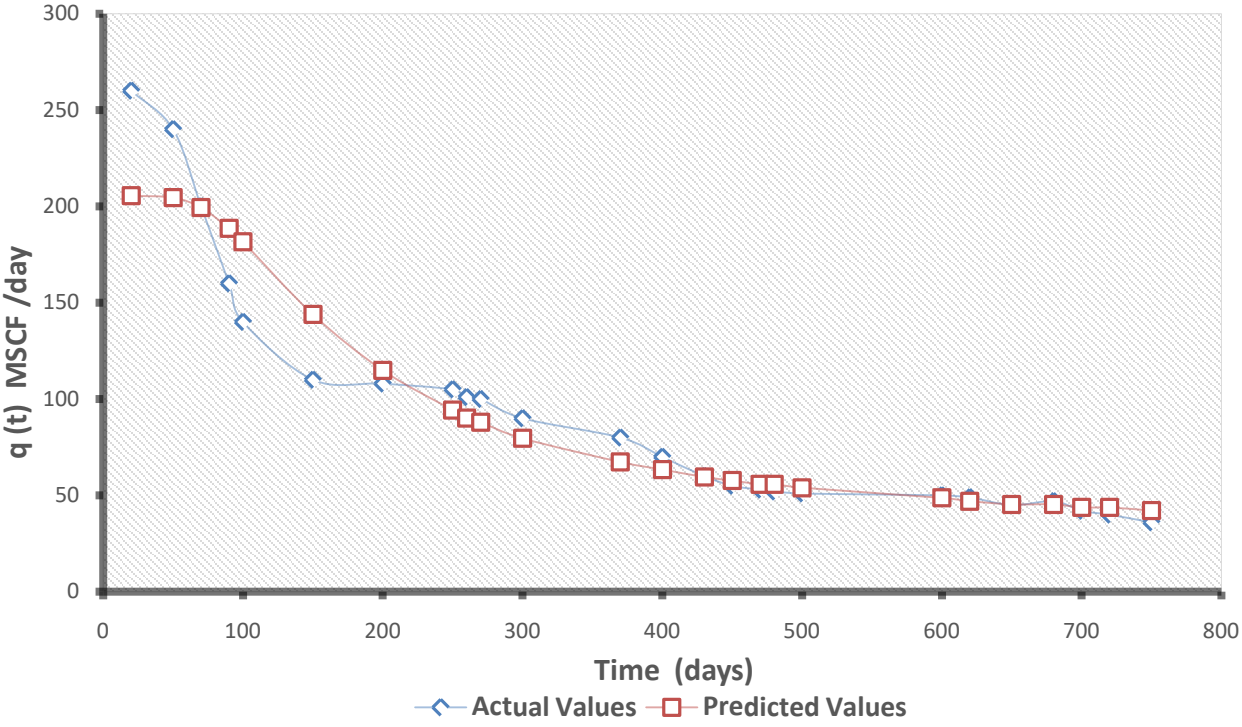


Figure 2: Graphical representation of actual flow rate vs. forecasted flow rate for shale gas production using the Arps model

The results for the model appear in some instances to over- and in other instances to underestimate the data. The results concur with literature, which suggests that the weakness of the Arps model is overestimation of results. Tan et al. (2018) [32] in their study highlighted that although the Arps model is simple and fast, it often fails to accurately fit the decline curve of unconventional reservoirs. They further explained that the model often tends to overestimate the EUR for shale gas wells because it assumes that a BDF regime is evident. Paryani et al. (2018) [3] concurred with these findings, explaining that the drainage area is not constant because the pressure pulse continues to spread from the fracture to other areasof the reservoir volume. Under these conditions, the bvaluepredicted by the Arps model for the actual production data will be greater than 1 as in this case b =1.10. This in turn leads to inaccurate estimates of reserves.

b) Results for the Duong Model

The parameters for the Duong model were q_i = 361.2, a = 1.07 and m = 1.10 respectively. In this instance a log–log linear plot (log *q* vs. log *t*) was used. The forecasting equation is given as:

$$y = bx + c \quad (18)$$

where b is the slope and c is the intercept. The actual and forecasted flow rate values can be seen in Figure 3.

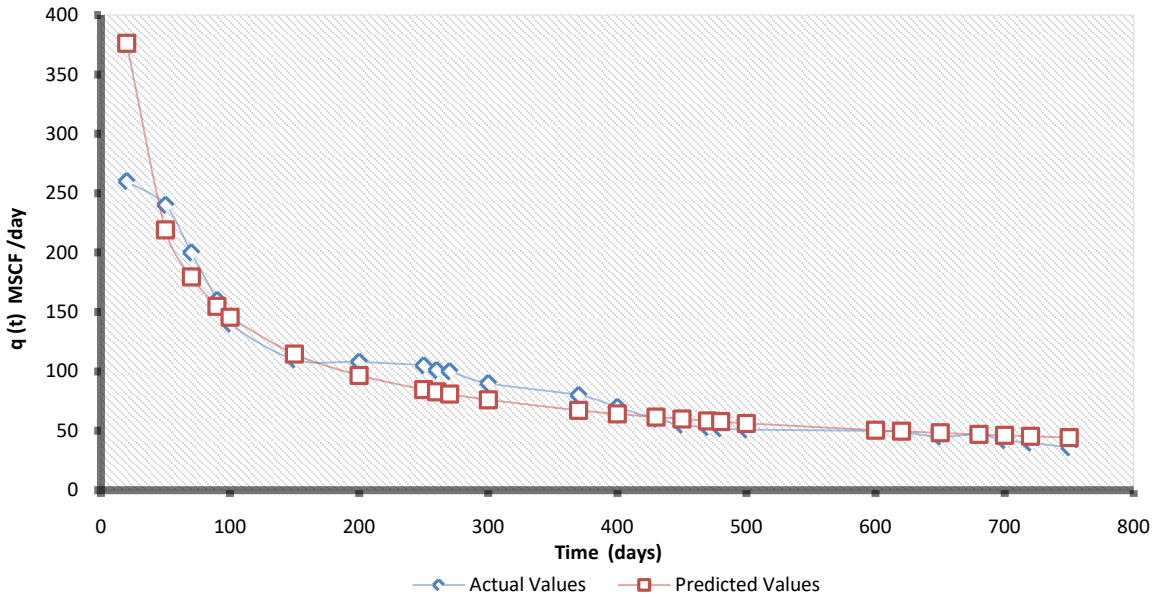


Figure 3: Graphical representation of actual flow rate vs. forecasted flow rate for shale gas production using Duong's model

The results for the Duong model indicate an overall underestimate of the data. Meyet et al. (2013) [33] mentioned in their work that the Duong model tends to provide the most conservative results. This could also be attributed to the fact that the Duong model tends to be more accurate for linear flows and bilinear–linear flows[28]. Paryani et al. (2018) [3] in their work found that the well fitted with 51% of the historical production data, and that the Duong model fits better with longer and less noisy historical production data.

c) Results for the Power Law Exponential (PLE) Model

The parameters used in the model for n and D_i are 0.182 and 0.268 respectively. A log–log plot (log *q* vs. log *t*) was used in the model forecasting. The forecasting equation is given as:

$$y = a + be^{cx} \tag{19}$$

where a is the asymptote, b is the scale and c is the growth rate.The actual and forecasted values can be seen in Figure 4.

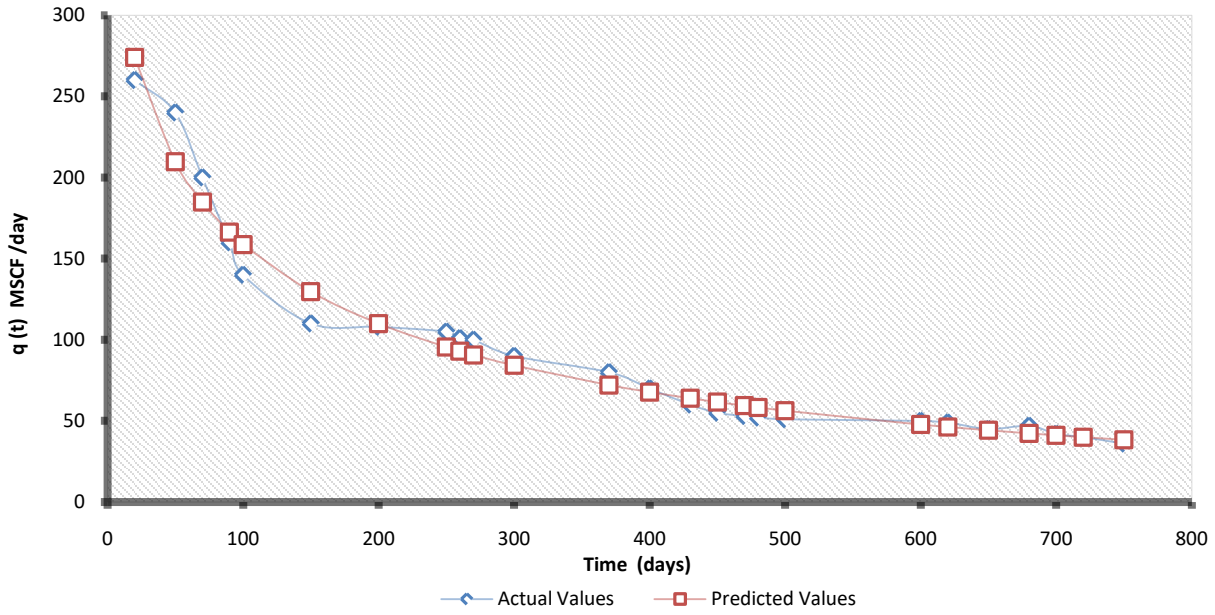


Figure 4: Graphical representation of actual flow rate vs. forecasted flow rate for shale gas production using the PLE model

The results for the PLE model appear to underestimate the data although the PLE considers BDF and TFR, which is an advantage of the model. Furthermore, the model was specifically developed for SGRs, hence it was assumed that the results would be better. This is comparative to the findings by Paryani et al. (2018) [3], as based on their results the PLE consistently gave the lowest forecasts for all the models. It is therefore the most conservative method for production forecasting and reserves estimation. Seshadri and Mattar (2010) [27] concluded that for tight gas wells, the PLE model is complex and non-intuitive. The power law model can result in a non-unique solution due to four degrees of freedom resulting from the four unknown parameters[34].

d) Result for the Arps-Duong-PLE Hybrid Model

A plot of $\frac{qt}{qi}$ vs. t was used in the model forecasting. The parameter q_i used was 361.2 which was noted earlier in Duong's model. The forecasting equation is given as:

$$y = a + be^{cx} \quad (20)$$

where a is the asymptote, b is the scale and c is the growth rate. The actual and forecasted values are graphically represented in Figure 5.

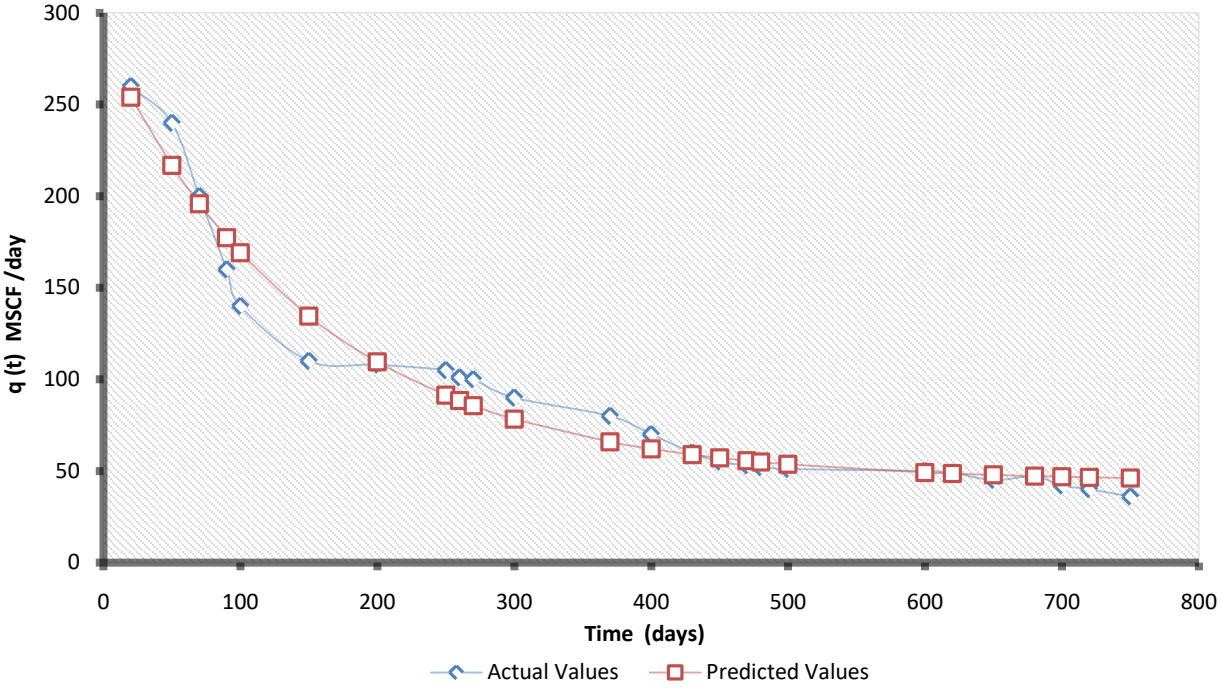


Figure 5: Graphical representation of actual flow rate vs. forecasted flow rate for shale gas production using the Arps-Duong-PLE hybrid model

Based on the results, the model appears to over- and underestimate the data. However, the gap between the actual and predicted results is minimised. This could be attributed to both BDF and TFR being considered. In addition, the conservative approach of Duong's and the PLE models along with the inaccurate fitting of the Arps decline curve of unconventional reservoirs could be a contributing factor.

e) Result for the Arps-Duong Hybrid Model

A plot of $\frac{qt}{t}$ vs.t was used in the model forecasting. The forecasting equation is given as:

$$y = a(1 - e^{-cx}) \quad (21)$$

where a is the asymptote, b is the scale and c is the growth rate. The actual and forecasted values can be seen in Figure 6.

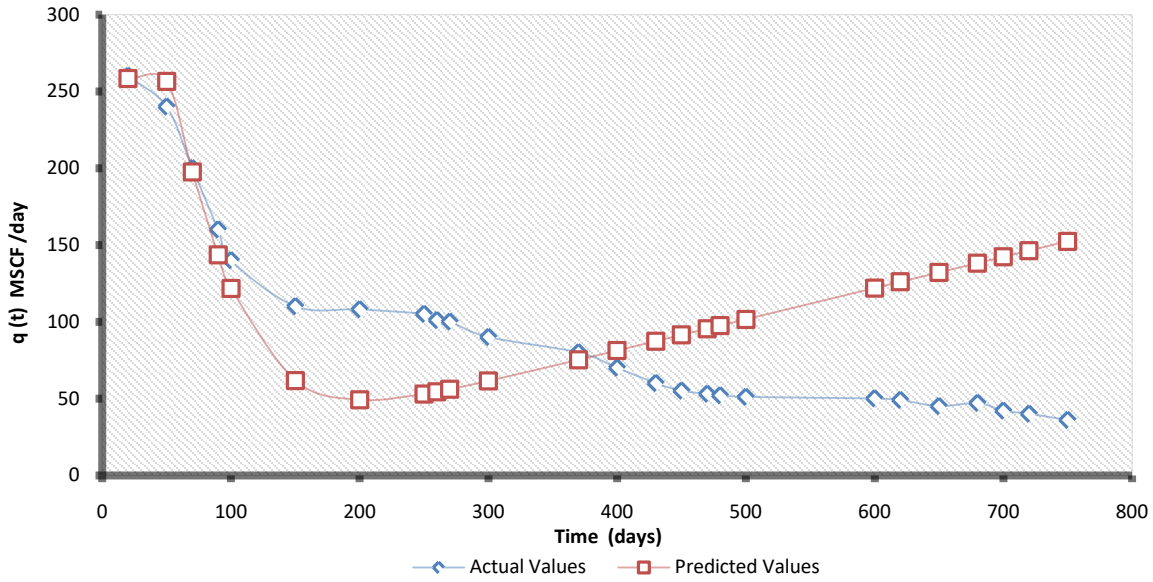


Figure 6: Graphical representation of actual flow rate vs. forecasted flow rate for shale gas production using the Arps-Duong hybrid model

The predicted results for the model appear to be severely overestimated from the actual results in the latter stage of production. This would be the result of combining the drawbacks of the two models, which causes the elevated results observed. In line with this, firstly, most shale gas wells rarely reach the boundary-dominated flow regime, hence the Arps model cannot be applied directly to SGRs without significant modifications [32].Secondly, in the findings of Paryani et al. (2018) [3], extremely high reserves estimates were occasionally observed with the Duong model. The results of Hu et al. (2018) [35] concurred with these results, for the Austin Chalk wells, whereby the Duong model gave the highest weighted residual of production rate.

f) Result for the Arps-Power Law Exponential Hybrid Model

A plot of $\frac{\frac{1}{b}}{qt}$ vs.t was used in the model forecasting. The forecasting equation is given as:

$$y = \frac{c}{1+e^{(-ax-b)}} \quad (22)$$

where c is the asymptote, b is the inflection point and a is the growth rate.The actual and forecasted values can be seen in Figure 7.

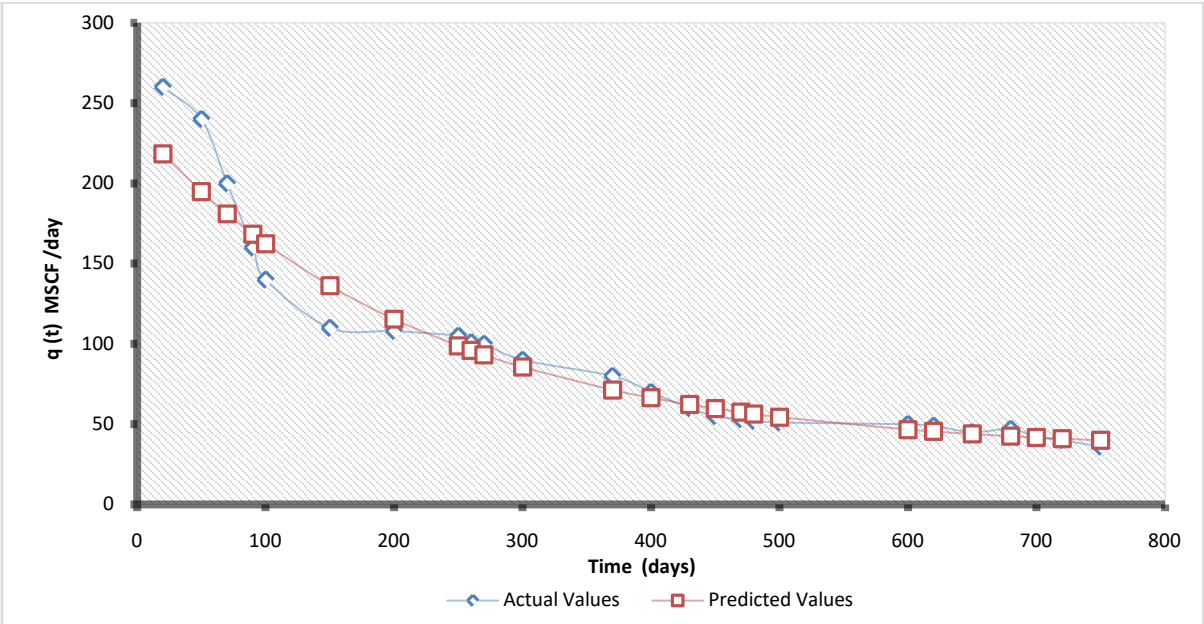


Figure 7: Graphical representation of actual flow rate vs. forecasted flow rate for shale gas production using the Arps-PLE hybrid model

The results from the model initially appear to over- and underestimate the data prediction; however, the results tend to move closer to the actual values over time. This would be attributed to the reliability in the Arps model and the fact that the PLE model was developed precisely for SGR. Moreover, both flow regimes are considered and since most shale gas wells rarely reach the boundary-dominated flow regime, the results appear to move closer to the actuals when reaching the TFR. Hence, by combining the models the overestimation of the predicted results is minimised over time.

g) The Duong-PLE Hybrid Model

A plot of $\frac{ln\ qt}{qm}$ vs. t was used in the model forecasting. The forecasting equation is given as:

$$y = a(1 - be^{-cx}) \quad (23)$$

where a is the asymptote, b is the scale and c is the growth rate. The actual and forecasted values can be seen in Figure 8.

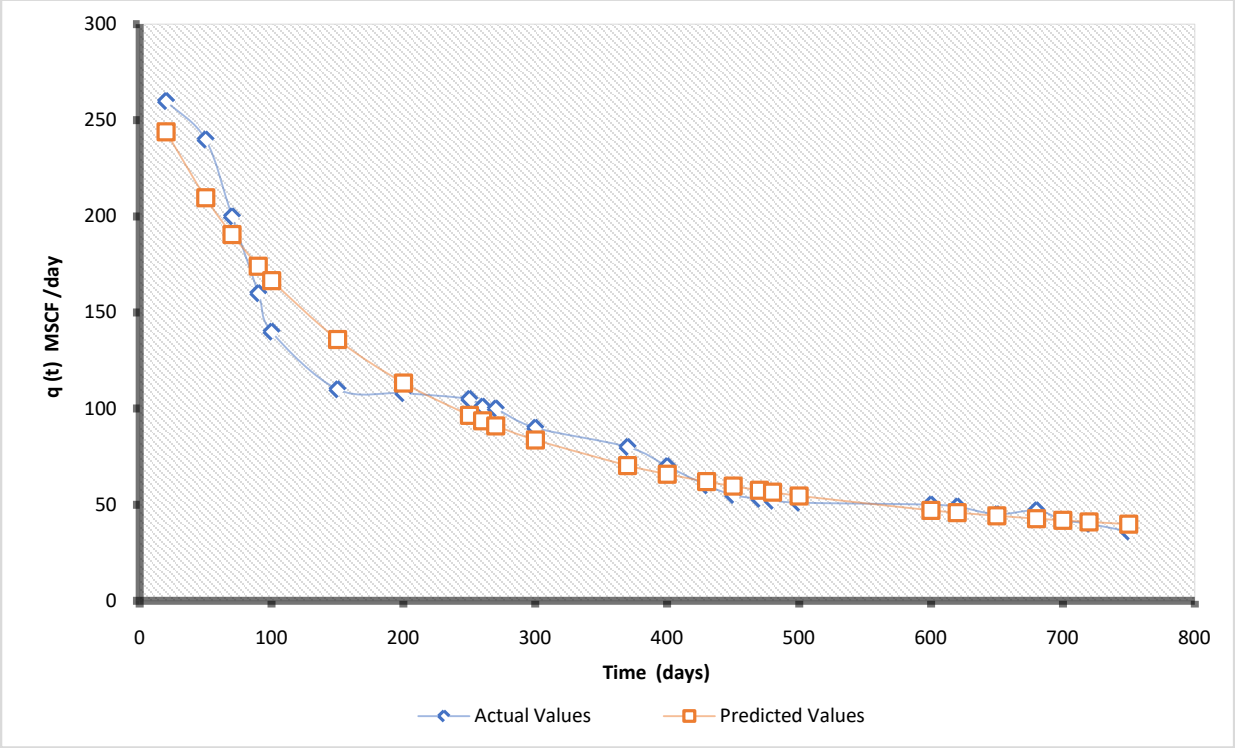


Figure 8: Graphical representation of actual flow rate vs. forecasted flow rate for shale gas production using the Duong-PLE hybrid model

The trend of the results indicate an over- and underestimation. As mentioned by Vanorsdale [36], the PLE and Doung's model will yield an optimistic recovery when the flow regime changes. This trend is clearly evident in the results when combining the models.

h) Result for the ARIMA Model

As mentioned earlier under the Research Methodology section, the best fit for the ARIMA model was a (2,1,2), which gave the best forecast values due tohaving the lowest MSE of 4.82, a low BIC of 8.23 and highest adjusted R^2 of 0,979. The best modelis reflected as follows:

$$Y_t = \theta_2 Y_{t-2} + \varphi_1 \varepsilon_{t-1} + \varphi_2 \varepsilon_{t-2} + \varepsilon_t \quad (24)$$

The actual and forecasted values can be seen in Figure 9.

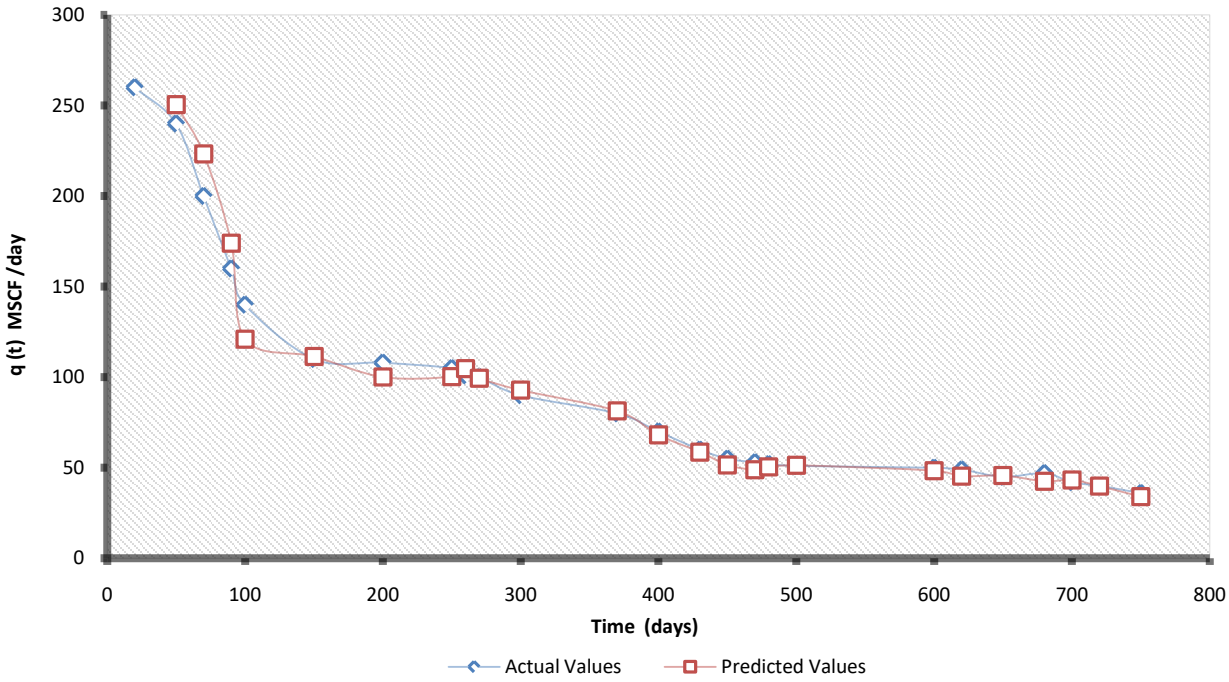


Figure 9: Graphical representation of actual flow rate vs. forecasted flow rate for shale gas production using the ARIMA model

The predicted results from the model appear to follow a close trend to the actual values. Raymond (2007) [37] suggested that ARIMA models have proved to be excellent short-term forecasting models for a wide variety of time series because short-term factors are expected to change slowly. This can explain the reason as to why the ARIMA fared well compared to the other models discussed so far.

i) Results for the ANN Model

In the case of this study, a univariate input layer and four nodes gave the best model fit i.e. (1-4-1) for the production flow rate over a period of time. The actual and forecasted values are graphically represented in Figure 10.

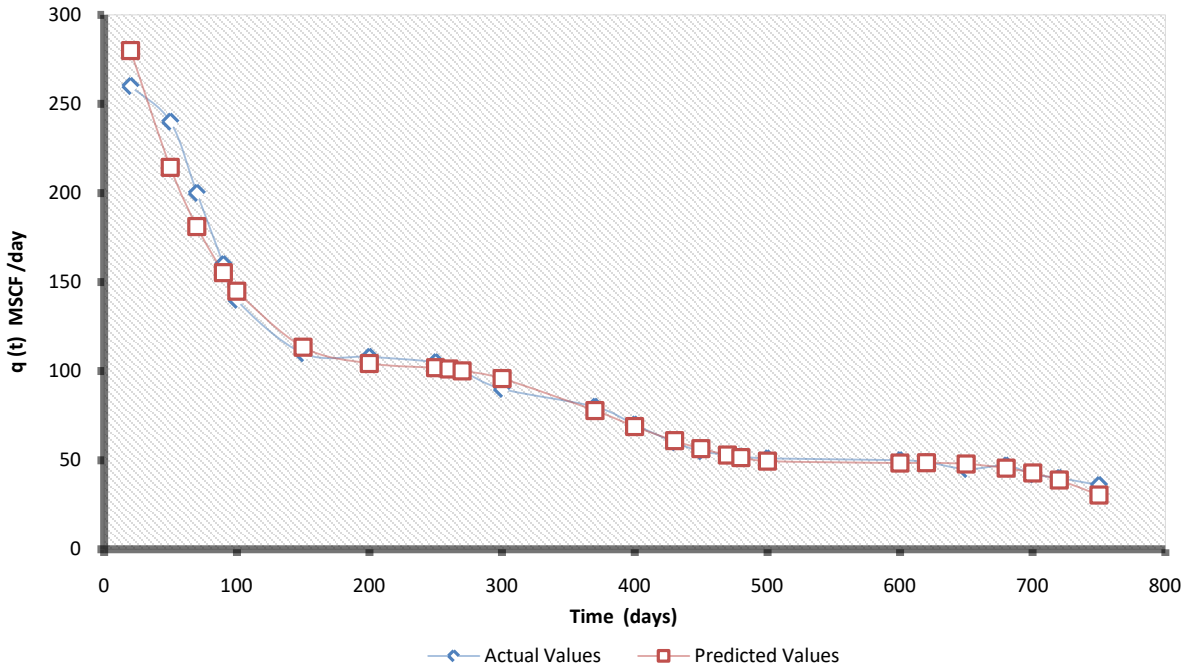


Figure 10: Graphical representation of actual flow rate vs. forecasted flow rate for shale gas production using the ANN model

The predicted results from the model appear to follow a very close trend to the actual values. Zhang (2003) [12] indicated that neural networks are useful for modelling and predicting the properties of time series data. Cybenko (1989) [38] described neural networks as having a universal non-linear function and a relatively good degree of forecasting accuracy. In addition, according to Hill et al. (1996) [39], neural network forecasting provides better results than traditional forecasting methods over monthly as well as quarterly periods.

j) Results for the ANN-ARIMA Hybrid Model

The steps employed by Ayub and Jafri (2020) [10] were used to construct the ARIMA-ANN hybrid model. This entailed a two-step process, which involved the following:

In the first step, the ANN is used to predict qt and residual et is produced and provided to the ARIMA to predict the error. In the second step, the predicted qt by ANN is summed with the error produced by the ARIMA model to give the final predicted values. The equation is as follows:

$$e_t = Y_t - N_t \quad (25)$$

Y_t is time series while N_t is the nonlinear component. ARIMA is used to reproduce e_t to generate the forecast series of q_t.The actual and forecasted values can be seen in Figure 11.

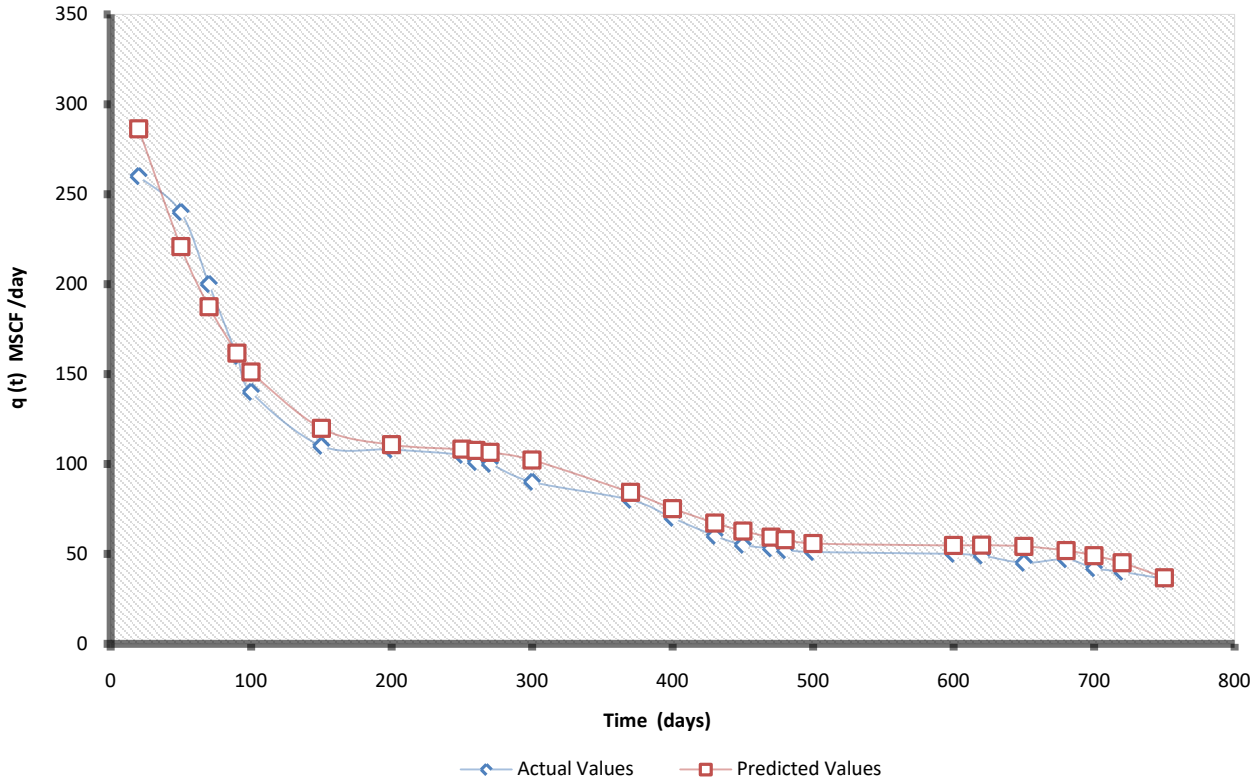
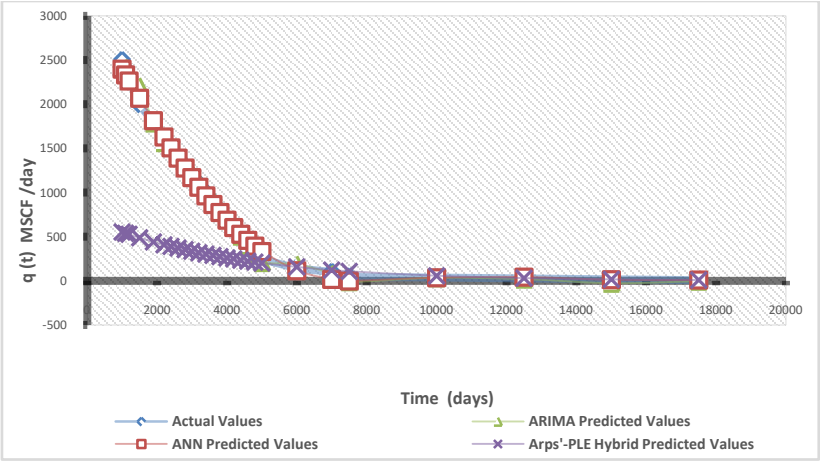


Figure 11: Graphical representation of actual flow rate vs. forecasted flow rate for shale gas production using the hybrid model

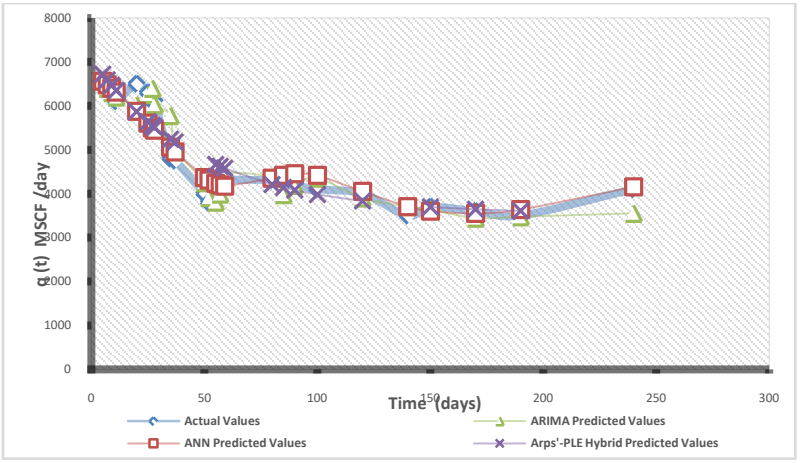
The predicted results from the model appear to be overestimated compared to the actual values. This result appears to contradict what has been indicated through the literature. According to Faruk (2010) [40], hybrid methods have a higher degree of accuracy than neural networks. Cybenko (1989) [38] indicated in his work that hybrid models combine the advantages of ARIMA with respect to linear modelling and neural networks in terms of non-linear edge modelling. However, Taskaya-Temizel and Ahmad (2005) [41] made reference in their work that in some circumstances, the single model approach can outperform hybrid models. This has been observed during this study.

k) Model Accuracy Evaluation

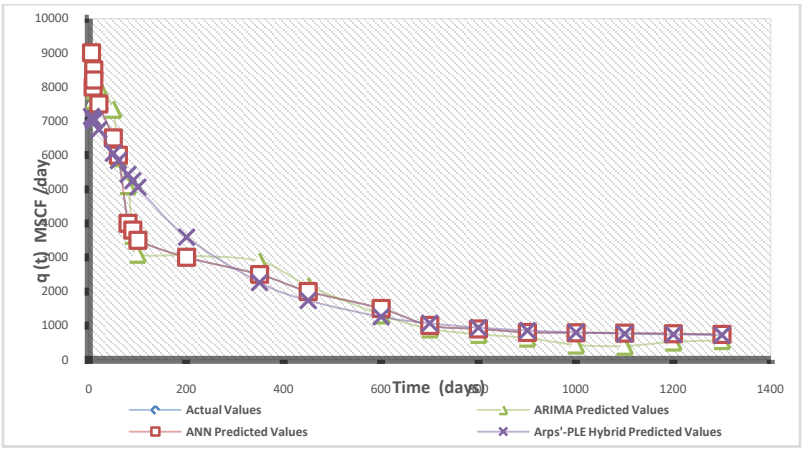
In order to assess the accuracy of the models, three sets of different production data were used to perform the evaluation. The estimated data was extracted from the work of Adekoya et al. (2009), Brantson et al. (2019) and Tan et al. (2018) [32;42;43]. Figure 12 illustrates the actual data vs. the predicted data for the ARIMA, ANN and Arps-PLE hybrid models.



(a)



(b)



(c)

Figure 12: Estimated production data to determine accuracy of the different hybrid models (a), (b) and (c) ARIMA vs. ANN vs. Arps-PLE hybrid model [32;42;43]

The results from graphs a, b and c indicate that the ARIMA and ANN models appear to predict the production data very close to the actual values in all three production data; however, this is not the same trend observed for the Arps-PLE hybrid model. The model appears in one instance to underestimate the data and in the other two instances to overestimate the data. Hence, the results prove that with the Arps-PLE hybrid model there is no consistency or accuracy in the prediction of results in the three different production data when compared to the ARIMA and ANN models.

IV. Conclusions

The objective of this study was to evaluate the forecasting performance of decline curve hybrid models and ANN-ARIMA hybrid models with Arps', Duong's, PLE decline models, ARIMA and ANN models respectively. The experimental results were obtained using the different prediction models i.e. Arps', Duong's, PLE, Arps-Duong-PLE hybrid, Arps-Duong hybrid, Arps-PLE hybrid, Duong-PLE hybrid, ARIMA, ANN and, lastly, the hybrid ANN-ARIMA model. The following can be concluded from the study:

- The current DCA models, Arps', Duong's and PLE models appear to over- and underestimate the data.
- The DCA hybrid models also did not give the best outcome, which it was assumed they would, in comparison to the individual DCA models. However, the Arps-PLE hybrid model gave the closest predicted results compared to the other DCA hybrid models and the individual models.
- Both the ARIMA and ANN models gave the best predicted results compared to all the models evaluated in this study. However, when both models were combined into the ANN-ARIMA hybrid model the strengths of both models referenced in literature did not provide accurate predictive data. The result was an overestimation in the production flow rate.
- Overall, the models which gave predicted values closest to the actuals in order of rank were the ARIMA, ANN and the Arps-PLE hybrid model.
- In the model accuracy evaluation, the Arps-PLE hybrid model did not provide a consistent prediction. The model under- and overestimated the production data compared to the ARIMA and ANN models.

In conclusion, this study contradicted the findings from literature which indicated that hybrid models have a higher degree of accuracy. However, the study concurred with Taskaya-Temizel and Ahmad (2005) [41], whereby in certain circumstances the single model approach can outperform the hybrid models. Future investigation should therefore validate the ARIMA and ANN models for SGR decline forecasting using the factors R^2, MSE and MAPE.

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Implementation of Lead Time Reduction in Merchandising Department using Lean Techniques

By Dhaarani U & Thenmozhi R

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GJRE-J Classification: *FOR Code: 091599*

Strictly as per the compliance and regulations of:

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Keywords: lead time reduction, time and action plan, better optimum results.

I. Introduction

Lean is a culture in which many people use as a tool to solve the continuous problems occurs in the manufacturing industry, the main goal is to provide customers expectation and satisfy their need, and it also helps to reduce the wastage. It promotes the flow of value to the work flow by implementing continuous improvement in the overall work in progress, some of the most used lean techniques are 5s, kaizen, value stream and just in time methods. It also helps to maintain inventory, better motion and it eliminates wastage, defects, over-processing, and over production. Lead time is the amount of time required from the start of a process until date of completion. The organizers are reviewing their lead time in the form of manufacturing, supply chain management, and project management during pre-processing, processing and post-processing stages. Reducing lead time can streamline the operations, improve productivity, increasing output and revenue Production processes, and inventory management both are affecting lead time. Transportation delay may lead to delay in the routing process, slows down the production and reducing output and return on investment (ROI). During high demand product production, productivity may increases that may lead to reducing production time automatically. The quicker production process to increase sales, customer satisfaction, and organizers' reputation. To maintain the production schedules and consumer demand, its necessary to manage the inventory. The production process will get stopped if the organization fails to have the required amount of stock. The inventory management has been done through vendor-managed inventory (VMI) program, which provides automated stock replenishment. These can be done by the off-site supplier, using just-in-time (JIT) inventory management for ordering and delivering components based on usage.

Some lead time delays cannot be predicted. A shipping delay may happen due to raw material shortages, natural disasters, human error, and other uncontrollable issues that will affect lead time. For a critical situations, the organization may employ a backup supplier to maintain production. Working with a supplier who keeps inventory on hand can prevent from delay. This research is to focus on increase lead time, productivity, and mange the inventory by applying lean techniques.

II. Literature Review

The quick changes in garment styles, the deviation of the requested amount, and the improvement of the quality level with the most minimal cutting rate require the garments producing industry to concentrate on more powerful and effective assembling procedures to get by in the profoundly serious market [1]. These days, the degree of rivalry is extremely high, and each industry is attempting to give great items at a sensible expense, so lean creation is the most recent device to accomplish this goal [2].To increase the profitability of the clothing ventures we have to diminish the wastage of the assembling and time to make the product. Lean is the device to decrease the wastage in all procedures of clothing manufacturing, diminishing expense, and worth added to the item [1]. The idea of lean assembling has been presented in Japan, and the Toyota creation framework was the first to utilize lean practices. Lean assembling helps in improving creation forms and boosting up the worker's work fulfillment (Singh, Garg, Sharma and Grewal, 2010c) [3]. Promoting capacities is to design clothing items to draw in their objective customers, a value that they ready to purchase, styles they need, and the ideal time they need

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to purchase. Earlier anticipating is one of the most significant angles to achievement in the present clothing industry [7]

Prior, India would send out low-esteem things, like fiber, to create textures for garments. Anyway, net revenues are most noteworthy in the texture. India has developed as an overall major sourcing base of cotton attire and the vast majority of the main US retailers, for example, J.C.penney, Gap and Nordstrom ,etc[13]

Deals execution by item classification, traffic stream structure, benefit commitments by item classification, the ID of promoting issues, targets for the coming exchanging period, marketing strategies, timing of usage, material providers, preparing necessities, contender response, spending plan and methods for assessment are the important significant reports kept up by the merchandiser[14]

With the active support and cooperation of the purchasing department and product developers, the development of samples was observed based on the technical data of specific buyers. Researchers directly or indirectly participated in the study of the sample preparation and approval process of the knitted composite material factory [6]

The sewing industry is a major part of the textile industry, which requires many operations to be performed by using sewing machines to assemble fabric pieces and attaching various accessories (such as elastic bands, buttons, and labels) [21].

Each department must mainly focus on lead time management to meet their customer needs. Lead time can be measured throughout the manufacturing process, which indicates how quickly raw materials can be transformed into finished products [8]. The exporter is the most important link in the industry where the manufacturer produces the goods ordered by the buyer. The buyer determines the specifications, quality, price, and time[11].

Most studies only focus on a single aspect of lean elements, and only a few focus on more than one aspect of lean elements, but to successfully implement lean organizations, organizations must focus on all aspects, such as value stream mapping (VSM), cellular manufacturing (CM), U-line system, production line balance, inventory control, single minute mold change (SMED), pull system, kanban, production leveling, and timely [4]

5S visual management is one of the lean tools to improve the process, used to establish the workplace organization to a more standardized level. Reduce problems in the work process, improve product quality and productivity [1] Kanban is a subsystem of the lean manufacturing system, and its purpose is to control inventory levels, component production, and supply [4]. This is an important tool to increase output from the push-pull system. Improve flexibility to respond to customer needs, simplify the procurement process and eliminate unnecessary paper work [1] From a production point of view, it is controlled by the logistics chain, which is an important way to realize JIT [21] Value stream-the collection of all the specific operations required to bring a specific product through the three key management tasks of any enterprise. Problem-solving, information management, and physical transformation, it is the process of mapping materials, and information flows to coordinate activities performed by manufacturers, suppliers, and distributors to deliver products to customers [4].

Just in time means to provide one part at a time, exactly when needed. It helps reduce batch size, buffer size,and order delivery time [3]. The JIT method is called continuous improvement or kaizen method, kai stands for change, and zen stands for better. Therefore, it means that continuous change is better to involve everyone in the company and gradually eliminate problems by collecting data [3] Indian apparel manufacturers try to eliminate waste and increase productivity at a lower cost. At the same time lean manufacturing tools help improve the process environment by eliminating waste with a reasonable investment. It helps manage garment manufacturing waste [1]

By using lean tools to control production, waiting, transportation, excessive inventory, unnecessary movement and excessive production of major defects, this is an efficient system that brings new achievements to the industry and customers, and it is also committed to the concept of zero waste and provide better quality and benefits to customers [2]. Lean surveys have been carried out to reduce some obstacles and make it possible to run counter to the implementation work, psychological problems, lack of responsibility, financial problems, lack of education, training, and demand turbulence are some of the drawbacks [3].

Utilizing the blended technique approach, the examination found that most organizations, as a major aspect of their methodologies, decided the point by point and genuine article of clothing cost by thinking about the benefit, texture, work, trim expense, and overheads. Cost in addition to technique, advertise investigation, markdown procedure, client-based evaluation, and market division were the most famous ways to deal with fixing articles of clothing costs [5]. The four distinct phases of an article of clothing costing are starter costing, cost evaluating, point by point cost, and real expense. New textures and conceivable change made to the examples likewise considered in the piece of clothing costing. Significant segments in the article of clothing cost are materials, trims, and work. Trims incorporate help materials, for example, interlining, strings, terminations, elastics, and names. Texture type and amount of the texture are regularly seen as a significant expense all together execution and wastage

level of the texture during the cutting procedure is the most troublesome procedure to evaluate [5].

Correspondence issues, for the most part, happen in apparel advertising and estimating, item advancement, speaking with purchasers and providers, finishing arranging including time and activity plan, sourcing of crude materials, haggling with all the required separate, example improvement and endorsement, valuing, booking, oversight, checking the request just as creation, obligations, and responsibility, request managing and controlling, revealing according to require, observing the whole process like CAD, cutting, sewing and washing and so forth, item conclusion, assessment and arranging, last shipment[6].

It identifies with all the divisions like from request to shipment; it guarantees that all the movement assists with enduring cash. Still, a large portion of the enterprises don't know an accurate number of tests required for the purchasers, so it results that consistently the greater part of the ventures shut down their business because of the absence of executing order[9]Industry finds it extremely difficult to identify and arrive at exact profit made from a particular order or style. To identify the actual manufacturing cost and compare it with the cost projected and identify the areas which exceeded the cost projected for each order and style [15].

Each division has a particular objective of diminishing the lead time with the planned impacts. Embracing innovation to take out more harms and decrease of wastage of pieces of clothing, it additionally assists with cutting down the remaining task at hand and serves to diminish the assembling cost. The business needs to guarantee that there is a legitimate progression of expected data to accomplish the shared objective of decreasing the assembling lead time [8].

Costing of clothing is evaluated at the hour of test advancement, including barely any attributes, for example, crude material cost, producing cost and over heads, regulatory overheads, and cost of transportation and benefit margin[10]. Fabric issue, shading conceal coordinating of texture, coloring, and imprinting in examining, conceal coordinating of frill and sewing string, crease puckering, sewing quality, shrinkage of pieces of clothing, completing of tests and untalented professional are the most widely recognized issues looked in the request execution[16] The finished sample garments undergo a thorough evaluation ,whether they want to present the overall picture of the styles in a particular collection. Then the sample garments are accepted or rejected [17].

For creation and all different procedures are isolated into two classifications: esteem included and nonesteem included. For the most part, it tends to be commonly characterized by other hardware, parts, materials, space, and work time, which are fundamental in increasing the value of the item or administration [21]. The total venture made on assembling an article of clothing is called fabricating cost; cost of a piece of clothing is anticipated at the hour of test advancement with numbers showed up at dependent on broad assembling boundaries, for example, crude materials, over heads, and overall revenue [10].

Generally speaking, assembling cost of the processing plant is estimated with Standard Average Minute (SAM) esteem; distinguish the utilization and different overheads. . An old-style model could be created to distinguish the specific expense brought about in thr assembling process, for instance: a specific style by evaluating the specific expense of crude material expense of creation per unit, overheads, genuine dismissal, edge, and cost ready. Growing such Add on arrangement could take as long as 60 days, i.e. is again controlled by the degree, multifaceted nature and different components [10].

Industry discovers it amazingly hard to recognize the specific benefit produced using a specific request, to distinguish the genuine assembling cost and indentify the concerned zone which surpasses the cost anticipated for each request and styles [12]Lead time in clothing assumes an indispensable job, so every office needs to concentrate on lead time decrease to fulfill their client need, and it very well may be estimated on the absolute assembling process it demonstrated about the completed item quality and the vibe of the item ,and it is the one of the most significant factors which will help the association [8].

Style industry requires gifted chiefs with a sharp feeling of the commercial center and finely sharpened administration aptitudes that empower them to settle on the basic choices expected to stay with a's product offering seriously attractive and profitable. A merchandiser is a mindful individual to make the item as per the purchaser's boundaries and fulfillment. Merchandisers need to care for each activity directly from purchasing the crude material, segments, and adornments, making the attire, completing the clothing, documentation, and correspondence to and from all colleagues to at last delivery and significantly more. The merchandisers assume the job of a 'support' inside clothing to send out associations, arrange and balance the business needs of the provider toward one side and purchaser on the other. Their exhibition influences the business aftereffects of clothing send out organizations [16].

Item advancement and its job in worldwide sourcing appear to be significant for merchandisers. The obligation could be as little as obtaining materials for item improvement, reaching out to the dynamic work relationship with item engineers. Merchandisers must comprehend the Item improvement procedure and worldwide sourcing and a period and activity schedule, to impart the hugeness of ideal subsequent meet-ups in crude sourcing materials [11].

Quality affirmation information in clothing assembles and conveyance proposing that quality confirmation encourages them to deal with the conveyance plans for a superior way. "Information on a unique item costing" and retail recommending that retail valuing figuring is to be overseen by merchandisers. Association and relational abilities have a better mentality, and it ought to contribute to improving the work culture of the association [14].

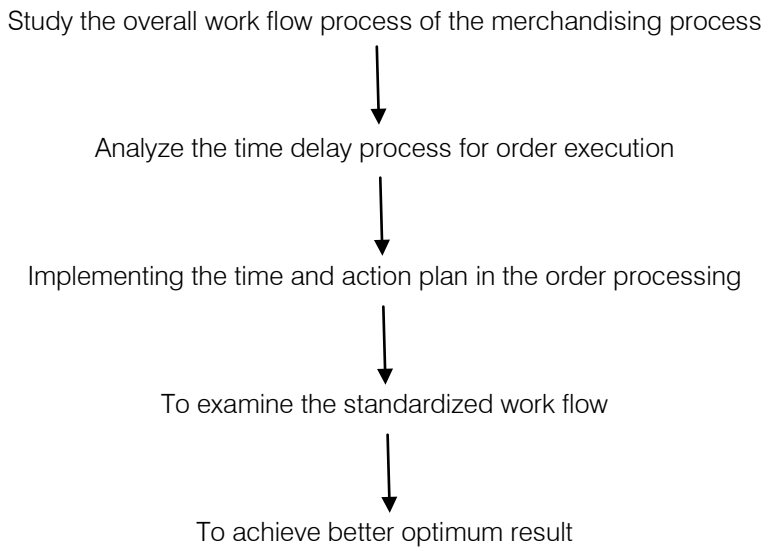
The reason for the examination is to distinguish the job and significance of marketing and the fulfillment level of overall revenue, scarcely any inquiries were engaged are does the client gets a similar item what he prefers, does it offers fulfillment to the buyer. It does the best possible promoting will build the productivity of retailers [20].

The components of configuration were related with useful, embellishing and tasteful highlights that are identified with the presentation, hues and format of the items [18] Due to the specialized impediment of photograph imprinting in a test where clients were requesting real view and shade coordinating of photograph print however in genuine case it was unrealistic due to some specialized constraint by the industrial facility since it requires some investment of test making and endorsement [16]. The merchandiser's wages are paid by the maker and relies upon retailers, his goal must be animate stock go into assembling and advertising economies are accomplished by the workers in the processing plant and this manner creating more beneficial exchanging [14].

To find out the strategic advantages of lean techniques in the apparel industry and helps to compare production data in terms of SMV target, line efficiency, bottlenecks, capacity utilization in both traditional and lean production line and to compare the productivity factors like transportation, inventory analysis, space utilization, defect analysis in both traditional and lean line production [19]. Technological problems were found in garment sample department are control of thread tension, the problem of thread puckers, irregular movement of fabric during take-up, sewing dynamics with change in fabric and thread mechanical properties, problem of needle heating and damage and needle penetration force [16].

Implementing lean techniques in the sampling department helps to optimize the better result for the sample development, and it also helps to compare the previous and future data of the sampling process.

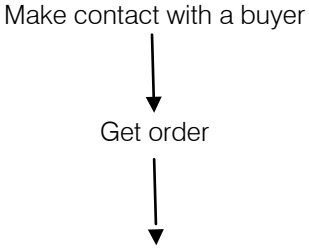
III. Methodology

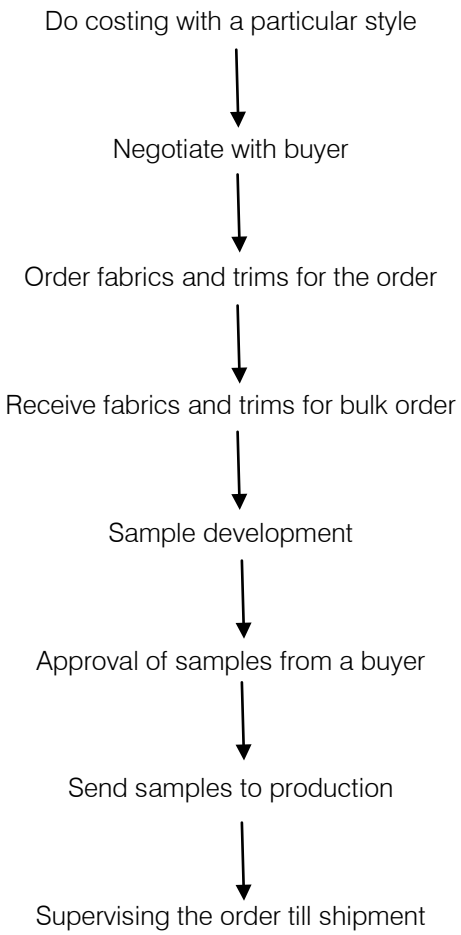


Methodology 1:

a) *Study the overall work flow process of merchandising process*

Merchandising is the department that intermediates between the buyer and the production team. A garment merchandiser has to interact with various departments to complete work on time. It involves understanding customer needs, planning and scheduling the work in progress, deciding on the pricing, and communicating with the people.





Methodology 2:

b) Analyze the time delay process for order execution

Time delay for the various process has been done. It was analyzed at various stages like pattern making process for complicated design, raw material delay, delay in the washing process, and lack of stock. It was observed from the study CAD department has played a major role in calculating fabric requirements for a particular order. If there is a delay in that process results in a delay in fabric manufacturing process. This type of delay may be delay in the washing process. Other than above process delay, the various list of process delay has been discussed here such as lack of fabric and trims, technical issues as improper and lack of machinery, insufficient man power, lack of communication between various departments, sample approval delay and delay in lead time. To over come all the above lean tools such as 5S and kaizen were implemented.

Methodology 3:

c) Implementing the time and action plan in the order processing

The time and action plan is an important tool for a merchandiser to analyze the day-to-day activities involved in the process of completing an order. TNA is the most important activity for timely shipment. This process involved various departments and the process of manufacturing. T&A plan helps the merchandising department to analyze every individual operation in terms of start and end of production activities. Time and action calendar define the ideal date and period within which the major activities of an order should occur against a scheduled delivery (i.e., defines the planned date and actual date) from that the delay period can be identified. The merchandising department is highly responsible for developing a list of activities that need to be performed for order in an excel sheet, in that need to mention the expected date of completion. After completion of the TNA calendar, the activities such as the execution of process and its problem were analyzed.

i. *Time and Action Plan: Order 2131U*

T & A plan for an order 2131U (Formal shirt) style had been analyzsed and listed the over all activities with the proper schedule.

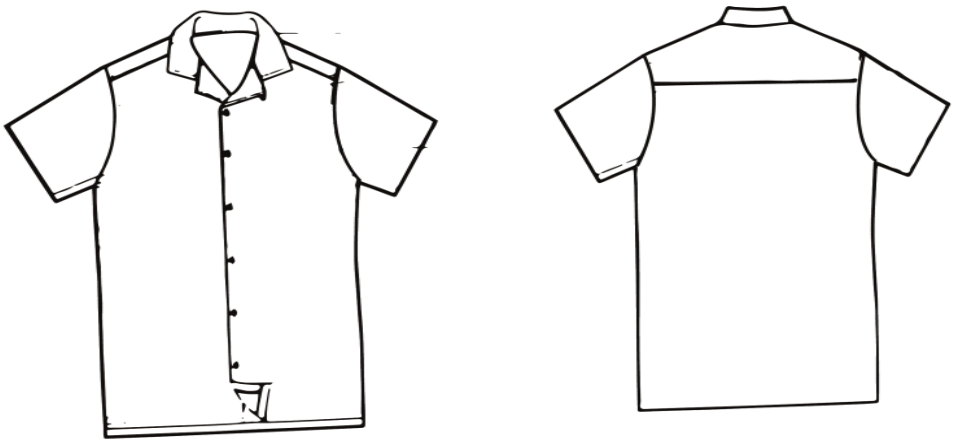


Fig. 1: Formal shirt

Table 1: Time and action plan

Buyer: M&S -T53	Style no: 2131 U			order quantity: 2000	
Fabric details: 100% cotton woven shirt	Product details: Women's LS denim shirt			Delivery date: April 21 2020	
Activity					
order details	Delay date		Days required	planned date	Actual date
order received date	0	1			
proto sample submission	0	2			
proto sample approval	0	2			
order confirmation	0	2	1	04.02.2020	04.02.2020
L/C received date	0	2	3	06.02.2020	06.02.2020
Lab dip status					
Lab dip sub date	0	5	5	08.02.2020	08.02.2020
Lab dip approval date	1	6	10	13.02.2020	14.02.2020
Fabric and trims for sample					
Requested fabric and trims for sample	0	6	16	19.02.2020	19.02.2020
Requested fabric and trims inhouse for sample	-1	3	22	25.02.2020	24.02.2020
sample making					
Fit sample approval	3	6	25	28.02.2020	02.03.2020
CS sample approval	6	7	31	05.03.2020	11.03.2020
Requested fabric and trims for bulk	0	3	4	07.02.2020	07.02.2020
Bulk fabric inhouse	5	38 days(1)	38	12.03.2020	17.03.2020
Bulk trim inhouse	3	34 days(5)	34	08.03.2020	11.03.2020
Test report approval	5	2	39	13.03.2020	18.03.2020
wash(heavy wash) and shade band approval	5	2	39	13.03.2020	18.03.2020
production					
planned cut date	-1	1	41	15.03.2020	14.03.2020
PP meeting	0	1	41	15.03.2020	15.03.2020
cutting	2	30 days(1)	42	16.03.2020	18.03.2020
Bulk production starts	2	30 days(3)	43	17.03.2020	19.03.2020

Finishing date	2	17	68	11.04.2020
In-line audit date	1	1	69	12.04.2020
Quality checking	1	1	69	12.04.2020
packaging	1	1	70	13.04.2020
Final quality inspection	0	30 days	71	14.04.2020
Ex factory	2	30 days	71	14.04.2020
shipment date		7 days	78	21.04.2020

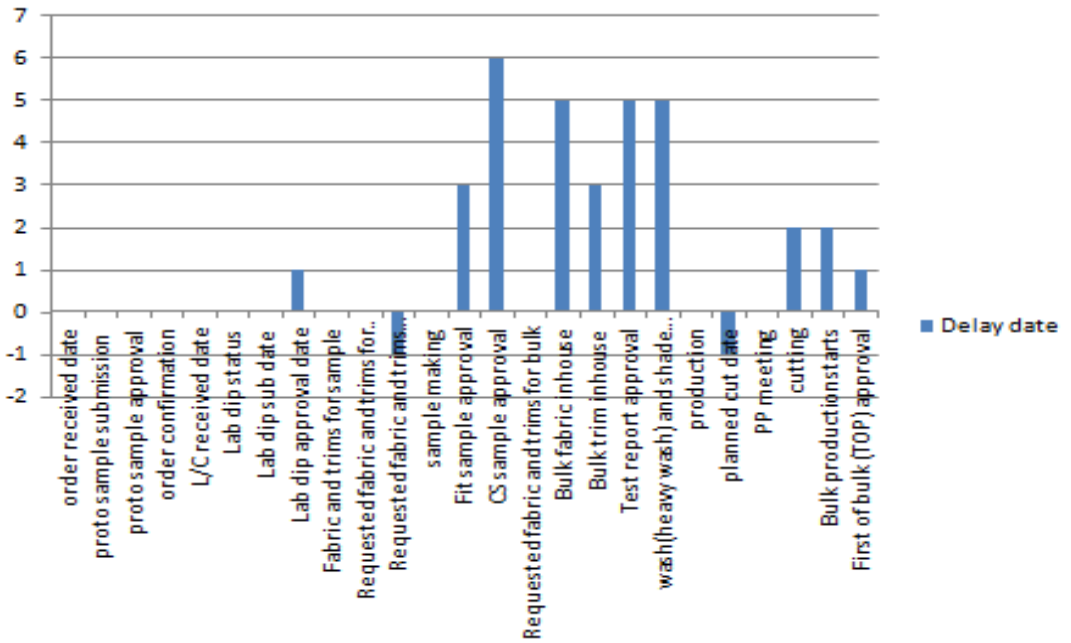
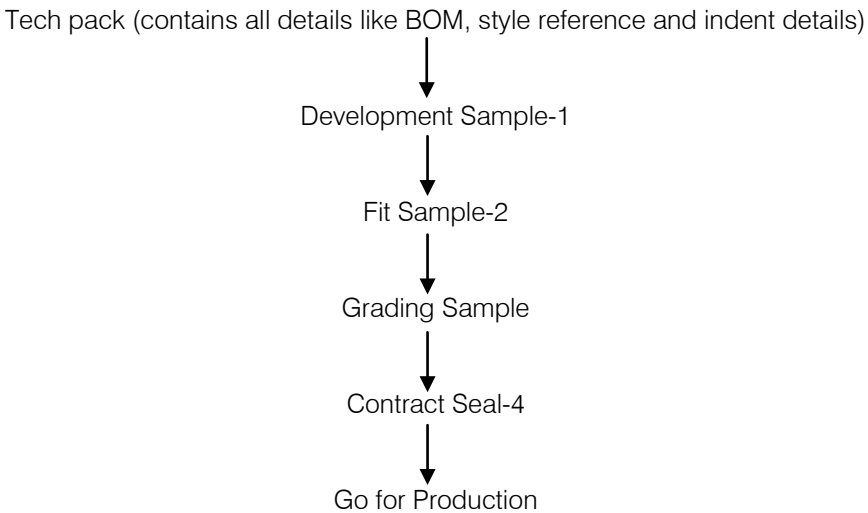


Fig. 2: Delay date

From the above flow chart, the time required for order execution has been identified. Analysis results showed that the sample making process takes more time than the planned actual time and for execution of few operations takes only less duration. This helps to identify the delay process, and fast making process by doing this study will also helpful for future order execution.

Methodology 4:

d) To examine the standardized work flow



Three contract seal samples (One sample for merchandiser reference and two samples for buyer approval), but usually one more extra sample had to be done for a factory use (to avoid production delay).

Methodology 5:

e) To achieve the better optimum result- comparing actual and planned capacity

i. *Actual capacity*

Two lines and 34 operators were allocated for development sample, fit sample and pre-production sample making. Based on the buyer requires the samples were made. The actual capacity per day is 50, and the monthly capacity is 1200 samples were done.

ii. *Planned capacity*

Operator capacity (garments/day) = 2
Total operators = 34
Total garments produced/day = Operator capacity X Total operators
= 2 X 34=68 garments/day

The actual capacity plan with a lean implemented capacity plan was analyzed and compared. It was observed from the results; the lean implemented capacity plan showed better results of productivity.

IV. Results and Discussion

By analyzing the overall process of the merchandising department, helps to know about the delay process like sample approval, wash delay, etc. To reduce time delay process, arrow chart and communication clarification to the buyer and Daily correspondence with the buyer has been done; this helps to built a proper communication with the buyer, response to the buyer complaints, understanding the requirements of the buyer and satisfy their needs by submitting the required samples and documents, follow up the comments from the buyer. By scheduling the TNA plan, the delay process for overall order execution has been identified and was implemented for the next order. To examine the standardized work in progress, the proper filing and better communication have been done. By accommodating samples to each, labor gives high capacity and also helps to submit the samples to the buyer on time without any delay; this also was executed the order without any time delay.

V. Conclusion

Studied the over all work flow process for order execution, analyzed the time delay process, implemented the time and action plan to avoid the delay period, balancing the standardized work process and increased the capacity by comparing with the existing plan results have been achieved by implementing the lean techniques.

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Obtaining an Empirical Equation for Correcting the Melt Flow Index of Virgin and Recycled Polypropylene Mixtures and Analysis of Mechanical Properties of the Blends

By Luiz Gustavo Barbosa, Cassiano Rodrigo Dalberto & Edson Luiz Francesquetti

Abstract- Polypropylene is one of the most used materials in the world because of its easy processability and good mechanical properties under different applications. As a result, a lot of polypropylene waste is being generated and recycling is important.The problem with recycling polypropylene is the changing in the properties when compared to virgin polypropylene. Processability parameters and mechanical properties of traction and impact can be changed after recycling this material, affecting companies in the polymer transformation sector. Thus, this work aims to obtain an empirical equation for the correction of the melt flow index of virgin and recycled polypropylene mixtures and also conducts a study on the mechanical properties of the mixtures comparing them with those of virgin polypropylene. The empirical equation found shows a linear relationship between the melt flow index of the mixture and the percentage amount of virgin polypropylene. From the mechanical properties, it was observed that the stiffness of the mixtures is similar to that of virgin polypropylene, however the energy absorbed under impact is considerably lower, compromising the use of recycled polypropylene for such application.

Keywords: *recycled polypropylene, melt flow index, mechanical properties of polymers.*

GJRE-J Classification: *FOR Code: 291899*

Strictly as per the compliance and regulations of:

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Keywords: recycled polypropylene, melt flow index, mechanical properties of polymers.

I. Introduction

Polymeric materials are an important group of the materials engineering because their easy production and wide range of applications. This group includes materials such as plastics and rubbers ranging from low density liquids to rigid solids [1].

The growth in the consumption of plastics in the world is evident. In 1964 around 15 megatons (Mt) were generated, in 2014 this production reached 300 Mt. This production is expected to double again within 20 years, and by the year 2050 it has practically quadruple [2].

Is estimated that if plastics were replaced by other packaging materials, there would be an increase of approximately 60% in the volume of waste produced, 57% electricity consumption over the entire product life cycle and between 78 Mt to 170 Mt of complementary greenhouse gas emissions [3].

Despite the use of plastics in general, more specifically the polymers, to exhibit a decrease in the generation of waste, their discard, as well of other consumable materials, also contributes to the production of urban waste and for the waste in the oceans with the aggravation of not being biodegradable, soon this residue remains for long periods in the nature [4].

One way to mitigate such problem is the reuse of polymeric materials, by secondary or mechanical recycling which according to the Union of the Plastic Material Industry of the State of São Paulo (Sindiplast) and the Environmental Company of the State of São Paulo (CETESB), "[…]is the converting of plastic waste into granules that can be reused by the productive sector to make other products […]" [5].

One of the most used plastics in the world is the polypropylene (PP) wich, due to the great increase in its productive capacity caused its cost to decrease, so it may be used in new much applications. PP has characteristics that allow it to be subjected to many processing techniques such as Injection, Extrusion, Thermoforming, Rotational Molding and Blowing [6]. The main application of PP is in the food sector, representing 32% in products such as: packaging, lids, tupperwares, jars, bottles and gallons. In the consumer goods sector PP represents 17% of the market and is applied in packaging and boxes. In civil construction represents 3% of the market and, among others, it replaces asbestos in fibre cement tiles and water tanks, and it serves as a partial substitute of concrete in slabs with the use of BubbleDeck [7]. Also, it is a raw material for the Pack Less, a plastic pallet. In the automotive sector it represents 9% of the market, being used in dashboards, door panels, bumpers, grilles, for example. [8]. Therefore, all this material when discarded can be recycled and originate new products. In Brazil, about 8.2% of the post-consumer polypropylene is recycled, which is processed into pellets through mechanical recycling and subsequently produces packaging,

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automobile components and other recycled products [9].

However, in its use, recycled PP has different properties in relation to virgin. One of these properties is the Melt Flow Index (MFI), defined by many authors as the material's processability index. The value of MFI is important for defining the polypropylene transformation process and also in the processability and quality of the parts produced with this material, being that PP's that have a higher MFI are more suitable for injection processes [10].

In practice, when a polypropylene is recycled presents a higher melt flow index than when virgin. The recycling causes changes in chemical structure, in the melt viscosity, crystallization behaviour, and tensile and fracture properties. The main effect of recycling is the lowering of the melt viscosity, which is attributed to molecular weight decrease and consequently increases the melt flow index [11]. From experience, it is known that changing the MIF can be responsible for problems during the plastics process transforming such as bubbles, fillers, poor filling of the mold, in injected parts in which this material is used.

In this context, and considering the PP's used for making parts in a plastics processing company in the state of Rio Grande do Sul, Brazil, which uses both recycled and virgin PP's, the purpose of this work is to obtain an equation to correct the melt flow index of virgin and recycled polypropylene mixtures in order to keep it within the processability values required by the company and standardize the material used. To verify if the parts injected with the mixture between virgin and recycled PP's attend the technical specifications, the mechanical properties of traction and impact were tested.

Its important to note that recycled polypropylene, in addition to having an interesting ecological bias, is also more economically viable. Therefore, virgin and recycled PP mixtures can attend projects requirements and economic and environmental demands.

II. Materials and Methods

a) Materials

Neat polypropylene (PPv), commercial grade PP CP442XP, was provided by Braskem S.A. (Brazil) with a melt flow index of 26g/10 min (230°C / 2.16 kg), with yield stress of 32 Mpa.

Polypropylene from secondary recycling (PPr) with a many different melt flow index: 5.91, 5.93, 7.70, 8.23, 8.36 and 12.29 g / 10 min (230°C / 2.16 kg) was provided by Coplast - LTDA from Manaus city (Amazonas, Brazil).

b) Methods

i. Mixture preparation

The materials used for the measure of the melt flow index were blended in the proportions shown in Table 1.

Table 1: Composition of the samples used in the tests of melt flow index

Sample	Composition	
	Virgin (%)	Recycled (%)
PPv100	100	-
PPr10	90	10
PPr20	80	20
PPr30	70	30
PPr40	60	40
PPr100	-	100

The specimens for the tensile and impact tests were injected in the proporcional for 30% of virgin PP and 70% of recycled PP, following the dimensional requirements of ASTM D638-02a and ASTM D256-02, respectively. Table 2 shows the parameters used during their injection.

Table 2: Injection Parameters Used in the Preparations of Test Specimens

Injection Parameter	Value
Maximum holding pressure (MPa)	35
Maximum injection pressure (MPa)	50
Maximum back pressure (MPa)	8
Decompression pressure (MPa)	55
Injection time (s)	5
Temperature of zones 1 to 4 (°C)	200
Temperature of zone 5 (injection) (°C)	195

ii. *Obtaining an equation to melt flow index of virgin and recycled polypropylene mixture*

The obtaining of an equation relating the melt flow index with the different proportions of PPv and PPr, was carried out empirically, carrying out tests with the different mixtures. After the rheological tests were performed, MFI x %PPV graphics were generated, and so the linear equations and the general equation was obtained of the melt flow index as a function to percent of virgin polypropylene in the mixtures.

c) Characterization

i. *Melt Flow Index - MFI*

The experiment was accomplished in IFRS – Campus Farroupilha, in Farroupilha city (Rio Grande do Sul, Brazil), using an INSTRON CEAST equipment, type 7023, at a temperature of 230°C , 2.16 kg and 420 seconds to stabilization in according to ASTM D1238.

ii. *Differential Scanning Calorimetry (DSC)*

The crystallization (Tc) melting (Tm) temperatures, and percentual of Polypropylene and polyethylene were measured by differential scanning calorimetry on a DSC 6000 PerkinElmer. Samples of 8 mg were analyzed under nitrogen atmosphere under a flow rate of 20 mL/min. In order to erase their thermal history, samples were initially heated at 30°C to 200°C with rates of 50°C/min and kept at 200°C for 2 min. Then, they were cooled down to 30°C with rates of 20°C/min to determine the crystallization temperature. A second heating to 200°C with rates of 20°C/min was conducted to evaluate the melting temperature of the composite.

The percentage of polyethylene (PE) and polypropylene (PP) in the composite was calculated using the melt enthalpy reference value obtained from the curves of the samples analyzed. To obtain the results, the method developed by Zamin [12] was used, in which, by the ratio Y = (ΔHPE / ΔHPP), is possible to determine PE percentage in the material, by the equation 1:

$$Y = 0.001X^2 - 0.0029X + 0.0804 \quad (1)$$

Where:

Y = (ΔHPE / ΔHPP) ratio
X1 (+) = Percertage of PE in te material
X2 (-) = Disregard

iii. *Fourier Transform Infrared Spectroscopy – FTIR*

Fourier transform infrared (FTIR) spectroscopy analysis was performed using a PerkinElmer Frontier spectrophotometer with an attenuated total reflectance (ATR) accessory. Each spectrum was obtained using five scans ranging from 4000 to 600 cm^{-1} at a resolution of 4 cm^{-1}.

iv. *Mechanical properties*

The tensile test were performed according to ASTM D638-02a, operating at a speed of 5 mm/min and at room temperature. Five specimens of each mixture were tested and then the mean values of elastic modulus, yield strength and yield strain were obtained. To perform the tensile tests a universal testing machine model WDWV100E, made by Time Group was used, located in the test laboratory of the IFRS –Campus Erechim, controlled by WinWDW software, and has a 100kN load cell and a strain gauge.

Impact tests were performed according to ASTM D256-02 in a controlled environment, with a room temperature of 23 ± 2°C and a relative humidity of 50 ± 10%. The impact strength value was obtained by the ratio of the average energy absorbed by 8 specimens tested according to the dimensions specified in the standard. The tests were performed with a Zwick Izod impact testing machine, located at the IFRS - Farroupilha Campus. The hammer used for the test provides 4.0 J of energy and was released from a height of 610 mm in relation to base.

III. Results and Discussion

a) Differential Scanning Calorimetry

The Table 3 show the results of melting enthalpy (ΔH), melting temperature (Tm), crystallization temperature and percentage of polyethylene in the material. The table shows that the melting temperatures of the materials have not changed since it is a blend, both were close to those found in the literature, HDPE 125 °C to 135 °C and PP 160 °C to 170 °C [12, 13].

Table 3: Results of Differential Scanning Calorimetry of PE/PP and percentage of PE in the mixtures

Sample	MFI (g/10min)	Tm PP (ºC)	Tm PE (ºC)	ΔH PP (J/G)	ΔH PE (J/G)	Tc (ºC)	Y = ΔHPE/ ΔHPP	% PE
PPr2	5.912	162.83	128.88	42.08	22.09	118.09	0.525	22.19
PPr4	8.36	162.34	128.03	46.72	20.35	118.16	0.436	19.51
PPr5	7.70	163.12	128.86	43.38	19.48	118.14	0.449	20.19

The values shown in Table 3, indicate that the material supplied by the Coplast company is not only composed of polypropylene, but has of 20% polyethylene. Therefore, the MFI variation does not depend on the percentage of polyethylene present in the composition of the material.

b) Fourier Transform Infrared Spectroscopy – FTIR

The FTIR-ATR spectra of the recycled polypropylenes (PPr) are presented in Figure 1. The FTIR spectra PPr matrices show characteristic bands of PP [14], with stretching of CH and CH_2 bonds between 2965 and 2820 cm^{-1}, and asymmetric and symmetrical deformations of CH and CH_3 at 1447 and 1378 cm^{-1}, respectively. Still in Figure 1, is possible to observe that in PPr4 there are changes in the range from 3600 to 3000 cm-1, related to the O-H groups, showing a peak that may be an indication of a lot of humidity in this sample. Its difficult to distinguish between PP and PE just by the FTIR test, as both have similar bands; which proves the presence of both materials is the DSC test.

In the graph of Figure 1 it is also possible to observe the presence of calcium carbonate in the material, through the absorption bands at 873 and 719 cm^{-1}, which are characteristic of $CaCo_3$ [16]. The PP's bands are in accordance with the ones found in the literature and can be seen in Table 4.

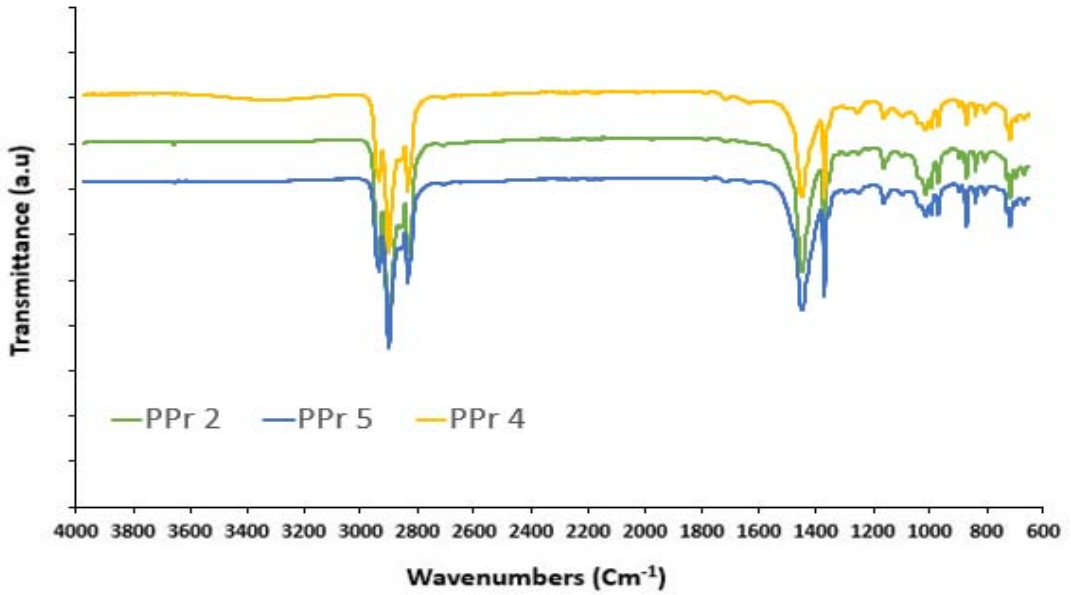

Figure 1: FTIR-ATR spectra for the PPr2, PPr4 and PPr5

Table 4: FTIR absorption bands assigned to PP and PE present in the samples

Wavenumber (cm^{-1})	Peak Assignment	Reference
PP Pe		
2952, 2918 and 2838	C–H stretching	[14]
2720	CH bending and CH3 stretching	[15]
1456	CH3 asymmetric deformation	[15]
1376	CH3 symmetric deformation	[15]
1165	Bending vibration of tertiary carbon	[15]
974, 841 and 808	C–H deformation out-of-plane	[15]
873	C-O, calcite, CaCO3	[17]
719	CO3 , stretching	[18]

c) Melt Flow Index

To evaluate the melt flow index of the raw material with which the company works, rheology tests were carried out on them, the first tests being carried out using 100% of the recycled material (PPr100) and 100% of the virgin material (PPv100). The PPv100 presented a MFI of 26 (g/10 min) according to the value provided by Braskem.

As the MFI considered ideal is between 9 and 13 (g/10 min) for injection processes in the company requesting the research, to obtain the equation and analyze the mechanical properties, recycled polymers with MFI above 9 (g/10 min) were not used in mixtures with PPv100. The Table 5 shows the measured values of melt flow index and the nomenclature used for each raw material studied.

Table 5: Measured values of MFI and the nomenclature used for each raw material studied

MFI measured (g/10 min)	MFI PP
26.00	MFI PPv100
12.286	MFI PPr1
5.912	MFI PPr2
5.93	MFI PPr3
8.36	MFI PPr4
7.70	MFI PPr5
8.23	MFI PPr6

The Table 6 shows the results of melt flow index of the recycled polymer samples with different percentages of virgin.

Table 6: Results of MFI of the recycled polymer samples with different percentages of virgin

Percentage of virgin PP (% PPv)	MFI PPr2 (g/10 min)	MFI PPr3 (g/10 min)	MFI PPr4 (g/10 min)	MFI PPr5 (g/10 min)	MFI PPr6 (g/10 min)
0	5.912	5.93	8.36	7.70	8.23
10	7.45	7.2	9.33	8.64	9
20	8.83	8.15	9.47	10.06	9.28
30	9.5	9.64	10.4	11	10.68
40	10.4	11.13	12.81	12.45	12.71
50	12.1	13.3	14.446	13.9	13.67
60	14.1	13.3	14.88	14.92	14.91

d) Obtaining the melt flow index equation for blends of virgin and recycled polypropylene

The Figure 2 shows the graph with the straight lines of each blend relating the melt flow index to virgin polypropylene percentage. MFIa being the straight line obtained by mixing with MFI PPR2, MFIb is the straight line obtained by mixing with MFI PPR3, MFIc the straight line obtained by mixing with MFI PPR4, MFId the straight line obtained by mixing with MFI PPR5 and MFIe is the straight line obtained by mixing with MFI PPR6.

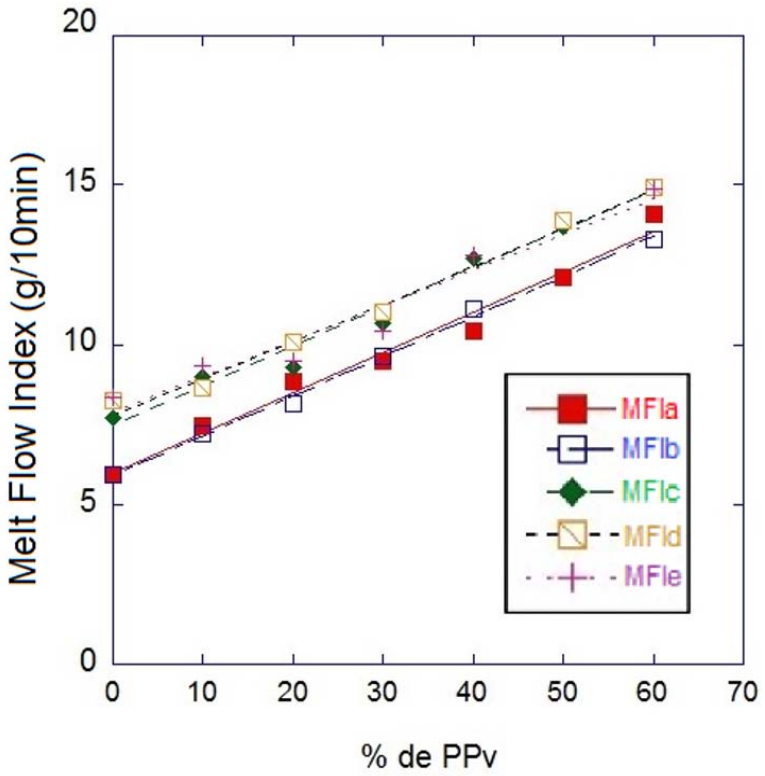

Figure 2: Graph with the straight lines of each blend relating the melt flow index to virgin polypropylene percentage

From the graph in Figure 2 is possible to observe an increase in the melt flow index of the mixtures proportional to virgin polypropylene percentage, thats can be approximated to a straight line for all mixtures. Thus, the line equations for the mixtures are as follow:

Line equation *MFIa*:

$$MFIa = 5.9637 + 0.12645x \quad R=0.98952 \qquad (1.1)$$

Where:

MFIa: Melt Flow Index of the mixture (g/10min)
x: Percentage of PPv in the mixture (%)
R: Correlation coefficient of the line (1)

Line equation *MFIb:*

$$MFIb = 5.8947 + 0.12489x \quad R=0.99824 \qquad (1.2)$$

Where:

MFIb: Melt Flow Index of the mixture (g/10min)
x: Percentage of PPv in the mixture (%)
R: Correlation coefficient of the line (1)

Line equation *MFIc:*

$$MFIc = 7.4517 + 0.12286x \quad R=0.98963 \qquad (1.3)$$

Where:

MFIc: Melt Flow Index of the mixture (g/10min)
x: Percentage of PPv in the mixture (%)
R: Correlation coefficient of the line (1)

Line equation *MFId:*

$$MFId = 7.7825 + 0.11797x \quad R=0.99382 \qquad (1.4)$$

Where:

MFId: Melt Flow Index of the mixture (g/10min)
x: Percentage of PPv in the mixture (%)
R: Correlation coefficient of the line (1)

Line equation *MFIe:*

$$MFIe = 7.9047 + 0.11139x \quad R=0.97113 \qquad (1.5)$$

Where:

MFIe: Melt Flow Index of the mixture (g/10min)
x: Percentage of PPv in the mixture (%)
R: Correlation coefficient of the line (1)

Through the results, the general equation obtained to increase the Melt Flow Index between PPv and PPr mixtures, which is show below:

$$MFIm = MFIr + 0.120712x \quad R=0.988468 \qquad (1.6)$$

Where:

MFIm: Melt Flow Index of the mixture (g/10min)
MFIr: Melt Flow Index of the recycled polypropylene (g/10min)
x: Percentage of PPv in the mixture (%)
R: Correlation coefficient of the line (1)

Where the *MFIr* is the linear coefficient of the equation, the value of 0.120712 which is multiplied by the percentage of PPv, it is an average of the slope coefficients of the lines found, and the R (correlation coefficient of the line) is an average of the R's of the all lines, which shows how close to an ideal equation it is. This general equation can be used for any MFIr value as long as mixture with PPv CP202XP.

e) Mechanical Properties

After the study of the mixture of virgin and recycled material to correct the MFI value of some recycled PP and obtained the general equation which will solve the company's problem, tensile and impact tests were carried out with the aim of analyzing the mechanical properties of the different mixtures and comparing them with properties of virgin raw material used.

The data obtained by the tensile test are shown in Table 7, where PP_{M1} has an MFI of 9.50 g/10 min, and PP_{M2} has an MFI of 10.68 g/10 min.

Table 7: MFI values, Yield Strenght (σ_e), Yield Strain (ε_l), Elastic Modulus (E) and impact resistance for PP_{M1}, PP_{M2} and PP_V samples

Composition	MFI (g/10min)	σ_e(Mpa)	ε_l	E (Mpa)	Impact Resistance (J)
PPM1 30% PPv 70% PPr2	9.50	20.23 ± 0.49	5.67 ± 0.18	1726.40 ± 355.65	0.1225 ±0.0361
PPM2 30% PPv 70% PPr5	10.691	21.11 ± 0.13	5.67 ±0.18	1684 ± 176.38	0.135 ± 0.0358
100% PPv Cp 202Xp	26	32	7	2023.42	3.6195

Table 7 shows that with the increase in the melt flow index of polypropylene, the yield strenght of the polypropylene also rises. In a comparison between the two mixtures made PP_{M1} and PP_{M2} it is possible to visualize an increase of 4.35% in the yield strength.The virgin material has a value of about 50% above that presented by the mixture between PP_V and PP_R of IF = 10.691 (g /10 min).For the chosen mixtures the values of

elastic modulus (E) are very close, so both samples have the same stiffness. It is also observed that both mixtures have lower E values than virgin material and therefore are less rigid.

As for the yield strain, was observed in table 7 that the values found for both PP_{M1} and PP_{M2} are equal. As with the elastic modulus, the highest deformation value is in the virgin material, about 23.5% in relation to PP_{M2}.

When observed the results of the energy absorbed in the impact, also in the Table 7, is possible to verify that both mixtures of virgin and recycled polymer absorb little energy under impact when compared to 100% virgin material.

IV. Conclusions

In the present work, the mixtures of virgin and recycled polypropylene were analyzed in order to obtain an equation to basically correct the melt flow index required by the company to correct the injection process. The results showed that there is a proportional relationship between the melt flow index and the amount of virgin polymer in the mixture. Therefore, for correction and elevation of the melt flow index of recycled polymer, a certain amount of virgin polymer must be insert to reach the desired index for processing. The evaluation of the mechanical properties showed that the mixtures of virgin and recycled polypropylene maintains rigidity similar that samples with 100% virgin polypropylene, but under impact the mixtures presents a drastic drop in the absorbed energy. Therefore, for applications that require impact, recycled polymers would have their use compromised.

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Development of Gravity Drip Irrigation System in Agricultural and Bio-Environmental Engineering Demonstration Farm, Auchi Polytechnic, Auchi

By Ahanmisi Edeki & Ajayi Asishana Stanley

Abstract- Agriculture is known to accounts for about 70 – 80% use of available water in the world. However, dwindling water availability has made it necessary to improve on the way water is used in Agriculture. Rainfall is the single most important factor affecting crop production. The objective of this study is to develop a gravity drip irrigation system for selected vegetable crops. This study was carried out in Auchi Polytechnic, which is located between latitude 70 10' and 70 20' north of the equator and longitude 60 16' and 60 36' east of the Greenwich Meridian with an altitude of 207m. Field preparation was done by clearing, ploughing and harrowing. PVC pipes were laid, 2 mm holes was made at distance of 30 cm on the 6 m PVC pipes. Components of drip irrigation system consist essentially of main line, sub mains, laterals and emitters. The main line delivers water to the submains and the submains to the laterals. The set up was tested to determine the uniformity of water emission from the drip emitters into the field, maize, pepper, tomatos was used as the test crops and there was uniform growth observed across the entire field. The low cost drip system developed in this study showed a high level of efficiency and uniformity of water emission across the entire study area.

GJRE-J Classification: *FOR Code: 090799*

Strictly as per the compliance and regulations of:

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Ahanmisi Edeki [α] & Ajayi Asishana Stanley [σ]

Abstract- Agriculture is known to accounts for about 70 – 80% use of available water in the world. However, dwindling water availability has made it necessary to improve on the way water is used in Agriculture. Rainfall is the single most important factor affecting crop production. The objective of this study is to develop a gravity drip irrigation system for selected vegetable crops. This study was carried out in Auchi Polytechnic, which is located between latitude 7^0 10' and 7^0 20' north of the equator and longitude 6^{0}16' and 6^{0}36' east of the Greenwich Meridian with an altitude of 207m. Field preparation was done by clearing, ploughing and harrowing. PVC pipes were laid, 2 mm holes was made at distance of 30 cm on the 6 m PVC pipes. Components of drip irrigation system consist essentially of main line, sub mains, laterals and emitters. The main line delivers water to the submains and the submains to the laterals. The set up was tested to determine the uniformity of water emission from the drip emitters into the field, maize, pepper, tomatos was used as the test crops and there was uniform growth observed across the entire field. The low cost drip system developed in this study showed a high level of efficiency and uniformity of water emission across the entire study area.

I. Background of the Study

Agriculture accounts for about 70 – 80% use of available water in the world (Duhrkoop*et al.*, 2009). However, dwindling water availability has made it necessary to improve on the way water is used in Agriculture. In other to make water available to farmers throughout the season to ensure food security (Keller and Bliesner, 1990). The increased competition for water among agricultural, industrial and domestic consumers creates the need for continuous improvements in techniques for judicious use of water in crop production. Efficient water use is becoming increasingly important and alternative water application methods such as drip and sprinkler irrigation may contribute substantially in making the best use of the scarce available water for crop production (Keller and Bliesner, 1990, Ewemoje*et al.,* 2006).

Irrigation is the artificial application of water to the soil or plant, in the required quantity and at the time needed, is a risk management tool for agricultural production. The risk of yield reduction due to drought is minimized with irrigation. Irrigation is widely carried out through surface, sub-surface and pressurized systems, characterized by the mode of transport of the water onto the point of application (Keller and Bliesner, 1990). When water is applied on the surface, a considerable amount is lost through evaporation, run off and deep percolation making it less efficient.

Field application efficiency in most traditional irrigation methods is still very low, typically less than 50 % (sprinkler irrigation) and often as low as 30 % (surface irrigation). Excessive application of water generally entails losses 2 because of surface run-off from the field and deep percolation below the root zone within the field. Both run-off and deep percolation losses are difficult to control under furrow irrigation system, where a large volume of water is applied at a single instance. An alternative water application method such as the drip irrigation method allow for much more uniform distribution as well as more precise control of the amount of water applied and also decreases nutrient leaching. Drip irrigation is defined as "the slow, frequent application of small volumes of irrigation water to the base or root zone of plants" (Smeal, 2007). More widespread adoption of this technology in recent years began in the late 1960s to early 1970s. Advantages of drip irrigation system include: less water loss, reduction in weed growth, less labour requirements, minimal evaporation compared to other watering methods, less usage of fertilizer, reduced soil erosion, equitable water distribution and higher crop production (Coelho and Or, 1999; Assouline, 2002; Wang *et al.* 2006).

Rainfall is the single most important factor affecting crop production (Rukuni and Carl 2004). The smallholder farming sector have been experiencing decreasing crop yield due to; the erratic rainfall patterns, non-uniform water requirement in all the growth stages, sensitivity of crops to water stress, competing use of water among different sectors due to climate change (Howell, 1980).

To address all these issues there is the need to develop an irrigation (drip irrigation) system that meets the water use and uniform water requirement of crops especially vegetables, to improve yield and production. Based on the problem above, this project is significant in the following ways: it will bring about maximum use of available water and no water being available to weeds,

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maximum crop yield, high efficiency in the use of fertilizers, less weed growth and restrictions of the population of potential hosts, low labour and relatively low operation cost, no soil erosion, improved infiltration in soil of low intake, readily adjustable to sophisticated automatic control, no runoff of fertilizers into ground water, less evaporation losses of water as compared to surface irrigation, improvement of seed germination and decreased to tillage operations. The objective of this study is to develop a low cost gravity drip irrigation system for selected crops (Coelho and Or 1999; Assouline, 2002; Wang *et al.* 2006).

Africa's regions with extensive periods of drought and inadequate rainfall contribute to the continent"s food shortage problem. While nature cannot be controlled, society does have the ability to develop and practice more efficient water usage techniques in order to improve water supply management. One type of technology that may contribute to the improvement of water supply management and the associated food crisis is drip irrigation. Drip irrigation systems (DIS) have discharge points or sufficiently small holes in sections of hose such that filtration is a primary concern (Benami *et al.,* 1984). These systems commonly use low flow rates and low pressures at the emitters and are typically designed to only wet the root zone and maintain this zone at or near an optimum moisture level. Hence, there is a potential to conserve water losses by not irrigating the whole field. Obvious advantages of drip irrigation include a smaller wetted surface area, minimal evaporation and weed growth, and potentially improved water application uniformity within the crop root zone by better control over the location and volume of water application (Benami*et al.,* 1984). Drip systems are also commonly designed to include fertigation and automation capabilities. In recent years, low-pressure drip irrigation (LPDI) systems have been developed for smaller farming areas. For many subsistence farmers, a standard pressurized system is too expensive and complicated, as pressurized systems are intended for large areas of land, and therefore do not match the needs of small subsistence farming (Phocaides, 2007, Ascough and Kiker, 2002).

Drip systems are commonly categorized according to either their physical structure or their placement in the field (e.g. surface, subsurface or suspended). The physical structures may be either: Flexible thin-walled drip (or trickle) tape made of polyethylene where the emitter is formed in the join, or the emitter is joined to the inside of the tape or drip (or trickle) tube where the structure is a thicker walled polyethylene pipe into which the separately formed emitter is inserted, welded, glued within, or attached externally to the hose. A major benefit of drip is the ability to apply small amounts of water at high frequency intervals. This provides the opportunity to maintain the soil moisture at a specified moisture content and changes the focus of irrigation scheduling away from "irrigating at a frequency which does not affect output quantity/quality" to "irrigating on a schedule which maximizes output quality/quantity". This change in emphasis may produce benefits depending on the specific crop response to moisture stress. However, where the crop is relatively insensitive to moisture stress and when the available moisture content is high the benefits of more frequent irrigation are likely to be minor if present at all. Hence, many researchers (Hanson and Patterson, 1974; Wendt *et al*., 1977; Bucks *et al*., 1981) have found that drip irrigation does not increase yield compared to other application systems where both the volume and timing of the water applied for evapotranspiration is non-limiting. Drip systems provide not only the potential to irrigate more frequently but also the ability to more readily maintain specific moisture deficits at a level below field capacity either for part or all of the irrigation season. Irrigating to maintain a specified root zone soil moisture deficit provides the opportunity for increased soil moisture storage from rainfall during the irrigation season (Bustan and Pasternak, 2008).

The potential water application efficiency of drip irrigation systems is often quoted as greater than 90% (Keller and Karmeli, 1975; Jensen, 1983). However, as with all irrigation systems, the ability to achieve high levels of efficiency is a function of the design, installation and management practices. Losses of water in drip irrigation systems principally occur through evaporation from the soil surface, surface run-off and deep drainage. Evaporation losses are generally small in subsurface irrigated systems due to a limited wetted surface area. Run-off losses are also normally small due to the low application rates. However, excessive watering periods and the use of shallow subsurface drip on low infiltration soils (e.g. sodic soils) can result in appreciable tunneling of flows to the surface creating surface ponding and the potential for localized run-off (Oriola, 2009, Polak*et al*., 1997).

II. Materials and Methods

a) Design Concept

The concept underlining the design is to develop a drip irrigation system that is cheap to rural farmers using low cost, readily available materials and adopting low technology which will require no special skills and will be adaptable to local environmental conditions in rural areas. The system should also be able to perform the following:

- Apply water to meet peak crop water requirement
- Maintain application and uniformity efficiencies at optimum levels
- Provide an energy and water efficient system to keep initial capital and operating cost as low as possible

b) Study Selection and Field Preparation

This study was carried out in Auchi Polytechnic, which is located between latitude 7^0 10' and 7^0 20' north of the equator and longitude 6^0 16' and 6^0 36' east of the Greenwich Meridian with an altitude of 207m.

Field preparation was done by clearing the field and preparing seed beds as shown in plate 1-3.Components of drip irrigation system consist essentially of main line, submains, laterals and emitters. The main line delivers water to the submains and the submains to the laterals. The emitters which are attached to the laterals distribute water for irrigation. The mains, submains and laterals are usually made of black polyvinyl Chloride (PVC) tubing. The emitters are also usually made of PVC materials. PVC material is preferred for drip system because it can withstand saline irrigation water and is also not affected by chemical fertilizers (Isrealson, *et al.,* 2002).

In this design the following specifications was used as adapted from Evans, (2011):

Length of ridge (lateral) = 1 m
Width of a ridge = 50 cm = 0.5 m
Area of a ridge =10 x 0.5 = 5 m^2
Depth of a ridge = 0.5 m
Centre to centre of a ridge =1 m
Operating pressure H =10 m
Slope of lateral line =1 %
No. of emitter = 10 = 17 spaced at 30 cm equally along the lateral line 0.6.

The laterals were laid with caution to ensure that there will be a uniform flow and distribution of water from each drip hole. Levelling instruments was used to get a good level of pipe placement on the field in the trenches.

The field preparation was carried out as explained in the headings below:

Site Clearing and Ploughing: Land clearing was carried to rid the land of debris, grasses, shrubs, stumps, stones etc. The land was previously cultivated with cassava, care was taken to do a proper work of uprooting left over stems after harvest. The land was plough to a depth of 30 cm using a tractor mounted mould board plough as shown in plate 1 and 2.

Plate 1: Clearing and stumping operation at the research site

Plate 2: Primary tillage operation at the site with a tractor mounted disc plough

Plate 3: Prepared field after harrowing (secondary tillage)

III. Installation of Drip Lines and Erection of Water Platform

The water storage tank was positioned on a raised platform high enough to allow the water flow into the field by gravity, this is shown in plate 4 – 7.

Construction of Concrete Platform: The site work began with the erection of a concrete platform (stand) for the 3, 000 litres water tank. Plates 4 – 6 shows the procedures for creating form work, pouring of concrete and installation of tank.

Installation of drip lines: There was a need for a plumber to install the drip lines. The plumber was mobilized with funds to secure the materials needed and to be installed subsequently and this was done in close supervision of the researchers.

Plate 4: Form work prepared for the platform

Plate 5: 3, 000 litres tank placed on the concrete platform

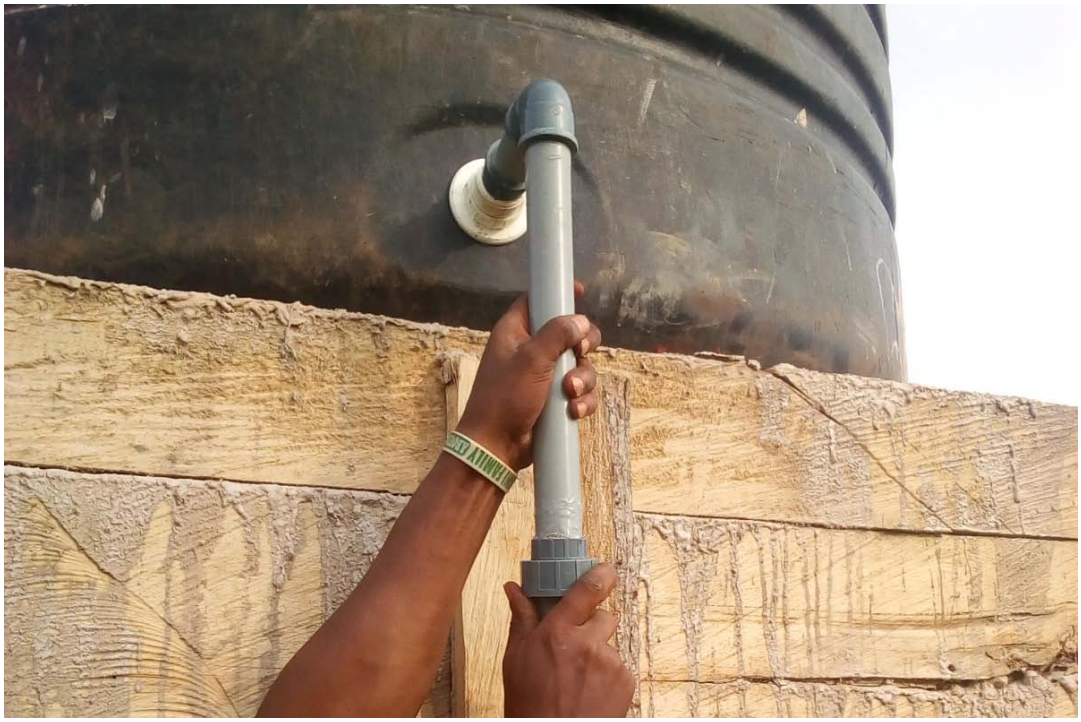

Plate 6: Installation of pipes from the tank to underground laterals

Plate 7: Buried ¾ inch laterals

a) Design procedures

Capacity of drip system

Drip irrigation system is generally not recommended to operate for more than 1.5 - 2.0 hours at a stretch to avoid losses of water through leaching. The equation to estimate Capacity of Drip System is:

$$Q = A \times CU \times \frac{T}{(\eta_a \times t)} \quad (1)$$

where,

Q = Capacity of drip system, lph
A = Total cultivated area, m^2
T = Irrigation interval, days
η_a =Water application efficiency (in fraction)
t = Duration of each irrigation, h

Discharge required per plant (Qp) can simply be estimated by dividing the drip capacity (Q) by the number of plants (n) in the area Qp = Q/n (Evans, 2011)

b) Length of main, submain and lateral lines

Length of main, submain and lateral lines can be calculated with the help of length, width and total number of equal sized blocks in a field, as follows:

Length of main line = width of block (if number of block i.e. NB = 1, in small fields)

Length of main, submain and lateral lines

- Total length of main line (Lm) = (NB-1) x width of block (if NB>1)
- Length of submain line (Ls) = width of block (Bw)
- No submain if NB = 1
- Total length of submain = Ls X NB
- Length of lateral line (LL)= Length of block (BL)
- Total length of lateral = LL X NB X NR

Where, NR = Number of plant row per block

Number of drippers and laterals

In orchard and vegetables crops (Evans, 2011)

- Drippers are installed close to each plant
- Laterals are placed along each row of plant
- Number of laterals is taken equal to the number of plant rows

Number of laterals and drippers

$$NLS = LS \div S \quad (2)$$

Where,

NLS = Number of laterals per submain
LS = Length of sub main pipe, m
S = Spacing between two rows of laterals, m

In large fields total number of laterals is estimated by multiplying the laterals per submain and the number of submain used

NL = LM ÷ S If NB =1
NL = NLS x Ns if NB >1

Where,

NL= Total number of laterals
LM = Length of main pipe, m

Numbers of plants per lateral are estimated by dividing the length of lateral pipe by the spacing between two plants(Evans, 2011)

$$NPL = LL \div PS \quad (3)$$

Where,

NPL =Number of plants per lateral
LL =Length of lateral pipe, m
PS =Spacing between two plants, m

Number of drippers per plant is estimated as follow:

$$QP = Q \div (NL \times NPL) \quad (4)$$

NDP = QP ÷ q

Where,

QP =Discharge required per Plant, lph
Q = Drip Capacity lph
NL= Total Number of laterals
NPL = Number of Plants per lateral
NDP = Number of Drippers per plant
q = Dripper discharge, lph

Total Number of Dripper required is estimated using the equations

NDL = NDP x NPL
ND = NDL x NL
NP = NPL X NL

Where,

NDL = Number of drippers per lateral
ND = Total number of drippers
NP = Total number of Plants
NL= Total Number of laterals
NPL = Number of Plants per lateral
NDP = Number of Drippers per plant

In close growing field crops

In close growing field crops the whole area needs to be wetted

Drippers are used to act as a line source of water rather than a point source

In case of closely spaced field crops large number of drippers are required

Installation and operation of such a large number of drippers may pose problems

Therefore, emitting pipes or laterals within built drippers placed at 30 to 40 cm along the lateral pipes better suit such a situation(Evans, 2011).

In close growing field crops in close growing crops, the spacing between two drippers, laterals and number of drippers per lateral are estimated by taking into consideration the movement of water front with time in vertical and horizontal direction in the soil

In close growing field crops Spacing between two drippers and laterals in a closely spaced field crop were estimated by using the relationship, allowing 20 % of overlapping of coverage's of two adjacent drippers (James, 1988, Evans, 2011).

$$r = 0.9\left[(3 \times q \times t \times 10^{-3}) \div 2(\theta_f - \theta_i)\right]^{\frac{1}{3}} \quad (5)$$

Where,

r = Wetted radius, m
θi = Initial moisture content of soil, per cent
θf = Final moisture content of soil, per cent

Emitter spacing is kept equal to twice the wetted radius

SE =2 x r

Where,

r = Wetted radius, m
SE = Emitter spacing, m

Number of emitters per lateral may be estimated by dividing the length of lateral by the emitter spacing

Total number of emitters are then estimated by multiplying the emitters per lateral with number of lateral

$$NEL = \frac{L}{SE} \quad (6)$$

$$QL = NEL \times q \quad (7)$$

$$QS = \frac{Q}{NS} \quad (8)$$

$$NLS = \frac{QS}{QL} \quad (9)$$

$$NL = Q \div QL \; if \; NB = 1$$
$$NL = NLS \times NS \; if \; NB > 1$$

Where,

NEL = Number of emitters per lateral
L = Length of Lateral, m
SE = Emitters spacing, m
q = Emitter discharge
Q = Drip Capacity or designed discharge
NLS = Number of Lateral per sub-main
NL = Total numbers of Laterals
QS = sub main discharge, lph
QL = lateral discharge, lph

Number of fittings and accessories

- Common PVC fittings are elbow, reducer, tee, straight connector, end cap and gate valve
- Accessories for laterals includes gate valve, tee, joiner, elbow, end caps and grommet takeoff etc
- All these components are available in 4, 10, 12, 16 and 20 mm sizes
- These takeouts/ starter and rubber grommet are used for taking out laterals lines from submain/ main line

c) Capacity of sub-main, lateral and main pipe

- The capacity of each lateral pipe can be estimated by multiplying the dripper discharge to number of drippers per lateral
- Capacity of sub main pipe can be estimated by multiplying the lateral capacity to number of laterals per submain
- Capacity of main line and control head can be estimated by multiplying the submain discharge to number of sub mains placed on it
- Qm = Qs x Ns
- Diameter of lateral pipe
- Lateral pipe is selected such that the head loss in lateral pipe is limited within 10 per cent of the operating pressure available at the head of the lateral
- Expected head loss in different diameter pipes are estimated and that smallest diameter pipe is selected in which the head losses are within 10 per cent of the operating pressure
- Lateral pipes having 10, 12, 16 and 20 mm internal diameter with wall thickness varying from 1 to 3 mm are used in drip irrigation system.

First a smaller diameter lateral pipe should be selected to reduce the total cost of system and the friction losses are estimated by using Equation

$$h = \frac{\left[789000 \times \left(\frac{Q}{N_1}\right)^{1.75} \times l \times F_d\right]}{d^{4.75}} \quad (10)$$

and then elevation head is added to this. If the variation in total friction losses are found within 10 % of the operating pressure then selected diameter is accepted.

Where,

Q = Capacity of drip system, lps
h = Frictional loss in lateral pipe, m
Fd = Factor for multiple outlet (Based on number of outlets)
d = Diameter of lateral pipe, mm

d) Laying of pipe in the field

The laterals were laid with caution to ensure that there will be a uniform flow and distribution of water from each drip hole. Levelling instruments were used to get a good level of pipe placement on the field in the trenches. As indicated in plate 8.

Plate 8: Installation of the emitting points and the perforated 1 inch pipe

e) Calibration of flow in PVC pipes (tied and untied)

To obtain a uniform flow of water from the laterals with a length of 6m, the pipes were calibrated to determine their uniformity of emission. To calibrate the pipe for uniformity of flow from 5 drip holes of 2mm diameter each per lateral of 6m x 4 = 24m, end cap fixed a tone end, elbow fixed at the other and join ted to a pipe of height 0.6m. This was connected to the main pipe through the elbows to supply water from the storage tank to the main laterals through the dripholes. Collector cans was used to collect water from the drip holes. The collector cans were placed on a leveled surface which was checked with a leveling device (spirit level), to ensure even distribution of water in the drip holes. The water collected from different drip lines at 5, 10, 20 and 30 minutes was measured using a measuring cylinder to check uniformity of water flow from each drip hole. The laterals are designated by numbers while the emitters are designated by letters A – I as shown in Table 1 – 4 and a plot of the uniformity distribution is shown in figure 1.

Table 1: Millilitres of water emitted in 5 minutes

Lateral/Emitter	A	B	C	D	E	F	G	H	I
1	5.0	5.0	6.0	7.0	5.0	6.0	5.0	4.5	4.8
2	4.5	4.5	4.4	4.7	5.1	4.6	4.3	4.4	4.9
3	5.2	5.2	6.2	7.2	5.2	6.2	5.2	4.7	5.0
4	4.7	4.7	4.6	4.9	5.3	4.8	4.5	4.6	5.1
5	5.4	5.4	6.4	7.4	5.4	6.4	5.4	4.9	5.2
Average	5.0	5.0	5.5	6.3	5.2	5.6	4.9	4.6	5.0

Table 2: Millilitres of water emitted in 10 minutes

Lateral/Emitter	A	B	C	D	E	F	G	H	I
1	7.7	7.7	8.7	9.7	7.7	8.7	7.7	7.2	7.5
2	7.9	7.9	7.8	8.1	8.5	8.0	7.7	7.8	8.3
3	8.3	8.3	9.3	10.3	8.3	9.3	8.3	7.8	8.1
4	7.6	7.6	7.5	7.8	8.2	7.7	7.4	7.5	8.0
5	8.6	8.6	9.6	10.6	8.6	9.6	8.6	8.1	8.4
Average	8.0	8.0	8.6	9.3	8.3	8.7	8.0	7.7	8.1

Table 3: Millilitres of water emitted in 20 minutes

Lateral/Emitter	A	B	C	D	E	F	G	H	I
1	15.4	15.4	17.4	19.4	15.4	17.4	15.4	14.4	15.0
2	15.8	15.8	15.6	16.2	17.0	16.0	15.4	15.6	16.6
3	16.7	16.7	18.7	20.7	16.7	18.7	16.7	15.7	16.3
4	15.2	15.2	15.0	15.6	16.4	15.4	14.8	15.0	16.0
5	17.3	17.3	19.3	21.3	17.3	19.3	17.3	16.3	16.9
Average	16.1	16.1	17.2	18.6	16.6	17.4	15.9	15.4	16.2

Table 4: Millilitres of water emitted in 30 minutes

Lateral/Emitter	A	B	C	D	E	F	G	H	I
1	25.0	25.0	30.0	35.0	25.0	30.0	25.0	22.5	24.0
2	22.5	22.5	22.0	23.5	25.5	23.0	21.5	22.0	24.5
3	26.2	26.2	31.2	36.2	26.2	31.2	26.2	23.7	25.2
4	23.6	23.6	23.1	24.6	26.6	24.1	22.6	23.1	25.6
5	27.2	27.2	32.2	37.2	27.2	32.2	27.2	24.7	26.2
Average	24.9	24.9	27.7	31.3	26.1	28.1	24.5	23.2	25.1

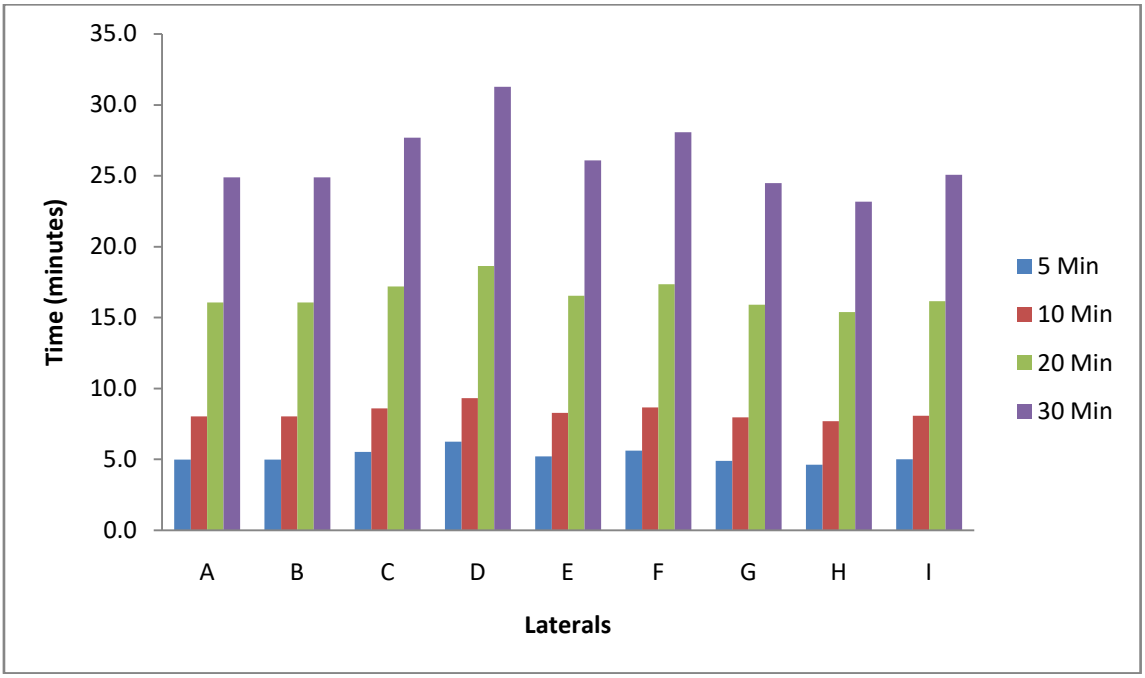

Figure 1: Average values of emitter uniformity

The results above shows a steady increase in the litres of water emitted with time. Unless there is a blockage in any of the emitters during long time operation, they are quite efficient in the uniform distribution of water over the land. Water quality and filtration are probably the most serious concerns when considering drip irrigation. In order to discharge very low flow rates, the diameter of the emitter orifices must be very small. This results in the emitters being blocked very easily by even the smallest contaminants in the water supply. Of particular concern are suspended solids, such as silt and sand, minerals that precipitate out of solution, such as iron or calcium, and algae that may grow in the water. Virtually every drip irrigation system must include a filtration system adequate to prevent plugging of the emitters. A system with poor quality water and poor filtration simply will not function reliably enough to warrant the maintenance requirements needed to keep it in operation. One will think that the emitter close to the main line along the lateral will yield more litres of water but as the water fills the lateral it discharges it at almost equal rate.

The hours of operation needed to meet the irrigation requirement will depend upon the flow rate of the emitting device, the irrigation interval, and the rate of consumptive water use by the crop. In no case should the total system be designed to operate more than 18 hours per day. This allows time for system maintenance,

and excess capacity for catch-up in case of breakdowns. Nor should any zone be irrigated for more than 16 hours continuously, to allow some time for aeration of the crop root zone.

This low cost drip irrigation system can be an extremely versatile production tool in horticultural enterprises. It can stretch a limited water supply to cover up to 25 percent more acreage than a typical sprinkler system. It can reduce the incidence of many fungal diseases by reducing humidity in the crop canopy and keeping foliage dry. It allows automation of the irrigation system, reducing labor requirements. It delays the onset of salinity problems when irrigation water of marginal quality must be used.

This low cost system requires careful water treatment to prevent emitter blockage problems. Frequent inspection of the system is necessary to insure it is functioning properly. Improper design and component sizing can result in a system with poor uniformity of application and a much lower than expected application efficiency.

A properly designed and installed drip irrigation system will normally be substantially more expensive than a sprinkler irrigation system initially. However, the lower operating cost and higher efficiency of the drip system can justify the added expense very quickly in many horticultural production systems.

IV. Planting of Crops

The crops planted are Maize, Tomato, Pepper and Melon. The following headings shows the agronomic steps involved in the planting and the planted crops shown in plate 9 and 10.

a) Amount of water to apply

Amount of water to apply was calculated based on the various growth stages of the maize variety. Rooting depth (Dr), depletion factor (Df), field capacity (FC)and permanent wilting point (PWP) were considered, resulting in the following equation;

$$Amount\ of\ water\ to\ irrigate = Df \times (FC - PWP) \times Dr \times Wetteddiameter \quad (11)$$

Df was considered to be 50% and Dr based on the maize and the other crops planted, the rooting depth at each growth stage of the plant. Wetted diameter of the calibrated pipe was17cm.

b) Calculation of Irrigation Requirements (The oritical/Ideal Flow)

Depth of water applied (d)
Cylindrical volume of soil
Volume of water applied(V)=Wetted area (A)×Depth of water(d)

$$V = A \times d \quad (12)$$

Wet ted area was given as

$$A = \pi d^2/4$$

A=3.1428× (34^2/4)

A=908.038cm^2= (9080.38mm^2)

Volume of water applied considering the capacity of the storage tank which is 25 liters. Taking the number of drip holes on the lateral (16 drip holes); each drip hole is expected to release an amount of 1.56 liters, assuming a perfectly uniform application.

c) Depth of irrigation water applying for 20.466 litres

(25 litre container was used for the calibration but because the tap was fixed closed to the bottom of the container some of the water was left at the bottom by letting 20.466 litres be collected through the catching cans and this applies to all liters used for the calibrations throughout the calibration of the pipe for 30L, 35L, 45L and 50L respectively).

Volume of water applied (V)=20.466liters/16dripholes

$$V = 1.28liters \times 1000cm^3$$

V=1280cm^3 (per drip hole) Therefore depth(d) of water applied=V/A

$$d = 1280cm^3/908.038cm^2$$

d=1.4cm= (14mm)

Depth of irrigation water applyingfor24.614litres
Volume of water applied(V)=24.614liters/16dripholes

$$V = 1.54liters \times 1000cm^3$$

V=1540cm^3 (per drip hole) Therefore depth (d) of water applied=V/A

$$d = 1540cm^3/908.038cm^2$$

d=1.7cm= (17mm)

Depth of irrigation water applyingfor28.650litres
Volume of water applied (V)=28.650liters/16dripholes

$$V = 1.8liters \times 1000cm^3$$

V=1800cm^3(per drip hole) Therefore depth(d) of water applied=V/A

$$d = 1800cm^3/908.038cm^2$$

d=2.00cm= (20mm)

Depth of irrigation water applyingfor36.851litres
Volume of water applied (V)=36.851liters/16dripholes

$$V = 2.3liters \times 1000cm^3$$

V=2300cm^3 (per drip hole) Therefore depth (d) of water applied=V/A

$d=2300cm^3/908.038cm^2$

$d=2.3cm=$ (23mm)

Depth of irrigation water applyingfor40.982litres
Volume of water applied(V)=40.982liters/16dripholes

$V=2.56liters \times 1000cm^3$

$V=2560cm^3$ (per drip hole) Therefore depth(d) of water applied=V/A

$d=2560cm^3/908.038cm^2$

$d=2.9cm=$ (29mm)

Plate 9: Planted Maize crop

Plate 10: Cross session of the entire field

V. Discussion of the Results

The results above shows a steady increase in the litres of water emitted with time. Unless there is a blockage in any of the emitters during long time operation, they are quite efficient in the uniform distribution of water over the land. Water quality and filtration are probably the most serious concerns when considering drip irrigation. In order to discharge very low flow rates, the diameter of the emitter orifices must be very small. This results in the emitters being blocked very easily by even the smallest contaminants in the water supply. Of particular concern are suspended solids, such as silt and sand, minerals that precipitate out of solution, such as iron or calcium, and algae that may grow in the water. Virtually every drip irrigation system must include a filtration system adequate to prevent plugging of the emitters. A system with poor quality water and poor filtration simply will not function reliably enough to warrant the maintenance requirements needed to keep it in operation.

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This low cost system requires careful water treatment to prevent emitter blockage problems. Frequent inspection of the system is necessary to insure it is functioning properly. Improper design and component sizing can result in a system with poor uniformity of application and a much lower than expected application efficiency.

A properly designed and installed drip irrigation system will normally be substantially more expensive than a sprinkler irrigation system initially. However, the lower operating cost and higher efficiency of the drip system can justify the added expense very quickly in many horticultural production systems.

Conclusion

Drip or trickle irrigation refers to the frequent application of small quantities of water at low flow rates and pressures. Rather than irrigating the entire field surface, as with sprinklers, drip irrigation is capable of delivering water precisely at the plant where nearly all of the water can be used for plant growth. Because very little water spreads to the soil between the crop rows, little water is wasted in supporting surface evaporation or weed growth.

The low cost drip system developed in this study showed a high level of uniformity of water emission across the entire study area.

- The study should be repeated in the dry season when soil moisture content can be effectively monitored.
- Further studies should focus on the design performance criteria.
- There is the need to determine the long-term effects of the depth of pipe placement and depth of water application on maize growth and yield.
- Economic analysis should be under taken to determine cost and benefits of the effects of depth of pipe placement and depth of water application on maize performance.

Conflict of Interests

The authors have not declared any conflict of interests.

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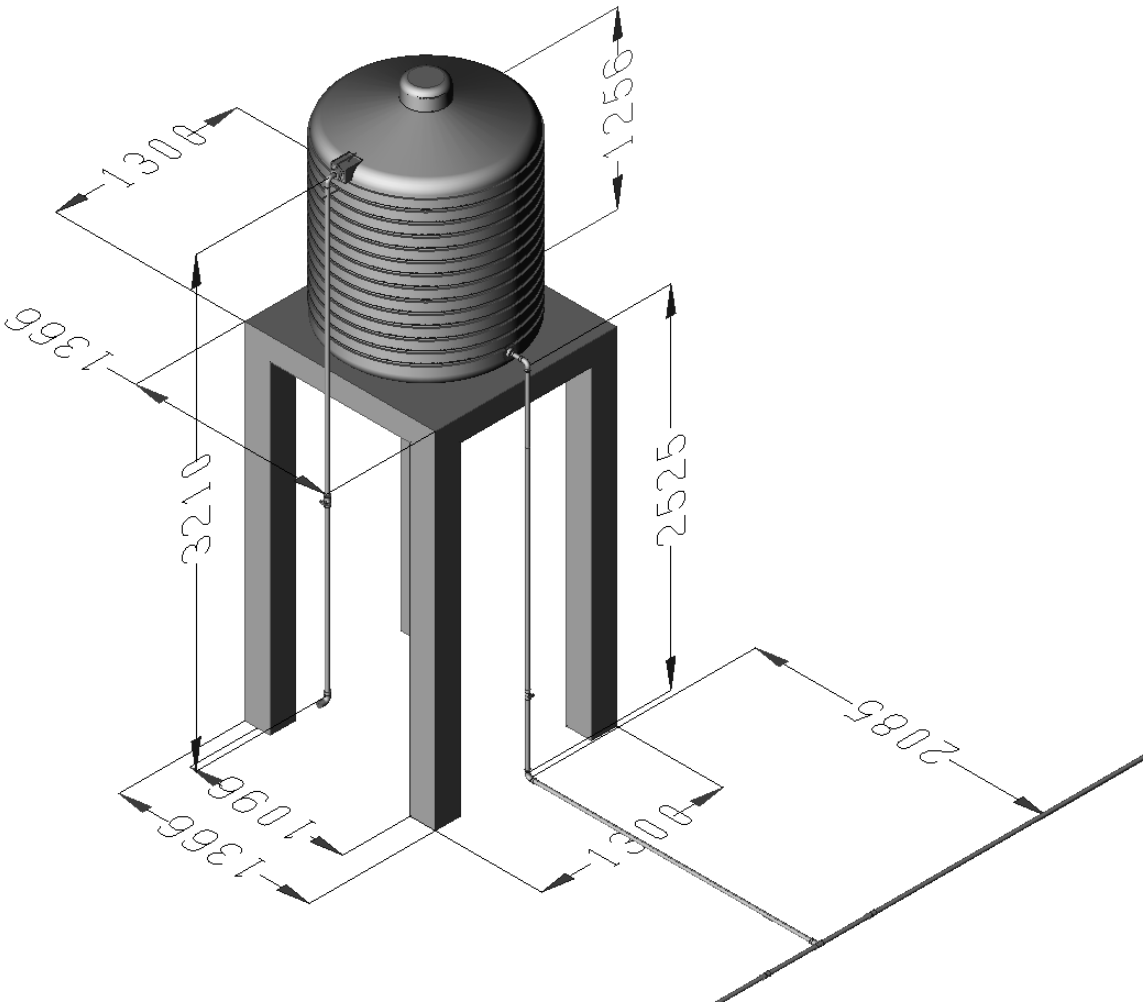
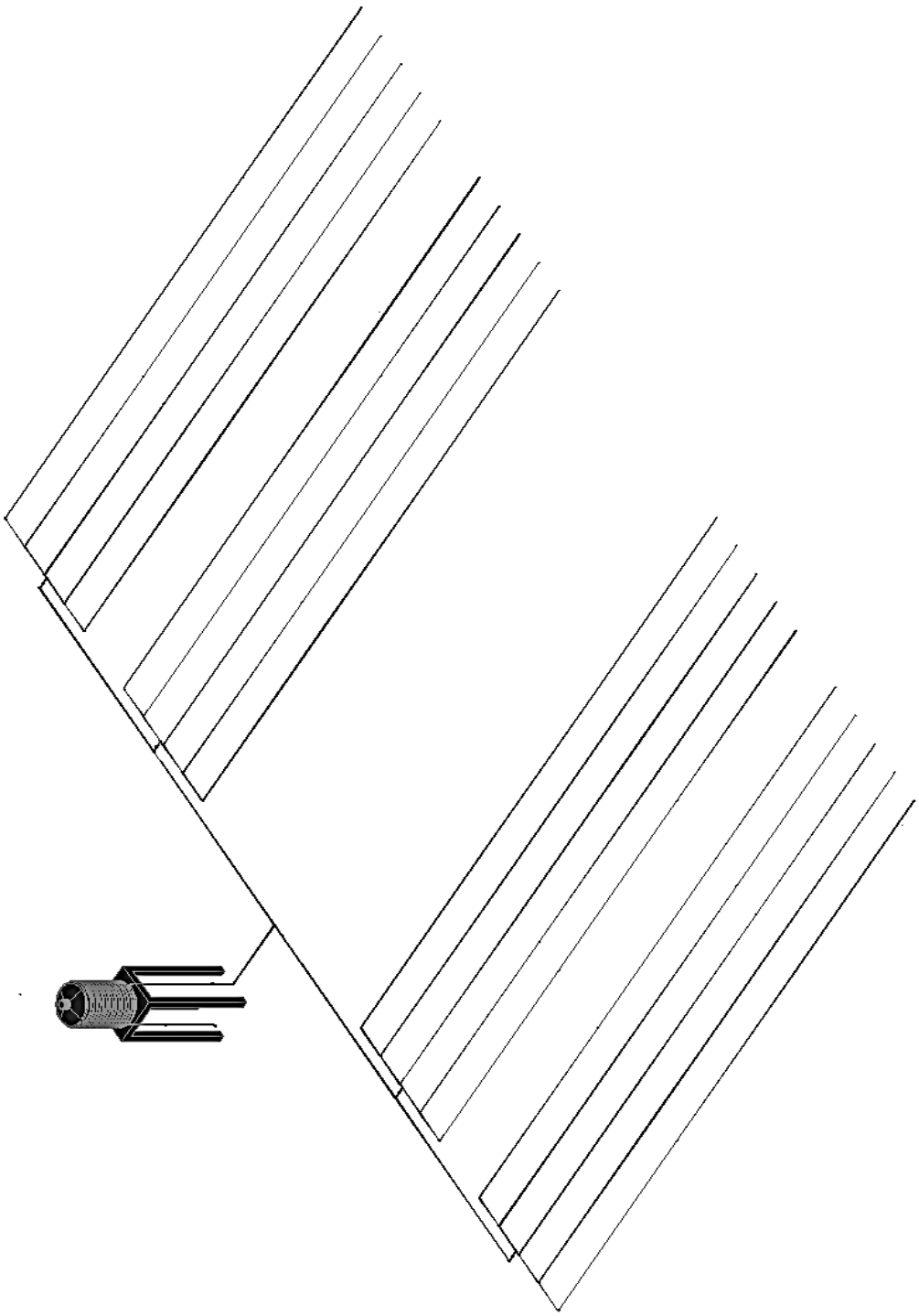
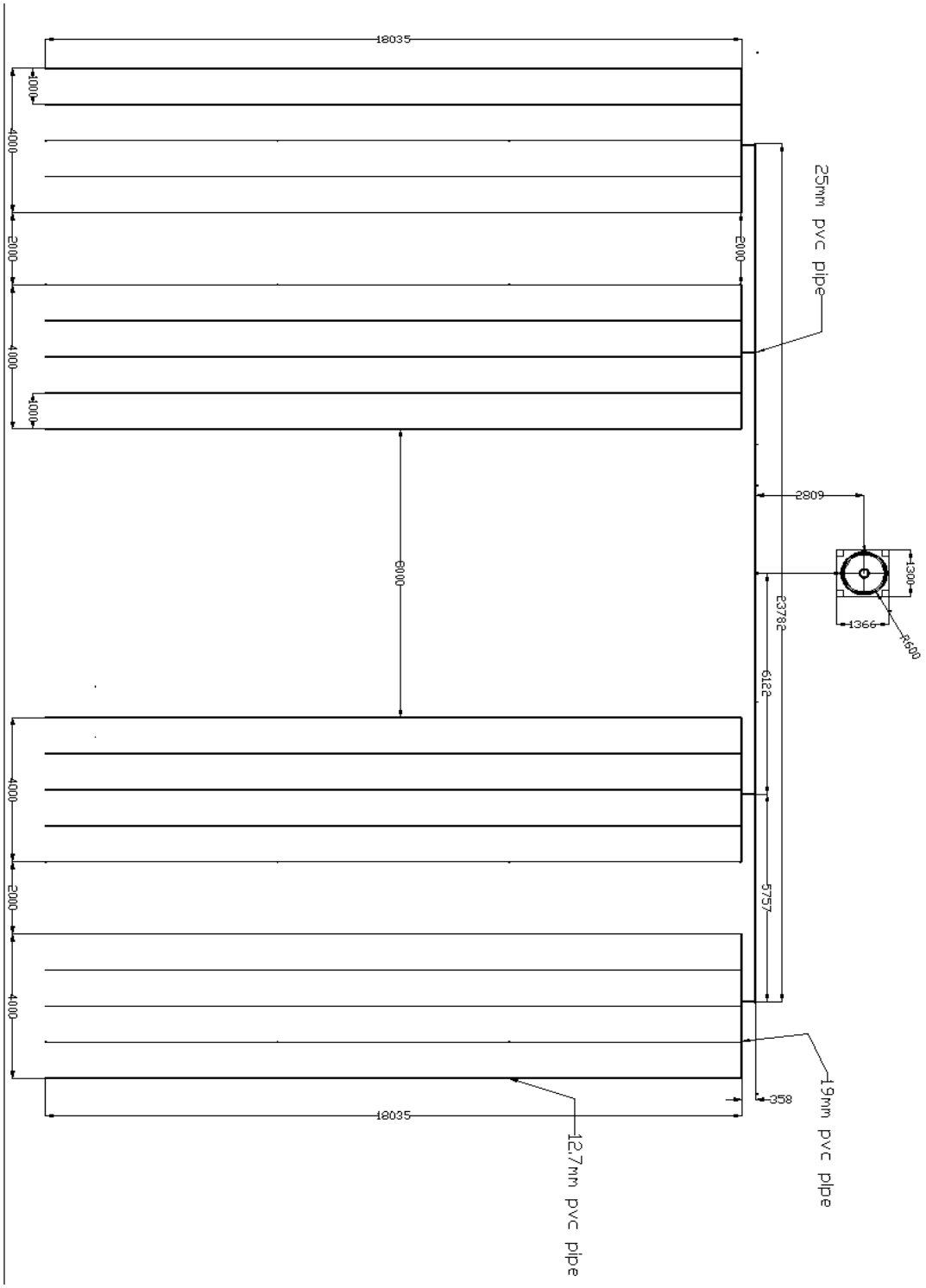
Appendix







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Designing Kids Wear: Summary of Research & Recommendation for Kids Wear Designers

By Archana

Abstract- The aim of this study was to present a satisfactory clothing design for new born baby girl aged 0 to 1. This study focuses attention on the need for comfort and easy wearable design in the new born girls market, and provides a basis for development of designs that are comfortable for children to wear, and reflect preferences of both children and parents. Research was executed to examine the history and changes of children's wear. Internet and market research were carried out. In-depth interview were done with their parents. A sample was made for one of the designs, and an evaluation showed very successful results. Summary of the research and the result is briefly explained below with its methodology to be done. This study will be also helpful for the kids wear designers.

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I. Introduction

When a designer is designing for a kid-centric brand, obviously it's important to focus on the kids. But also he should remember it's not just about the kids. It's about their parents, too. Kids are the main focus of the Indian families, thus the parents wish to dress up their kids like them. Parents consider few things while buying a dress for their new born like material, style, design, comfort and most importantly whether it is easy to wear and remove without disturbing their baby.

A kid's wear designer should be aware of few things before designing for new born babies. For first few days' right after birth, babies will be sporting umbilical cord out for the first 10-20 days. This umbilical cord can be short or long depending on where it was clamped. so the designer should bear in mind and design in such a way that the dress won't rub and irritate the baby.

Designer should also consider that the mother will feel little bit intimidate in the beginning to put or remove the babies dress. so the design of the dress should not be like pull something down over baby's head. And he should also keep in mind about the fabric he going to use according to the demography. The authors discussed about the lean role in the industries that is discussed below:

"Children's clothing serves as a screen on which are projected all kinds of beliefs, anxieties and Aspirations about children." (Bodine, 2003, 60)

How and why should we think about children and children's clothing in the field of organization studies? How does children's emotionally 'uncontrollable' and dressed bodies impact on the everyday life of organizations? What could the clothing of children as a seemingly mundane, earthy, and material topic potentially offer to the field of organization studies (OS), more broadly? As a multidimensional, inherently personal and theoretically rich territory, clothing and dress intimately connect material cloth to our skin and bodies (Entwistle, 2009).

Clothes relate to our identities, embodied experiences, and social contexts, more broadly. Acting as something of an intermediate skin, protection or aesthetic surface between 'inside' and 'outside' or 'us' and 'the world', the type of clothes we wear on the surfaces of our bodies make us act, move, perform and feel differently in our bodies. "It almost seems that to be human is to understand the structure of cloth, its interlacing's, and its feltings", Ripping (2012, 144) suggests.

The marketing literature relating to children's consumption has been and continues to be dominated by 'consumer socialisation' research (John, 1999) that is heavily underpinned by cognitive, developmental psychology and that aims principally to understand how individual children accrue - across predictable 'age-stages' (Piaget, 1960) - an increasing level of sophistication in interpreting marketing messages and operating competently and autonomously within the market place (e.g. John, 1999; Oates et al., 2001; Chaplin and John, 2007).

II. Methodology

Method followed for achieving the desired result was followed through conduction of research starts with collecting secondary data through already available research papers and articles which give a wide view of kids wear market. The second step is collecting primary data by surveying, fixed number of consumer were interviewed, as well as by observation of present trend of clothing among kids by visiting various public places like parks and malls and local market was done. Finally the collected data was analyzed and results were developed.

a) Collecting secondary data

We have to keep in mind that the parents are going to be changing a lot of diapers throughout the day for newborns, so the designer should design clothing

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that makes this easier for the parents. Designer should also remember that newborns grow fast, so you really don't need to go crazy with newborn outfits. Few already existing designs for kids are.

Onesies are the staple of baby's wardrobe .People use onesies instead of regular shirts because they snap at the crotch, thereby preventing them from hiking up. Unless you live in a warm climate, long-sleeved onesies are preferred to keep those pudgy little arms warm.

Pants, If it's not warm, babies need pants to accompany the afore mentioned onesie and cotton pants are much more comfortable. The footed onesie is the most awesome, easy, useful piece of clothing you can buy. Forget about an onesie, pants, socks, shoes, and mitts. Jammies are also easier to find because stores just call them pajamas, unlike the aforementioned situation. Footed jammies are the best to ensure those little feet stay nice and warm.

b) Preparing a questionnaire

Questionnaire is prepared accordingly:

QUESTIONNAIRE

(DESIGNING KIDS WEAR: SUMMARY OF RESEARCH & RECOMMENDATION FOR KIDS WEAR DESIGNERS)

Parent name:

Location:

Baby name:

Gender:

Age:

1. How often do you purchase for your baby?

O Very often O often O rare O very rare

2. What are the things you consider before buying? (Can mark more than one answer)

O fabric O design O style O price

3. What fabric do you prefer?

O cotton O linen O knit fabrics O bamboo rayon

4. Your design preference?

O simple designs O plain O heavy embellishment O moderate embellishment

5. What kind of print do you prefer?

O simple O plain O colorful O doesn't matter

6. Difficulties in the already existing baby wear?

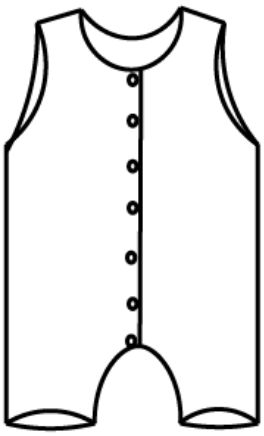
7.any suggestion for the new design?

c) Analyzing the report

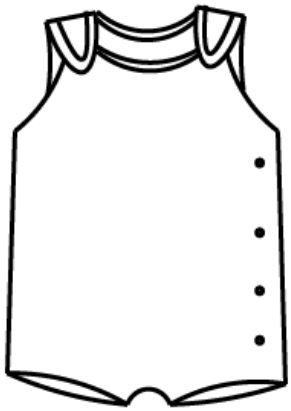
19 new born baby girls mother was asked to answer this questionnaire. Their answers are collected and analyzed to make a final report.

- 70 % people picked "very often" and remaining 30 % picked "often". The other two options were picked by none.
- 40 % people picked "style",30 % people picked "fabric",20% people picked "design" and only 10% people picked "price"
- 30%people picked "cotton", 40% people picked "knit fabric", 20 % people picked "linen "and only 10% people picked "bamboo rayon".
- 60 %people marked "simple" and "plain", 20% people marked "colorful", and the rest selected "doesn't matter".
- Most of the new born baby's parents feel difficulty in removing the dress over the head of their baby. And they are concerned about the fasteners in the back of the neck, since new born babies are lying in their back most of the times; they need a simple solution for this.

d) Designing kids wear



Design no.1



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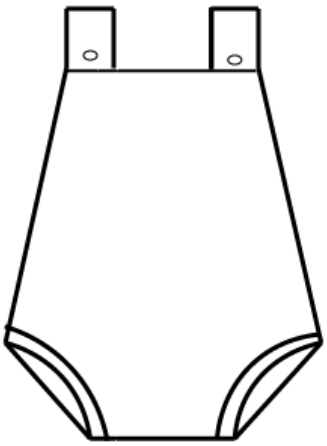
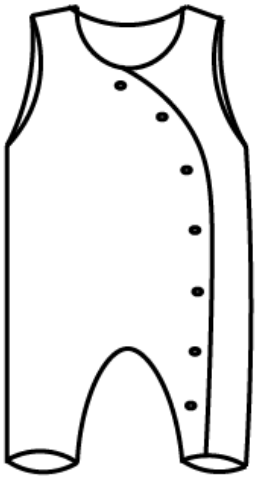


Design no.3

Design no.4



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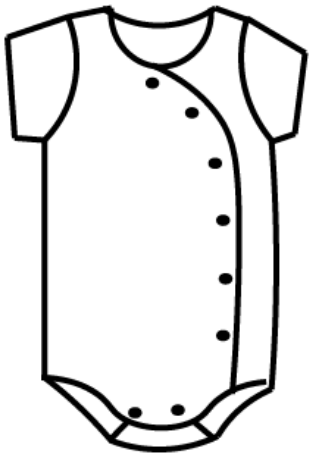
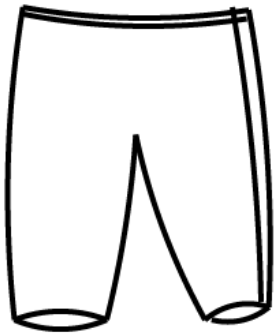


Design no.6

Design no.7



Design no.8

e) Parents Feedback about design

19 new born baby girls mother was asked to give feedback about the designs made. Their answers are collected and analyzed to make a final report.

- Design no 1: easy to wear without disturbing the baby but for frequent diaper change it's not that helpful
- Design no 2: easy to wear and remove, the closure at the shoulder is innovative
- Design no 3:same like the design no 1,thus not helpful for the diaper change
- Design no 4:60% parents picked this dress for their baby.but they preferred the same design with short sleeves
- Design no 5: suitable as a night wear or for winter rainy season.
- Design no 6,7&8 are the most liked design thus sample of each one is made.

f) Results

Design no 1:

Design no 2:

Design no 3:

III. Conclusion

Thus from above review a design for new born baby girl is suggested and designed, This was to present a satisfactory clothing design for new born baby girl aged 0 to 1, the proposed focuses attention on the need for comfort and easy wearable design in the new born girls market, and provides a basis for development of designs that are comfortable for children to wear, and reflect preferences of both children and parents. A sample was made for one of the designs, and an evaluation showed very successful results. Summary of the research and the result will be also helpful for the kids wear designers.

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Global Network Management under Spatial Grasp Paradigm

By Peter Simon Sapaty

Abstract- The paper describes basics of high-level management model and technology for dealing with large distributed human or technical systems which can be represented as dynamic physical-virtual networks covering any terrestrial or celestial environments. The main technology component, Spatial Grasp Language (SGL), allows us to obtain powerful and compact spatial solutions of different problems by directly expressing their top semantics while hiding traditional system organization and management routines inside efficient networked implementation. Different network creation, evolution, matching, and transformation approaches are investigated and shown in SGL on general networks, which may be practically useful in a variety of areas influencing the dangerously growing world dynamics and caused, for example, by climate change, military, religious and ethnic conflicts, terrorism, refugee flows, weapons proliferation, political and industrial restructuring, growing inequality, economic instability, global insecurity, and very recently, due to the world-wide pandemic horror.

Keywords: *world dynamics, high-level network management, spatial grasp technology, spatial grasp language, network evolution, network dynamics, graph pattern matching, distributed simulation, parallel and distributed programming.*

GJRE-J Classification: *FOR Code: 091599*

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Keywords: world dynamics, high-level network management, spatial grasp technology, spatial grasp language, network evolution, network dynamics, graph pattern matching, distributed simulation, parallel and distributed programming.

I. Introduction

We are witnessing rapidly growing world dynamics caused by climate change, military, religious and ethnic conflicts, terrorism, refugee flows, weapons proliferation, political and industrial restructuring, inequality, economic instability, global insecurity, and very recently, due to the world-wide pandemic horror [1-10]. Dealing with frequently emerging crises may need rapid integration of scattered heterogeneous resources into capable operational forces pursuing goals which may not be known in advance. Proper understanding and managing of unpredictable and crisis situations urgently need their detailed simulation at runtime and even ahead of it [11-30]. This may also require deep integration of advanced simulation with live control and management within united and enriching each other concepts of virtual, physical, and executive worlds, which should be effectively organized in both local and global scale [31-42].

The developed Spatial Grasp formalism and Technology (SGT), which was patented and revealed in numerous previous publications (Wiley, Springer, and Emerald books including) [43-48] provides basics for deep integration, actually symbiosis, of different worlds allowing us to unite advanced distributed simulation with spatial parallel and fully distributed control. The investigated applications included classical graph and network theory problems, missile defense, massive collective robotics, evolution of space systems, flexible command and control, industrial, social and international security problems, also effectively expressing main gestalt theory laws allowing them to cover any distributed systems rather than just human mind and brain. The developed formalism allows us to directly exist, operate, and move in different worlds and their combinations, while shifting traditional numerous and boring system management and simulation routines (DIS and HLA [19-27] including) completely to automatic networked interpretation of the basic Spatial Grasp Language (SGL), with resulting solutions often hundreds of times shorter and simpler.

Many problems in the mentioned areas can be formulated on distributed dynamic physical and virtual networks, from their initial creation, growth and evolution to possible decline and death. The current paper analyzes and shows SGT capabilities for parallel and often holistic expression of some basic operations on general networks of arbitrary size and physical distribution, which may be practically useful in all listed above areas for solving various problems. The demonstrated networking approach can also cover much greater spheres, up to creation and evolution of the very universe, by offering practical mechanisms for its simulation on arbitrary large distributed computer networks with millions to billions of communication nodes.

The rest of the paper is organized as follows. Section 2 provides basic details of the developed spatial

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paradigm that resulted in Spatial Grasp Technology (SGT) with its basic Spatial Grasp Language (SGL) suitable for creation and management of large dynamic systems in distributed and parallel mode. Section 3 describes examples in SGL of simulation of hypothetical business networks covering certain physical spaces, highlighting top level network creation, its hierarchical growth, appearance of new inter-node relations, and further unlimited evolution. Section 4 gives an example of how arbitrary large network can be created in SGL in a randomized and parallel mode, in a single breath, symbolically mimicking "Big Bang" hypothesis. Sections 5 and 6 are investigating different kinds of pattern matching techniques on the created network example. In Section 5, only constant patterns are used with known names of all nodes and links, also ranging from simple to arbitrary topologies. In Section 6, different patterns with variables are considered, first with variables in nodes only, then with variables in both nodes and links, and additionally, with variable graph structures.

Examples of possible global network dynamics are considered in Section 7, from their gradual shrinking to unlimited expansion. Regarding the shrinking process, it is shown how to substitute arbitrary sub-network with a single node having same links to the remaining nodes the removed nodes had. This shrinking also continued in a repeated swallowing by such node of new neighbors in a "Black Hole" mode, until the whole net degenerates into a single node. Another possible network self-destruction is shown where nodes self-discovering fewer neighbors than a threshold given are ceasing to exist, thus weakening in such a way their direct neighbors, and so on. A technique is also shown in SGL for the opposite process – unlimited network growth by the number of nodes and links, and also expansion in physical space up to the whole universe (imitating "Dark Matter" hypothesis too). Section 8 concludes the paper showing possibility of SGT implementation in traditional environments and the ongoing researched of its applicability in other areas.

II. Spatial Grasp Technology Basics

a) General SGT Idea

Within Spatial Grasp Technology (SGT), a high-level scenario for any task to be performed in a distributed world is represented as an active self-evolving pattern rather than traditional program, sequential or parallel. This pattern, written in a high-level Spatial Grasp Language (SGL) and expressing top semantics of the problem to be solved, can start from any world point. It then spatially propagates, replicates, modifies, covers and matches the distributed world in parallel wavelike mode, while echoing the reached control states and data found or obtained for making decisions at higher levels and further space navigation. This inherently parallel and fully distributed spatial process is very symbolically shown in Fig. 1.

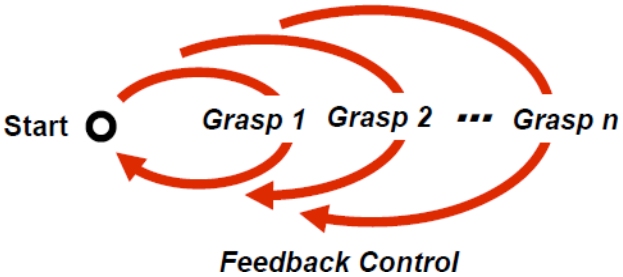
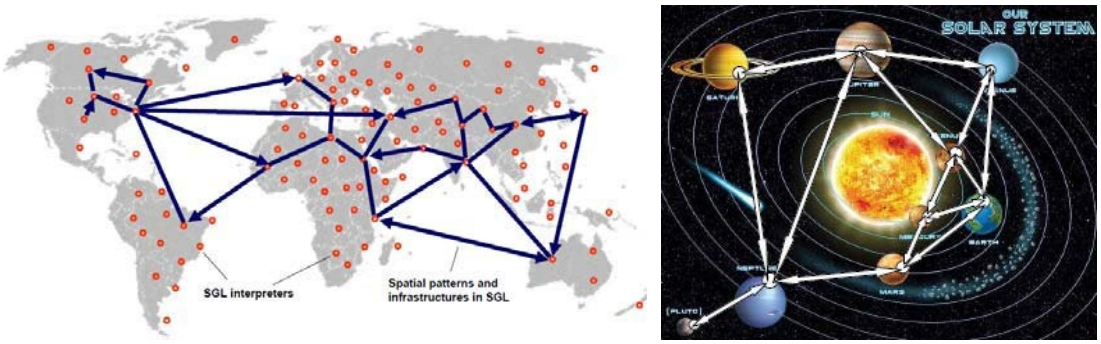


Fig. 1: Controlled navigation & matching & grasping of distributed spaces

Many spatial processes in SGL can start any time and in any places, cooperating or competing with each other, depending on applications. The self-spreading & self-matching SGL patterns-scenarios can create knowledge infrastructures arbitrarily distributed between system components which may cover any regions, from terrestrial (Fig. 2,a) to even celestial in the future (Fig. 2,b).



a b

Fig. 2: Spreading spatial patterns and creation of distributed infrastructures

These infrastructures, which may remain active any time, can effectively support or express distributed databases, advanced command and control, situation awareness, autonomous and collective decisions, as well as any existing or hypothetical computational and or control models.

b) Spatial Grasp Language

General SGL organization is as follows, where syntactic categories are shown in italics, vertical bar separates alternatives, parts in braces indicate zero or more repetitions with a delimiter at the right if multiple, and constructs in brackets may be optional:

grasp → ***constant*** | ***variable*** | [***rule***] [({ ***grasp*** , })]

From this definition, an SGL scenario called grasp, supposedly applied in some point of the distributed space, can just be a constant directly providing the result to be associated with this point. It can be a variable whose content, assigned to it previously when staying in this or (remotely) in other space point (as variables may have non-local meaning and coverage), provides the result in the application point too. It can also be a rule (expressing certain action, control, description or context) optionally accompanied with operands separated by comma (if multiple) and embraced in parentheses. These operands can be of any nature and complexity (including arbitrary scenarios themselves) and defined recursively as grasp too, i.e. can be constants, variables or any rules with operands (i.e. as grasps again), and so on.

Rules, starting in some world point, can organize navigation of the world sequentially, in parallel or any combinations thereof. They can result in staying in the same application point or can cause movement to other world points with obtained results to be left there, as in the rule's final points. Such results can also be collected, processed, and returned to the rule's starting point, the latter serving as the final one on this rule. The final world points reached after the rule invocation can themselves become starting ones for other rules. The rules, due to recursive language organization, can form arbitrary operational and control infrastructures expressing any sequential, parallel, hierarchical, centralized, localized, mixed and up to fully decentralized and distributed algorithms. These algorithms, called *spatial*, can effectively operate *in*, *with*, *under*, *in between*, *over*, and *instead of* (as for simulation) large, dynamic, and heterogeneous spaces, which can be *physical*, *virtual*, *management*, *command and control*, or *combined*.

SGL full syntax description, as of its latest version, is as follows, with the words in Courier New font being direct language symbols (boldfaced braces including).

grasp → *constant* | *variable* | [*rule*] [({ *grasp* , })]
constant → *information* | *matter* | *custom* | *special* | *grasp*
information → *string* | *scenario* | *number*
string → ‘{*character*}’
scenario → **{**{*character*}**}**
number → [*sign*]{*digit*}[.{*digit*}[e[*sign*]{*digit*}]]
matter → “{*character*}”
special → thru | done | fail | fatal | infinite | nil | any | all | other | allother | current | passed | existing | neighbors | direct | forward | backward | synchronous | asynchronous | virtual | physical | executive | engaged | vacant | firstcome | unique | usual | real | simulate
variable → *global* | *heritable* | *frontal* | *nodal* | *environmental*
global → G{*alphameric*}
heritable → H{*alphameric*}
frontal → F{*alphameric*}
nodal → N{*alphameric*}
environmental → TYPE | IDENTITY | NAME | CONTENT | ADDRESS | POINT | QUALITIES | WHERE | BACK | PREVIOUS | PREDECESSOR | DOER | RESOURCES | LINK | DIRECTION | WHEN | TIME | STATE | VALUE | IDENTITY | IN | OUT | STATUS | MODE | COLOR
rule → *type* | *usage* | *movement* | *creation* | *echoing* | *verification* | *assignment* | *advancement* | *branching* | *transference* | *exchange* | *timing* | *qualifying* | *grasp*
type → global | heritable | frontal | nodal | environmental | matter | number | string | scenario | constant | custom
usage → address | coordinate | content | index | time | speed | name | place | center | range | doer | node | link | unit

movement → hop | hopfirst | hopforth | move | shift | pass | return | follow
creation → create | form | linkup | delete | unlink
echoing → state | rake | order | unit | unique | sum | count | first | last | min | max | random | average | sortup | sortdown | reverse | element | position | fromto | add | subtract | multiply | divide | degree | separate | unite | attach | append | common | withdraw | increment | decrement | access | invert | apply | location
verification → equal | nonequal | less | lessorequal | more | moreorequal | bigger | smaller | heavier | lighter | longer | shorter | empty | nonempty | belong | notbelong | intersect | notintersect | yes | no
assignment → assign | assignpeers | associate
advancement → advance | slide | repeat | align | fringe
branching → branch | sequence | parallel | if | or | and | choose | quickest | cycle | loop | sling | whirl | split
transference → run | call
exchange → input | output | send | receive | emit | get
timing → sleep | allowed
qualification → contain | release | free | blind | quit | abort | stay | lift | seize

c) SGL Interpreter

The SGL interpreter main components and its general organization are shown in Fig. 3.

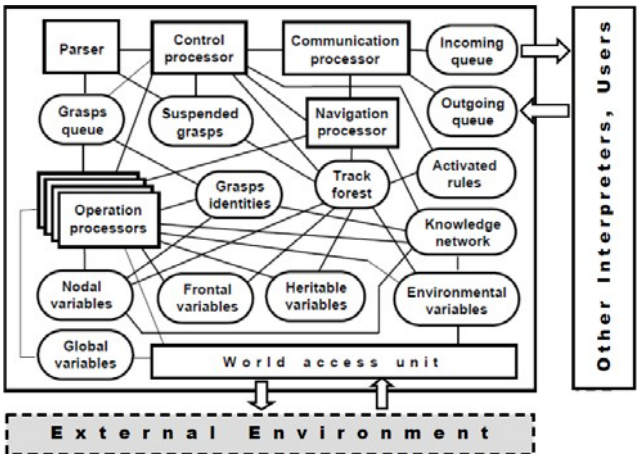


Fig. 3: SGL interpreter main components and their interactions

The interpreter consists of a number of specialized *functional processors* (shown by rectangles) working with and sharing specific data structures. These include: Communication Processor, Control Processor, Navigation Processor, Parser, different Operation Processors, and special (external & internal) World Access Unit directly manageable from SGL. Main *data structures* (also referred to as *stores*) with which these processors operate (shown by ovals) comprise: Grasps Queue, Suspended Grasps, Track Forest, Activated Rules, Knowledge Network, Grasps Identities, Heritable Variables, Fontal Variables, Nodal Variables, Environmental Variables, Global Variables, Incoming Queue, and Outgoing Queue. SGL interpretation network generally serves multiple scenarios or their parallel branches simultaneously navigating the distributed world, which can cooperate or compete with each other.

As both *backbone and nerve system* of the distributed interpreter, its *hierarchical spatial track system* dynamically spans the worlds in which SGL scenarios evolve, providing *automatic control of multiple distributed processes*. Its part related to the current interpreter is kept in the Track Forest store which is interlinked with similar parts in other interpreters, forming altogether *global control coverage*. Self-optimizing in parallel echo processes, this (generally forest-like) distributed track structure provides *hierarchical command and control* as well as *remote data and code access*. It also supports spatial variables and merges distributed control states for making decisions at different organizational levels. The track infrastructure can be automatically distributed between different world points during scenario spreading in distributed environments.

Each interpreter can support and process multiple SGL scenario code which happens to be in its responsibility at different moments of time. More details on SGT, SGL, its implementation and investigated and tested applications can be found elsewhere, including in [44-48]. Implanted into any distributed systems and integrated with them, the interpretation network (having potentially millions to billions of communicating interpreter copies) allows us to form *spatial world computer* with practically unlimited power for simulation and management of the whole mankind.

III. Creation and Growth of Business Networks

We will show here how the birth and growth of hypothetical business centers with subordinate units and evolution of different kinds of channels and relations between them can be expressed in the spatial grasp mode provided by SGL. All network nodes will be considered as having all three (i.e. physical, virtual, and executive) dimensions discussed in [65], and the randomized development of business network will be taking place in a physical region with certain boundaries.

a) Top Level Network Creation

Creation and activation of initial top level business nodes (having names for simplicity in digits) with their random physical distribution, as in Fig. 4, may be done in SGL as follows (where these initial business loci can be created in parallel, thus simulating possible concurrent appearance of different businesses in a distributed area).

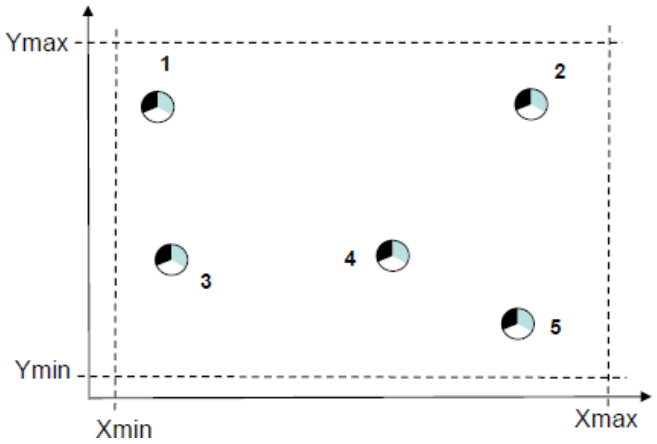


Fig. 4: Creation of initial business centers

```
parallel(1,2,3,4,5); Name = VALUE;
create_node(
  IDENTITY(Name), CONTENT("top"),
          coordinate(random(Xmin, Xmax), random(Ymin, Ymax))); activate(current)
```

Explicit mentioning of the combined type of these nodes (i.e. by using TYPE = P_V_E) is optional, because such features as IDENTITY and linkage to physical (i.e. X-Y defined) space are just speaking for themselves. In a three- dimensional environment (like, for example, in outer space) coordinate Z may be needed too.

Linking the created top level nodes by a sort of global channels, as shown in Fig. 5 by hard lines, may be done as follows.

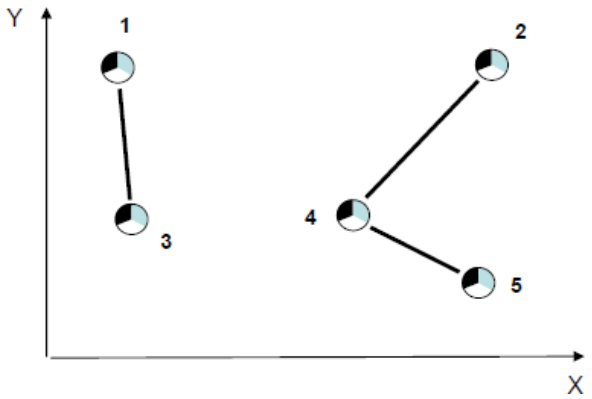


Fig. 5: Linking business centers by global channels

```
parallel(
 (hop_node(1); linkup("global", node(3)),
 (hop_node(4); parallel_linkup("global", nodes(2, 5)));
```

Introducing additional top level nodes randomly distributed in space too, which could be done in parallel, with random and parallel linking them by global channels to the already created nodes, as in Fig. 6, may be achieved by the following SGL scenario.

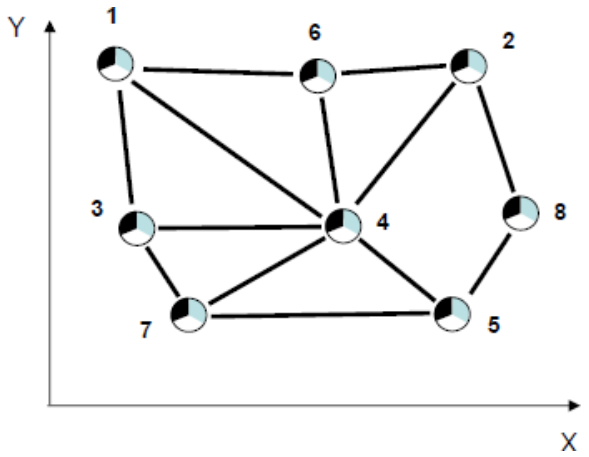


Fig. 6: Creating new centers and connecting with previous ones

```
parallel_branch(6,7,8); Name = VALUE;
create_node(
  IDENTITY(Name), CONTENT("top"),
    coordinate(random(Xmin, Xmax), random(Ymin, Ymax))); stay_parallel_linkup("global",
                    randon_nodes(1, 2, 3, 4, 5)), activate(current))
```

b) Hierarchical Network Evolution and Growth

Let us consider a possible further hierarchical extension and growth of the created network, by introducing additional subordinate nodes to the already created top nodes with establishing directed management links from them, as in Fig. 7, with possible SGL scenario following. Three subordinate nodes (with digital sub-names from 1 to 3) for each top node are planned, with a randomly defined distance to them within certain threshold (expressed in italics).

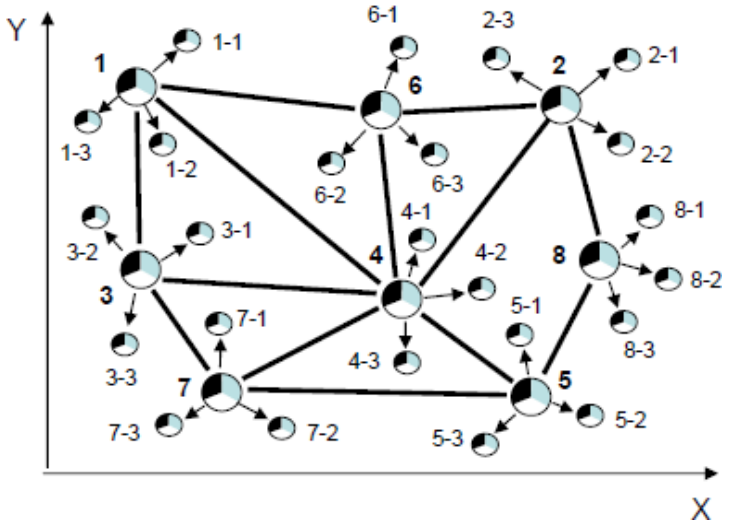


Fig. 7: Hierarchical evolution and growth of business network

```
hop_nodes(all); parallel(1,2,3);
Below = VALUE;
create(link(+"manage"),
       node(IDENTITY(NAME & '-' & Below), CONTENT("subordinate"),
            coordinate_random(maxdistance)));
                                  activate(current)
```

c) Appearance of Additional Inter-Node Relations

Imagine now that these new subordinate nodes (already having direct control, management and business links with their top level nodes) want to establish additional direct local business or even joint production relations with other subordinate nodes existing in some vicinity, as shown by dashed lines in Fig. 8 and by the SGL scenario following.

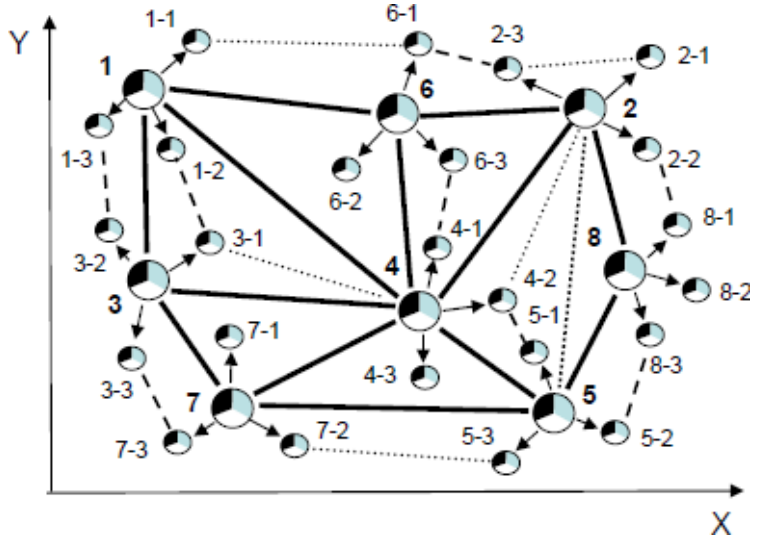


Fig. 8: Establishing new business and information relations between nodes

```
hop_random_nodes(CONTENT("subordinate"));
linkup("business",
            hop_random_nodes(distance(maxdistance), CONTENT("subordinate")))
```

We may also suppose that any nodes of this network already operating for some time, may establish different kinds of information exchange or shared knowledge links regardless of distance between them, as shown in Fig. 8 in dotted lines and by the following scenario.

```
hop_random_nodes(all); linkup("information",
random_nodes(others))
```

d) Further Network Growth

Using similar SGL scenarios as above, we can continue growing the network of Fig. 8, both hierarchically by adding more levels of nodal subordination (names of lower level nodes may be extended from the names of the previous level, similar to Fig. 4), and also introducing additional direct links between different types of nodes, as shown in Fig. 9.

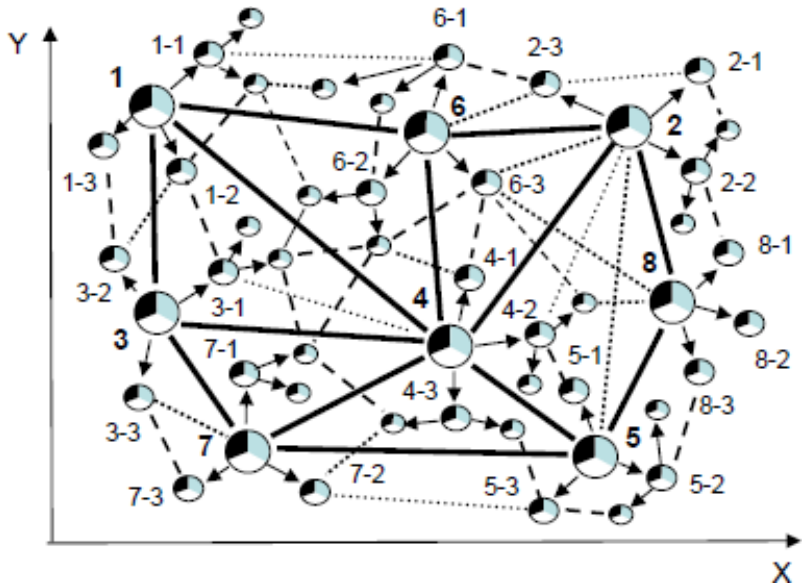


Fig. 9: Further growth of the business network

In further developments, new top level nodes may appear with new global links between themselves and already existing top nodes, which, in their turn, may create subordinate nodes within any levels of hierarchy. Various new links with other nodes can be established too, and so on, thus effectively imitating industrial growth in both terrestrial and celestial environments, including its inevitable extension to Moon, Cislunar Space, even Mars and beyond, and all this can be clearly and concisely described and simulated in SGL.

IV. Parallel Creation of Arbitrary Network

In the previous section we have described an example of creation and growth of industrial-like networks in distributed environments which, despite generality, had certain specifics like general hierarchical organization and particular semantics-oriented types of relations and connections between nodes.

For investigation of various operations on general networks in the subsequent sections we will consider here the creation of arbitrarily large exemplary virtual network in a single breath mode, symbolically imitating the "Big Bang" hypothesis [49]. It will be using node names expressed for simplicity by digits and links randomly connecting such nodes with random number of other nodes, with link names as lower case alphabetic letters. This is shown in Fig. 10 and by the following parallel SGL scenario (using for compactness of the picture only a limited number of nodes named from 1 to 20, with the number of possible connections to other nodes just between 2 and 6).

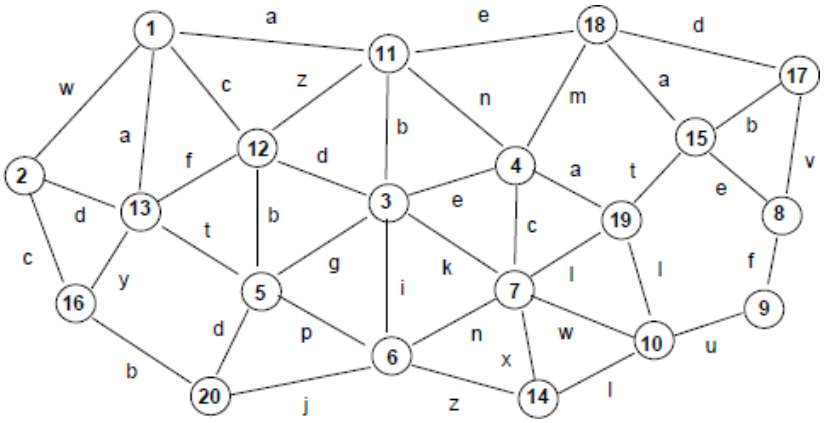


Fig. 10: Parallel creation of exemplary network in a single breath

```
create_parallel_nodes(fromto(1, 20));
 linkup_parallel(
   random(lower_case_letters),
                nodes(number_random_fromto(2, 6), names_random(all_others)))
```

If to consider distribution of the created nodes in physical space, the scenario may look like follows, with nodes supposedly allowed to be randomly linked with each other only within certain threshold distance between them. And the nodes' physical positions should also be within certain boundaries defined by: Xmin, Xmax, Ymin, and Ymax.

```
 create_parallel_nodes(
   fromto(1, 20), coordinates(random(Xmin, Xmax), random(Ymin, Ymax)));
 linkup_parallel(
   random(lower_case_letters),
     nodes(number_random_fromto(2, 6), names_random(all_others), distance(maxdistance)))
```

As the network and its distribution in physical space were performed randomly by this scenario, its real visual planar picture may not be as nice as in Fig. 10, which we have drawn here only for conveniently showing and explaining various solutions on general networks, to be discussed in the subsequent sections. It to consider a 3-D network creation, distribution and growth, say, like both on Earth and in outer space, we should engage the third dimension too, with Zmin and Zmax as its expected limits.

V. Network Pattern Matching with Constant Patterns

Describing and finding different structures in distributed networks has numerous applications in different areas of system management. We are starting here with discovering various structures in arbitrary networks that have known topology and names of all their nodes and links, which can be found by applying corresponding constant graph patterns to the whole network.

a) Examples of Particular Patterns and Their Matches

Three simple traditional patterns are shown in Fig. 11, with Pattern 1 just reflecting two linked nodes, Pattern 2 as a star, and Pattern 3 as a tree.

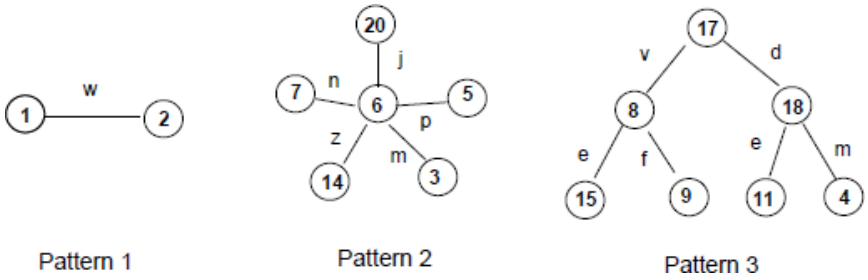


Fig. 11: Simple graph patterns with constant nodes and links

The following is there expression and network matching in SGL, with output of the matching success possible in different locations.

Pattern 1

Starting in the first node and output in the second node:

```
hop_node(1); hop(link(w), node(2)); output(OK)
```

Starting in the first node and output in it too:

```
hop_node(1); if(hop(link(w), node(2)), output(OK))
```

Output in the outside location from which the scenario was issued and then started in the first node:

```
if((hop_node(1); hop(link(w), node(2))), output(OK))
```

Similar to all above will be if to start matching from the second node of the pattern. The only match of this pattern is shown in Fig. 12.

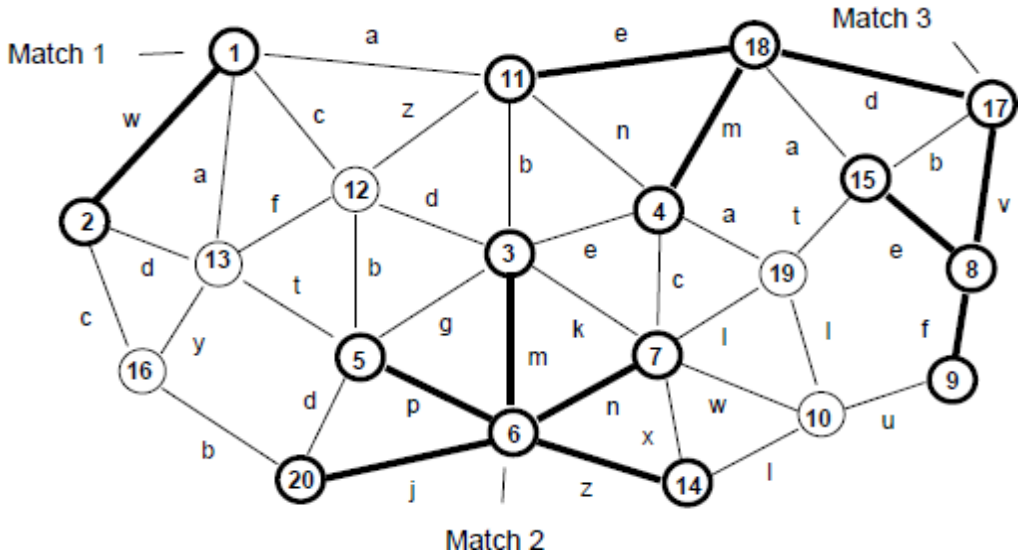


Fig. 12: Matching solutions for simple patterns

Pattern 2

The output in case of matching success can be issued in the central pattern's node (i.e. 6) or in the scenario starting location, with SGL code for the second case following and matching result in Fig. 12

```
if((hop_node(6);
    and_parallel(
      hop(link(j), node(20)),
      hop(link(p), node(5)),
      hop(link(m), node(3)),
      hop(link(z), node(14)),
      hop(link(n), node(7)))),
   output(OK))
```

.Pattern 3

The output for this tree-structured pattern can be issued in the top tree node (i.e. 17) or in the scenario starting location as for the previous pattern, with SGL code for the second option following and successful match shown in Fig. 12.

```
if((hop_node(17);
    and_parallel(
      (hop(link(d), node(18));
       and_parallel(hop(link(m), node(4)),
                    hop(link(e), node(11)))),
      (hop(link(v), node(8));
       and_parallel(hop(link(f), node(9)),
                    hop(link(e), node(15))))))),
output(OK))
```

b) Dealing with Arbitrary Patterns

Any constant graph pattern can be easily represented as a tree too, as in the previous case, which should cover all pattern's nodes and all links, and for this, some nodes may be repeated more than once, as for the pattern in Fig. 13,a and one of its possible tree representation shown in Fig. 13,b. The repeated nodes in this tree will be as: 6, 7, 10, and 14.

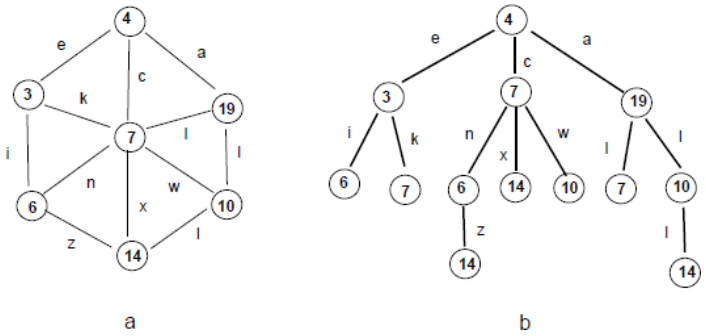


Fig. 13: Representation of arbitrary graph pattern by a tree with repeating nodes

The SGL matching scenario will be as follows, with matching result to be issued in the outside position issuing the scenario (the output can also be organized in the top tree node, here 4).

```
if((hop_node(4);
    and_parallel(
      (hop(link(a), node(19));
       and_parallel((hop(link(l), node(10)); hop(link(l), node(14))),
                    hop(link(l), node(7))),
      (hop(link(c), node(7));
       and_parallel(hop(link(w), node(10)),
                    hop(link(x), node(14)),
                    (hop(link(n), node(6)); hop(lik(z), node(14)))),
      (hop(link(e), node(3));
       and_parallel(hop(link(k), node(7)),
                    hop(link(i), node(6))))))),
output(OK))
```

Successful matching result for this tree-converted pattern is shown in Fig. 14.

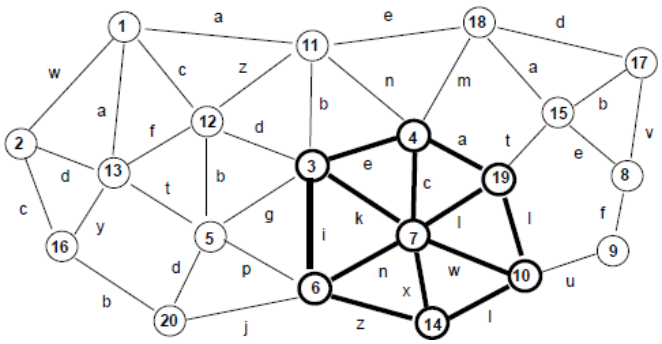


Fig. 14: Matching result for arbitrary graph pattern

VI. Using Graph Patterns with Variables

In the previous section we considered finding parts of the network with exact structures, exact number of nodes and links, and all link and node names as known constants, with all this expressed in detail in the search patterns. In the current section, we will be considering matching patterns having variables associated with their different elements: nodes, links, as well as total graph structures with not known in advance numbers of nodes and links.

a) Patterns with Variables in Nodes Only

Such patterns will be having variables in all nodes only with their meanings to be found after successful matches with the network, by using different constant graph structures, from simplest to most general.

i. *Particular patterns with nodal variables*

We will be using simple patterns with variables in nodes as in Fig. 15, which are similar to the patterns with all constants of Fig. 11.

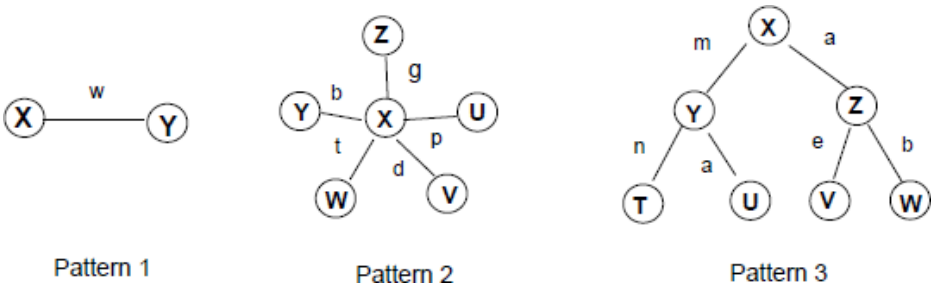


Fig. 15: Simple graph patterns with variables in nodes

Pattern 1

Collecting X and Y meanings and printing the successful match in the second (or Y) node, as follows.

```
frontal(X);
hop_nodes(all); X = NAME; hop_link(w); Y = NAME; output(X && Y)
```

Printing the match in the second node without explicit using variables X, Y:

```
hop_nodes(all); hop_link(w); output(PREDECESSOR && NAME)
```

Similar, but printing the matching result in the first (or X) node:

```
hop_nodes(all); output(hop_link(w); PREDECESSOR && NAME)
```

Similar, but printing all possible matches in the external location from which the scenario was issued (showing particular results as parenthesized units to distinguish between different solutions):

```
output(hop_nodes(all); hop_link(w); unit(PREDECESSOR && NAME))
```

Output of all solutions (see Fig. 16) will be: (2, 1), (1, 2) , (7, 10), (10, 7).

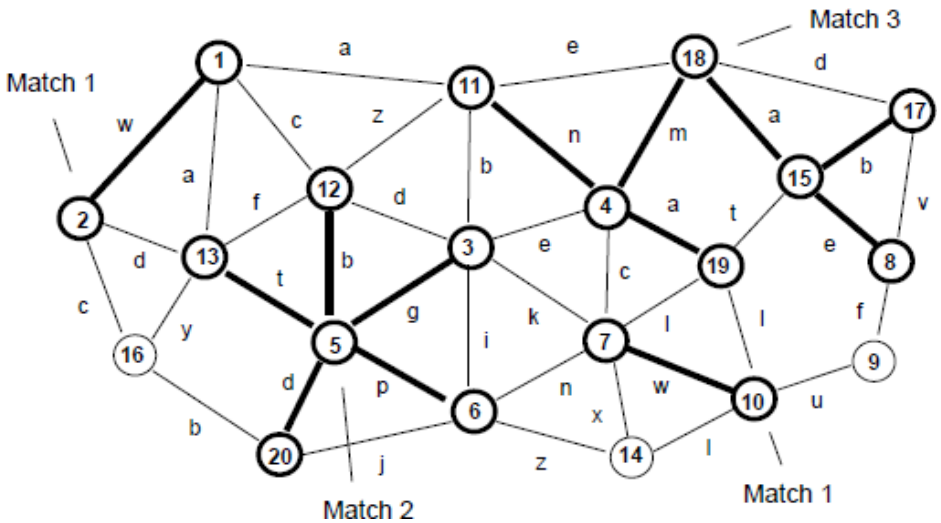


Fig. 16: Matching results for simple patterns with variables

Pattern 2

Printing the match found in the central, X- related node can be achieved by:

```
 hop_nodes(all);
 output(
   and_parallel(
    'X:' & NAME,
    (hop_link(b); 'Y:' & NAME),
    (hop_link(g); 'Z:' & NAME),
    (hop_link(p); 'U:' & NAME),
    (hop_link(d); 'V:' & NAME),
(hop_link(t); 'W:' & NAME)))
```

Output (see Fig. 14) will be as: X:5, Y:12, Z:3, U:6, V:20, W:13.

Printing in the scenario starting location of all possible matches where different matches as separate units should be enclosed in parentheses to be distinguishable from each other, if more than one (we only have a single match for this pattern, as in Fig. 16).

```
 output( hop_nodes(all);
   unit(and_parallel(
         'X:' & NAME,
         (hop_link(b); 'Y:' & NAME),
         (hop_link(g); 'Z:' & NAME),
         (hop_link(p); 'U:' & NAME),
         (hop_link(d); 'V:' & NAME),
(hop_link(t); 'W:' & NAME))))
```

The printed solution will be as: (X:5, Y:12, Z:3, U:6, V:20, W:13).

Pattern 3

A particular match for this pattern, if found, can be issued in the X-related node, and all matches can also be printed in the scenario starting position (similar to the previous case). We are showing here the second option, with only a single match available for the network of Fig. 16.

```
output(
       hop_nodes(all);
       unit(and_parallel(
          'X:' & NAME,
          (hop_link(a);
           and_parallel('Z:' & NAME,
                        (hop_link(b); 'W:' & NAME),
                        (hop_link(e); 'V:' & NAME))),
          (hop_link(m);
           and_parallel('Y:' & NAME,
                        (hop_link(a); 'U:' & NAME),
(hop_link(n); 'T:' & NAME)))))
```

Output of the only match (see Fig. 14) will be: (X:18, Y:4, Z:15, U:19, V:8, W:17, T:11).

ii. *Using arbitrary graph patterns*

One of possible matching techniques for arbitrary patterns with variables in nodes, actually the simplest one, can be based on a path through all pattern's nodes, simplifying collection of all found values of variables for a particular match at the end of the path (see Fig. 17,a,b). Some nodes and links may have to be represented more than once in such a pass (not for the case of Fig. 17,a).

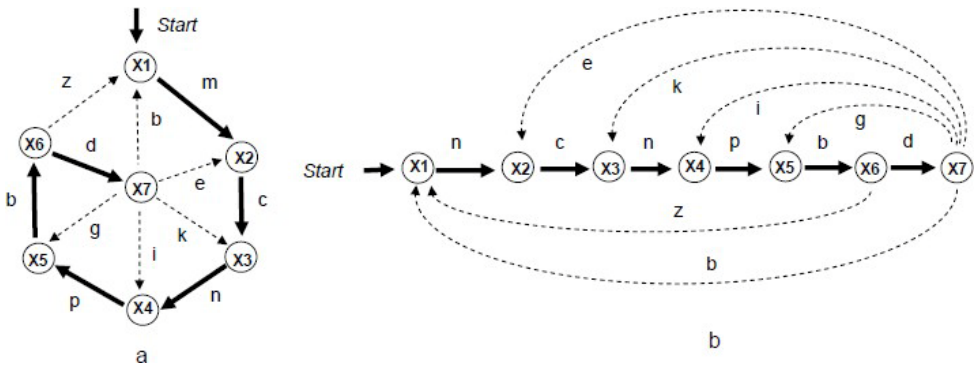


Fig. 17: Universal linear representation of arbitrary pattern with variables in nodes

With the resultant node matches represented in the order reflecting indexing of variables Xi in the path, and the remaining links always leading to the previous nodes of the path, the SGL solution for Fig. 17,b will be as follows, with the output in final node of the path corresponding to variable X7.

```
 hop_nodes(all); frontal(X) = NAME;
 hop_link(n); X &&= NAME; hop_link(c);
 X &&= NAME; hop_link(n); X &&= NAME;
 hop_link(p); X &&= NAME; hop_link(b);
 true_hop(link(z), node(X[1])); X
 &&= NAME; hop_link(d);
 true_hop(link(e), node(X[2]));
 true_hop(link(k), node(X[3]));
 true_hop(link(i), node(X[4]));
true_hop(link(g), node(X[5])); X &&= NAME; output(X)
```

Resultant match for variables X1 to X7, issued in the final node match 3, will be as: 11, 4, 7, 6, 5, 12, 3 (see also Fig. 18)

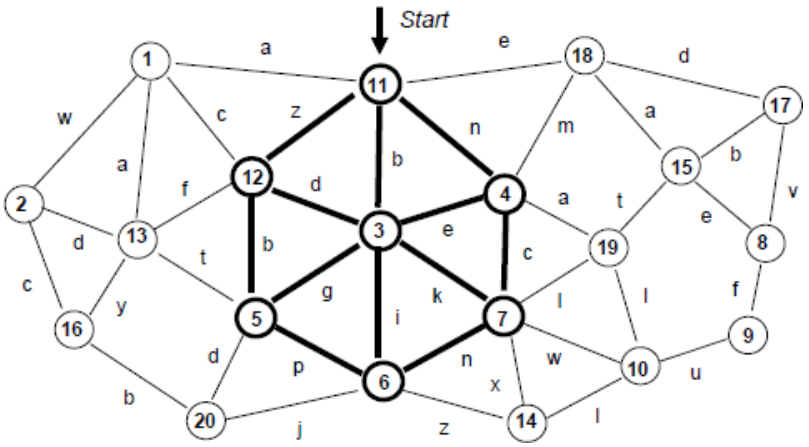


Fig. 18: Matching result for the arbitrary pattern with variables

By introducing parallel branches and issuing all possible matches in the external position from which the matching scenario was issued, the SGL solution will be as follows:

```
 output(
   hop_nodes(all); frontal(X) = NAME;
   hop_link(n); X &&= NAME; hop_link(c);
   X &&= NAME; hop_link(n); X &&= NAME;
   hop_link(p); X &&= NAME; hop_link(b);
   true(hop(link(z), node(X[1]))); X
   &&= NAME; hop_link(d);
   true_and_parallel(
      hop(link(e), node(X[2])),
      hop(link(k), node(X[3])),
      hop(link(i), node(X[4])),
hop(link(g), node(X[5])))); unit(X && NAME))
```

The only available match (same as before) will be issued in the outside position as a parenthesized unit: (11, 4, 7, 6, 5, 12, 3). We could also issue each match after its full completion in the starting node of the pattern (corresponding to variable X1, i.e. found node 11), as was shown for the previous patterns.

b) Arbitrary Graph Patterns with Variables in Both Nodes and Links

An example of such pattern, similar to the previous one of Fig. 17 but with variables on links too, is shown in Fig 19,a,b, where the indexing of variables for nodes and links is chosen to be arbitrary and possibly more convenient, not necessarily following the path though all nodes as before. (This is accomplished by organizing sets of variables as indexed lists allowing for their growth and access to elements in any order, by explicit indices, during storing of different matches of nodes and links).

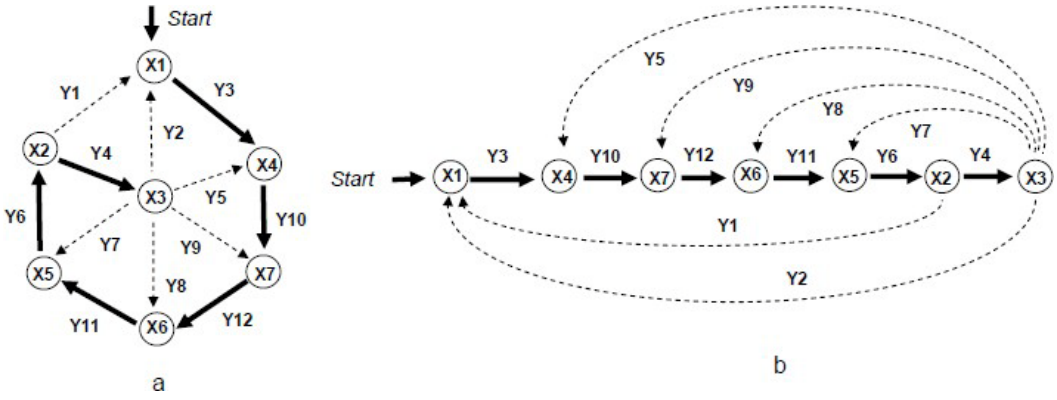


Fig. 19: Arbitrary graph pattern with variables in nodes and links and its linear matching template

Each matching solution can be issued in the path final node related to X3, in its starting node related to X1, and we can also collect all possible matches in the scenario starting outside position, similarly to the previous patterns, with the solution for the third option just following.

```
output(
  hop_nodes(all); frontal(X, Y);
  X[1] = NAME
  hop_link(any); X[4] = NAME; Y[3] = LINK;
  hop_noback_link(any); X[7] = NAME; Y[10] = LINK;
  hop_noback_link(any); X[6] = NAME; Y[12] = LINK;
  hop_noback_link(any); X[5] = NAME; Y[11] = LINK;
  hop_noback_link(any); X[2] = NAME; Y[6] = LINK;
  nonempty(Y[1] = (hop(link(any), node(X[1])); LINK));
  hop_noback_link(any); X[3] = NAME; Y[4] = LINK;
  true_and_parallel(
       nonempty(Y[5] = (hop(link(any), node(X[4])); LINK)),
       nonempty(Y[9] = (hop(link(any), node(X[7])); LINK)),
       nonempty(Y[8] = (hop(link(any), node(X[6])); LINK)),
       nonempty(Y[7] = (hop(link(any), node(X[5])); LINK)));
unit(unit('X: ', X), unit('Y: ', Y)))
```

The output of all matches for the network of Fig. 10 (possibly, in a different order) will be as follows, with the order of printed names of nodes and links in each match corresponding to the indices of related X and Y variables of the pattern in Fig. 19.

14 matches found for the graph of Fig. 18 shown in bold:

((X: 11, 12, 3, 4, 5, 6, 7), (Y: z, b, n, d, e, b, g, i, k, c, p, n)), … ,

And also there are 14 matches for the graph of Fig. 14, in bold too:

((X: 4, 3, 7, 19, 6, 14, 10), (Y: e, c, a, k, l, i, n, x, w, z , l)), … .

Multiple matches for same graphs of Figs 14 and 18 appeared because each node of these graphs can match the starting pattern's node, i.e. X1, and also the circular path from it via remaining nodes can develop in two opposite directions (like clockwise and counterclockwise), but all the mentioned above matches are formally different and legitimate.

c) Patterns with Variable Structures

All previous cases with constants or variables in nodes and links considered exact, fixed structures of the patterns which should be matched with the network. But the pattern's structure can also be a sort of a variable too, say, by fitting solutions with different number of nodes and links, as well as their interconnections. We will consider here a simple example of finding structures representing a cyclic chain (ring) of interconnected nodes which may not have known in advance number of nodes (say, with its maximum limited by some threshold), with all nodes and links as variables too, as in Fig. 20. Special constraints are also be added to this pattern -- that all nodes of these rings do not have other connections with each other than those forming the ring, and also there is no at least a single outside node that has links with all nodes of the ring (like "external authority", say, for special applications).

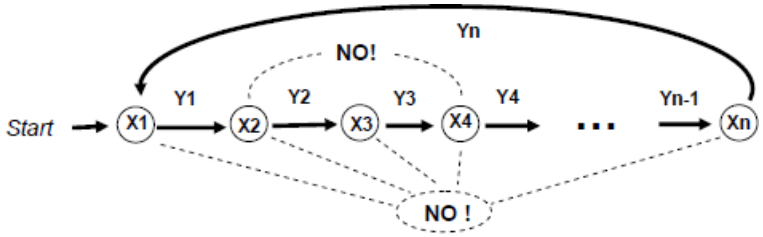


Fig. 20: Example of a pattern with variable number of nodes and links

Finding such a match with output in its finally found (i.e. Xn related) node can be achieved by the following scenario, with the threshold number of nodes (or count) in such matches taken as 5.

```
hop_nodes(all); frontal(X = NAME, Y);
repeat(
  hop_noback_links(all); append(LINK, Y);
  if(NAME = X[1],
     done(no(hop_nodes(X); hop(links(all), nodes(not(X));
             and_parallel_hop(links(any), nodes(X)));
output(unit('X:',  X),  unit('Y:',  Y)));  notbelong(NAME,  X);  no_hop_noback(links(any),
nodes(X)); append(NAME, X); count(X) <= 5)
```

Output in the scenario starting position of all possible matches can be achieved by:

```
output(
 hop_nodes(all); frontal(X = NAME, Y);
 repeat(
  hop_noback_links(all); append(LINK, Y);
  if(NAME = X[1],
     done(no(hop_nodes(X); hop(links(all), nodes(not(X));
             and_parallel_hop(links(any), nodes(X)));
unit(unit('X:',  X),  unit('Y:',  Y)));  notbelong(NAME,  X);  no_hop_noback(links(any),
nodes(X)); append(NAME, X)); count(X) <= 5))
```

Output of only some matches in the scenario starting node will be:

((X: 1, 11, 12), (Y:a, z, c)), ((X: 3, 7, 6), (Y: k, n, i)), … -- all three nodes
((X: 16, 13, 5, 20), (Y: y, t, d, b)), ((X: 4, 18, 15, 19), (Y: m, a, t, a)) -- four nodes
((X: 19, 15, 8, 9, 10), (Y: t, e, f, u, l)) -- five nodes

Some of the found matches are shown in Fig. 21 in bold or dashed lines if solutions intersect, where full result includes all triangles. Each match will actually have repetitions, as its search starts from all nodes of the same solution, also develops in both ways in the ring (like clockwise and counterclockwise), which will be reflected by indices of the resultant values of X and Y variables.

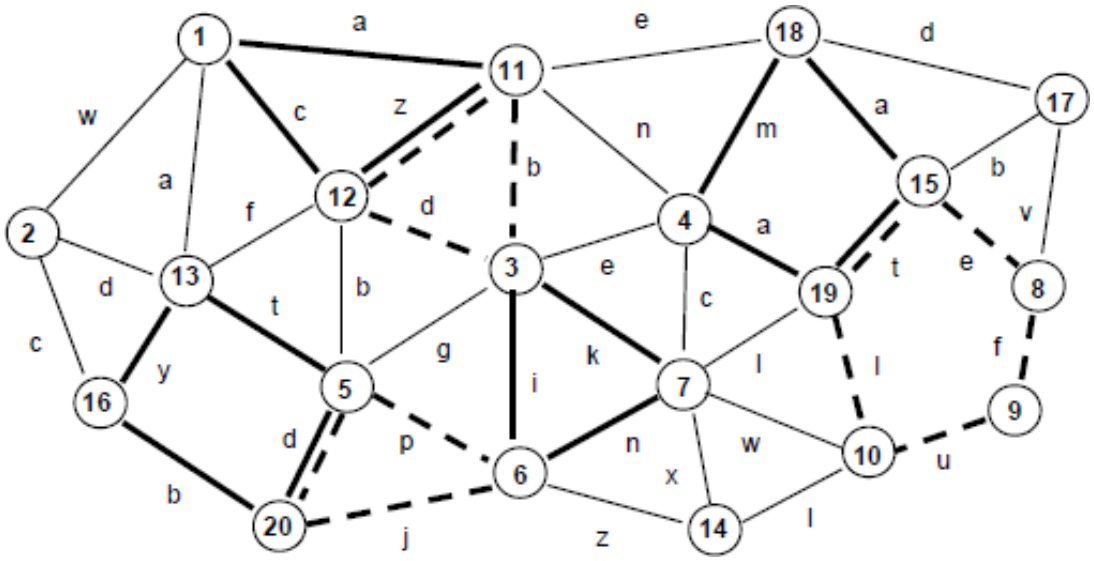


Fig. 21: Some matching solutions for the pattern with variable structure

Multiple repeated solutions, which may start from each node of the ring and develop in two directions, can be easily reduced to only two. This is achievable by allowing them to start only with the node having the strongest name (or address) among all nodes of the ring. In this respect, we can extend the string just before the last one in two previous scenarios as follows:

```
X[1] > NAME; notbelong(NAME, X); no(hop_noback(links(any), nodes(X)));
```

If to take other than 5 threshold number of nodes in the previous scenario, we will have additional ring solutions without "central authority", as below for count(X) <= 6, see also Fig. 22.

((X: 2, 1, 12, 5, 20, 16), (Y: w, c, b, d, b, c))
((X: 13, 12, 3, 6, 20, 16), (Y: f, d, i, j, b, y))
((X: 11, 18, 15, 19, 7, 3), (Y: e, a, t, l, k, b))

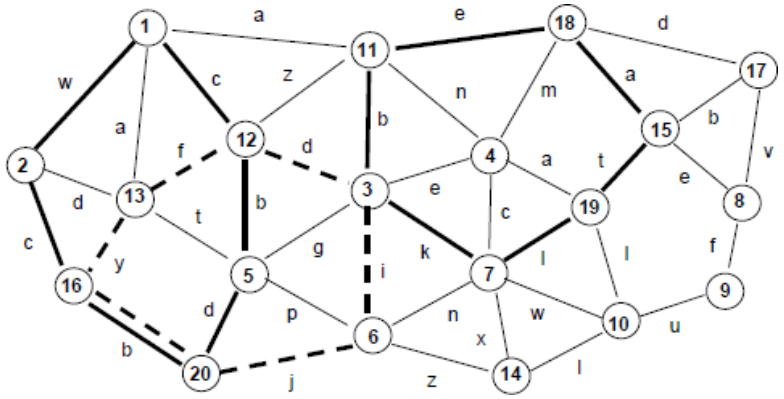


Fig. 22: Additional matches for the variable pattern with increased threshold on the number of nodes

VII. Examples of Global Network Dynamics

We will be considering here some massive operations and transformations on distributed networks in a global scale and their effective expression in SGL.

a) Shrinking Networks

We will show here how to express massive gradual self-reduction of the network in its size, i.e. in a number of its nodes and links, from its full body to the ultimate naught, by using different kinds of parallel techniques.

i. *Substituting of a group of nodes with a single node*

By first considering the pattern of Fig. 17 with variables in nodes, will be trying to substitute all nodes of its match found in Fig. 18 by a single node, say, with a symbolic name 100, which should have all links to the remaining nodes the substituted pattern had, as in Fig. 23. Also assuming the CONTENT of this new node will reflect the number of substituted nodes by it.

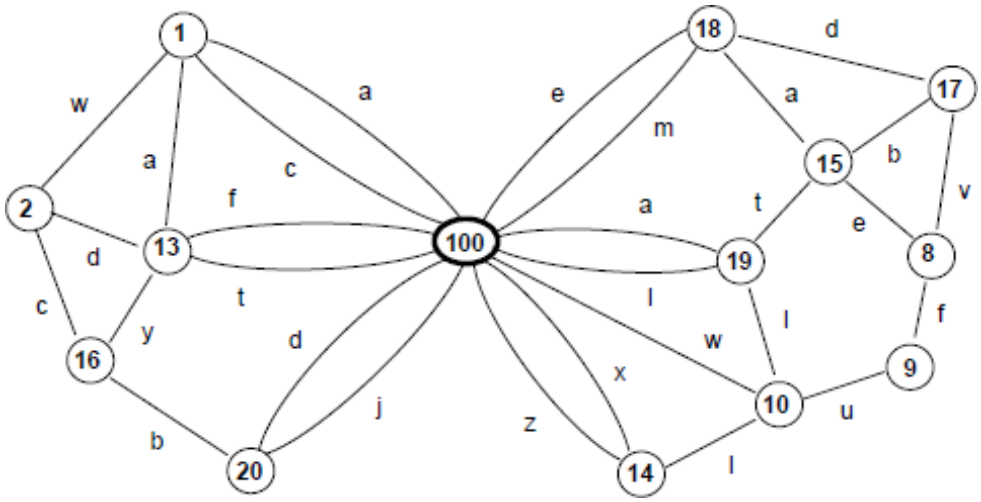


Fig. 23: Substituting a group of nodes by a single node with saving links to other nodes

A possible SGL solution for such substitution is shown below together with the initial finding the match of the pattern of Fig. 17.

```
 frontal(Group) = ( hop_nodes(all);
   frontal(X); hop_link(m); X =
   NAME; hop_link(c); X &&= NAME;
   hop_link(n); X &&= NAME;
   hop_link(p); X &&= NAME;
   hop_link(b); X &&= NAME;
   true_hop(link(z), node(X[1]));
   hop_link(d); X &&= NAME;
   true_and_parallel(
       hop(link(e), node(X[2])),
       hop(link(k), node(X[3])),
       hop(link(i), node(X[4])),
       hop(link(g), node(X[5]))); X
   && NAME);
 sequence(
   (create_node(100); CONTENT = count(Group);
    frontal(New) = ADDRESS;
    hop_nodes(Group);
    hop(links(all), nodes(notbelong(Group));
    linkup(LINK, node(New))),
remove_nodes(Group))
```

If the group's nodes to be substituted are known in advance, the SGL solution will be shorter, as follows. Also, we may place the new node into the averaged topological center of the deleted group if physical positions of its nodes are known, like for the case of virtual-physical world integration.

```
frontal(Group) = (11, 4, 7, 6, 5, 12, 3);
Center = average(hop_nodes(Group); WHERE);
sequence(
   (create_node(100, coordinate(Center));
   frontal(New) = ADDRESS; CONTENT = count(Group);
   hop_nodes(Group);
   hop(links(all), nodes(notbelong(Group));
   linkup(LINK, node(New))),
```

The CONTENT of node 100 will be 7, reflecting the number of nodes it substituted.

ii. *Black hole mode of further network shrinking*

Having substituted part of the network by the new node named 100, as above, let us consider further shrinking of this network in the "Black Hole" [50] mode, where each time this new node absorbs all neighboring nodes and establishes all links with the nodes these neighbors had before their consumption. Let us also increase the CONTENT of this Black Hole node by the number of newly swallowed nodes by it. This spatial iterative process, shown in three stages in Fig. 24 after obtaining the network of Fig. 23, results in the only renaming node 100 as the ultimate Black Hole, with SGL solution of such gradual shrinking-consumption process being as follows.

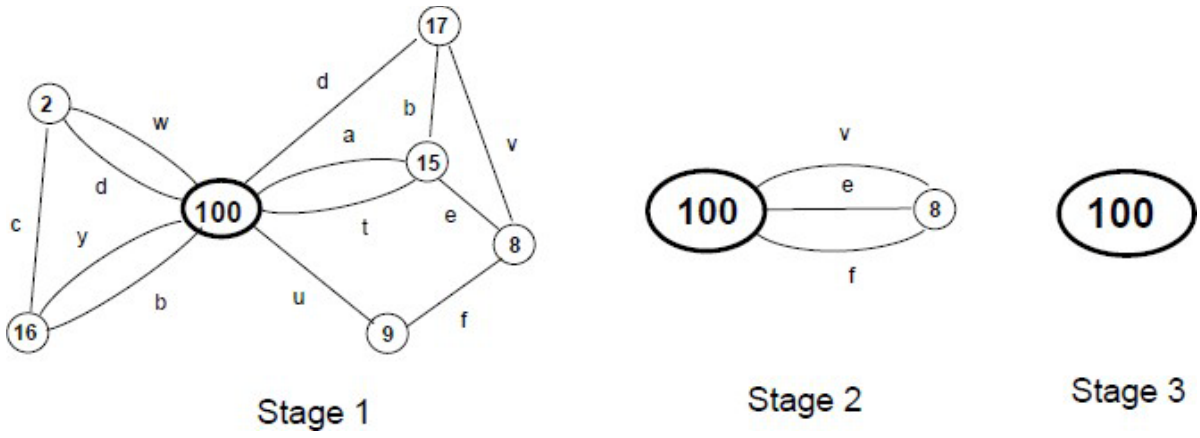


Fig. 24: Repeated "black hole" modes for further network shrinking

```
 frontal(Hole) = 100; hop_first_node(Hole);
 repeat(
   nonempty(Around = (hop_links(all); NAME));
   CONTENT += count(Around);
   stay_sequence(
     (hop_first_links(all); hop_first_links(all));
      linkup(LINK, node(Hole))),
remove(links(all), nodes(Around)); sleep(delay))
```

The final CONENT of the resulting Black Hole node will be: 7 + 5 + 5 + 1 = 18.

iii. *Gradual asynchronous self-destruction of the whole network*

The main idea here is that nodes having fewer connections with other nodes than a certain threshold are considered weak and cannot exist any more, thus removing themselves from the network. The SGL solution below is hopping to all nodes only once and staying in them as long as possible until discovering the lower number of neighboring (i.e. directly connected) nodes than the established threshold, with subsequent self-destruction. In Fig. 25, the three stages are shown of parallel self-shrinking of the network of Fig. 10 (the fourth stage would just be the empty network), with the nodes initially or subsequently (after the neighboring nodes dying) having 3 or less neighbors ceasing to exist.

```
 hop_nodes(all);
 repeat(
if(count(hop_links(all)) <= 3, remove(current)); sleep(delay))
```

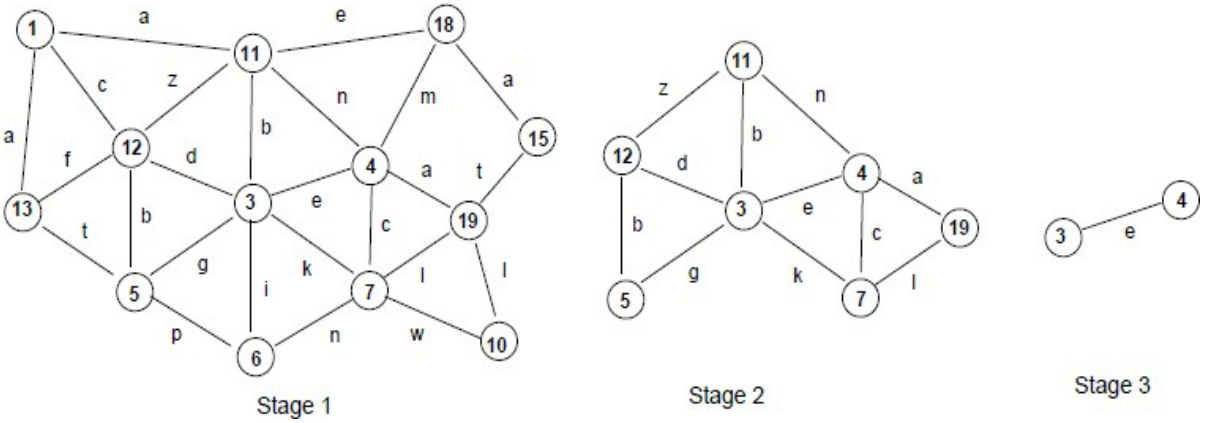


Fig. 25: Gradual network self-destruction by the death of weakest nodes

Under topologies other than of Fig. 10, and also with more links between different nodes, a part or parts of the network can survive despite initially having nodes below the given threshold number of neighbors, and this threshold can also be made varying during the network dynamics.

b) Expanding Networks

In the previous section we considered mechanisms that can provide global shrinking of networks, from their full body to ultimate naught. In the current section, we will be showing how the network can unlimitedly expand in size (i.e. the number of nodes and links) and in physical space, also imitating a sort of its symbolic explosion.

i. *Growing by the numbers of nodes and links*

We are providing here a very simple example of a possible massive expansion of the network of Fig. 10 by introducing additional nodes instead of each link, which the new nodes connected with the two nodes of the substituted links by the same named links. The new nodes may also randomly establish additional links with other nodes in certain vicinity by obeying allowed distance (or radius) in the explored region, as shown in Fig. 26 and expressed by the following parallel SGL scenario.

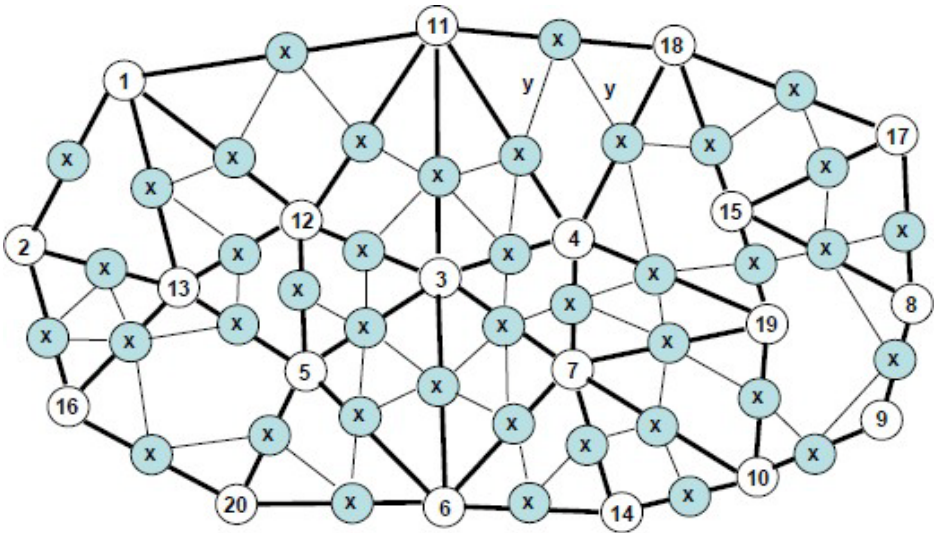


Fig. 26: Massive network expansion with a symbolic "dark matter" effect

```
hop_nodes(all); frontal(Start = NAME; Radius = maxdistance);
hop_links(all); Start > NAME; frontal(Link) = LINK;
remove(LINK); create(link(Link), node(x));
parallel(
       linkup(Link, node(Start)),
       linkup(y, random_nodes(Radius)))
```

In this elementary example of massive network expansion, we assume that all new nodes and all new links from them are same named, respectively as x and y. In Fig. 26, links with previous names that directly connected nodes of the network of Fig. 10 are shown in bold. After adding more semantics to this simplified network extension example the names and contents of new nodes and links may be quite different.

Using same ideas as above of the network extension, we may now substitute again all links between nodes by new nodes with establishing new links with other nodes, and so on, thus providing endless and unlimited extension, actually explosion, of the network of Fig. 10. The following SGL scenario is based on the previous one by just repeating it certain number of times, here 50 (for prevention of unlimited explosion), with all new nodes and links, for simplicity, again named x and y. The scenario uses synchronized global repetition controlled from outside.

```
repeat_50(
  stay(hop_nodes(all); frontal(Start = NAME, Radius = maxdistance);
       hop_links(all); PREVIOUS > ADDRESS; frontal(Link) = LINK;
       remove(LINK); create(link(Link), node(x));
       parallel(
         linkup(Link, node(Start)), linkup(y,
         random_nodes(Radius)));
  sleep(delay))
```

Asynchronous internal unlimited self-growth, only first time contacting all nodes from outside, while further extending from the new nodes only, can be achieved by the following recursive scenario procedure named Blow.

```
frontal(Blow) =
 {frontal(Start = NAME, Radius = maxdistance); hop_links(all);
  PREVIOUS > ADDRESS; frontal(Link) = LINK; remove(LINK);
  create(link(Link), node(x));
  stay_parallel(
     linkup(Link, node(Start)), linkup(y,
     random_nodes(Radius)));
sleep(delay); run(Blow)}; hop_nodes(all); run(Blow)
```

ii. *Network expansion in physical space*

We can assume that the growing number of network nodes and links can be naturally linked with network's expansion in physical space too. The gradual expansion of the net in physical space can be organized as follows. If randomly found possible new location of a node (using the Radius-like threshold distance which can also grow during network's physical expansion)

increases summary distance to other nodes directly connected with it, or at least minimal distance to them, the current node may change its physical coordinates in space to the new location found. Placing such rules into all nodes of the growing net, which can operate repeatedly all the time regardless of success or failure of current attempts to change physical position, may be done by the following scenario.

```
hop_nodes(all);
repeat(
  Radius = max(hop_links(all); distance(BACK, WHERE));
  Sum = add(hop_links(all); distance(BACK, WHERE));
  Min = min(hop_links(all); distance(BACK, WHERE));
  New = (move_random(Radius); WHERE);
  Sum1 = add(hop_links(all); distance(New, WHERE));
  Min1 = min(hop_links(all); distance(New, WHERE));
  if(or_seq(Sum1 > Sum, Min1 > Min), WHERE = New);
  sleep(delay))
```

Combining this physical extension with the previously considered network growth by the number of nodes and links, we can effectively simulate unlimited expansion, even explosion, of the network in both virtual and physical environments, actually covering the whole universe. This can be clearly expressed by the following SGL scenario using procedures Blow and Spread.

```
frontal(Blow) =
 {frontal(Start = NAME,
          Radius = average(hop_links(all); distance(BACK, WHERE)));
  hop_links(all); PREVIOUS > ADDRESS; frontal(Link) = LINK;
  remove(LINK); create(link(Link), node(x, random(Radius)));
  stay_parallel(
    linkup(Link, node(Start)), linkup(y,
    random_nodes(Radius)));
  sleep(delay); parallel_run(Blow, Spread)};
frontal(Spread) =
 {repeat(
    Radius = max(hop_links(all); distance(BACK, WHERE)); Sum
    = add(hop_links(all); distance(BACK, WHERE)); Min =
    min(hop_links(all); distance(BACK, WHERE)); New =
    (move_random(Radius); WHERE);
    Sum1 = add(hop_links(all); distance(New, WHERE));
    Min1 = min(hop_links(all); distance(New, WHERE));
    if(or(Sum1 > Sum, Min1 > Min), WHERE = New);
    sleep(delay))};
hop_nodes(all); parallel_run(Blow, Spread)
```

In establishing new links of a node with other nodes, we are regularly updating the considered depth of their vicinity by recalculating the value of Radius, as the network itself is constantly expanding in physical space.

In our simple example, the shadowed new x nodes (as of Fig. 26) may symbolically look like imitating a sort of “Dark Matter” [51] of the universe. This matter by the above scenario will, however, quickly dominate the whole network as the latter grows both virtually and physically only due to the increase of the number of shadowed nodes, with other, initial, nodes remaining in the same quantity.

VIII. Conclusions

In this paper we have shown how different operations on general networks can be described and implemented in fully distributed and highly parallel mode using the developed Spatial Grasp model and Technology and its basic spatial Grasp Language, SGL. The obtained experience of using SGT and SGL and shown exemplary solutions on networks may be useful for solving different problems in many important areas reviewed at the beginning of the paper, most of which can be conveniently formulated on distributed dynamic networks. These solutions in SGL proved to be simple and concise as the model and language allow us to directly exist and operate in distributed spaces by expressing top level problem semantics, with hiding numerous traditional system routines inside effective networked technology implementation.

At first sight, SGT and SGL may have some philosophical and conceptual resemblance to physical phenomenon like waves [52, 53] (the ancestor versions of SGL were named as WAVE [43-45]), also to biological and computer viruses [54, 55] and what is called “mobile agents” [56-58]. Yes, SGL allows us to freely move in distributed spaces in a highly parallel mode, but it also readily provides, if needed, the return of any

remote results directly to any previous space points, with their analysis and possible launching of new waves there, or the return to already gained remote space positions and further wavelike development from them, and so on. With such forward-backward recursive mode this is effectively covering and controlling any distributed systems with any power, to any depth, and by any hierarchy needed. Moreover, after and even during space coverage in recursive SGL mode, arbitrary complex and active infrastructure may be explicitly or implicitly embedded into the distributed world fabric (like openly, on agreements, or in a stealth mode for special applications). With these infrastructures effectively modeling any other concepts and models (like Petri nets or neural networks) and also capable of launching themselves new parallel waves, and so on, SGT may provide the most powerful paradigm and technology for conquering and ruling of the universe.

SGT continues its development in different areas, including advanced mosaic-type operations in distributed systems [59], in trying to understand and simulate such extremely complex features as awareness and consciousness [60], in providing philosophical and technological support of space conquest and advanced terrestrial and celestial missions [61], and many others. Among the latest publications related to other SGT applications, [62-65] can be named. The latest SGL version can be implemented even within standard university environments, similar to its previous versions in different countries under the author's supervision. The technology can be installed in numerous copies worldwide and deeply integrated with any other systems, actually acquiring unlimited power for simulation and management of the whole world.

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11. Pick a good study spot: Always try to pick a spot for your research which is quiet. Not every spot is good for studying.

12. Know what you know: Always try to know what you know by making objectives, otherwise you will be confused and unable to achieve your target.

13. Use good grammar: Always use good grammar and words that will have a positive impact on the evaluator; use of good vocabulary does not mean using tough words which the evaluator has to find in a dictionary. Do not fragment sentences. Eliminate one-word sentences. Do not ever use a big word when a smaller one would suffice.

Verbs have to be in agreement with their subjects. In a research paper, do not start sentences with conjunctions or finish them with prepositions. When writing formally, it is advisable to never split an infinitive because someone will (wrongly) complain. Avoid clichés like a disease. Always shun irritating alliteration. Use language which is simple and straightforward. Put together a neat summary.

14. Arrangement of information: Each section of the main body should start with an opening sentence, and there should be a changeover at the end of the section. Give only valid and powerful arguments for your topic. You may also maintain your arguments with records.

15. Never start at the last minute: Always allow enough time for research work. Leaving everything to the last minute will degrade your paper and spoil your work.

16. Multitasking in research is not good: Doing several things at the same time is a bad habit in the case of research activity. Research is an area where everything has a particular time slot. Divide your research work into parts, and do a particular part in a particular time slot.

17. Never copy others' work: Never copy others' work and give it your name because if the evaluator has seen it anywhere, you will be in trouble. Take proper rest and food: No matter how many hours you spend on your research activity, if you are not taking care of your health, then all your efforts will have been in vain. For quality research, take proper rest and food.

18. Go to seminars: Attend seminars if the topic is relevant to your research area. Utilize all your resources.

19. Refresh your mind after intervals: Try to give your mind a rest by listening to soft music or sleeping in intervals. This will also improve your memory. Acquire colleagues: Always try to acquire colleagues. No matter how sharp you are, if you acquire colleagues, they can give you ideas which will be helpful to your research.

20. Think technically: Always think technically. If anything happens, search for its reasons, benefits, and demerits. Think and then print: When you go to print your paper, check that tables are not split, headings are not detached from their descriptions, and page sequence is maintained.

21. Adding unnecessary information: Do not add unnecessary information like "I have used MS Excel to draw graphs." Irrelevant and inappropriate material is superfluous. Foreign terminology and phrases are not apropos. One should never take a broad view. Analogy is like feathers on a snake. Use words properly, regardless of how others use them. Remove quotations. Puns are for kids, not grunt readers. Never oversimplify: When adding material to your research paper, never go for oversimplification; this will definitely irritate the evaluator. Be specific. Never use rhythmic redundancies. Contractions shouldn't be used in a research paper. Comparisons are as terrible as clichés. Give up ampersands, abbreviations, and so on. Remove commas that are not necessary. Parenthetical words should be between brackets or commas. Understatement is always the best way to put forward earth-shaking thoughts. Give a detailed literary review.

22. Report concluded results: Use concluded results. From raw data, filter the results, and then conclude your studies based on measurements and observations taken. An appropriate number of decimal places should be used. Parenthetical remarks are prohibited here. Proofread carefully at the final stage. At the end, give an outline to your arguments. Spot perspectives of further study of the subject. Justify your conclusion at the bottom sufficiently, which will probably include examples.

23. Upon conclusion: Once you have concluded your research, the next most important step is to present your findings. Presentation is extremely important as it is the definite medium though which your research is going to be in print for the rest of the crowd. Care should be taken to categorize your thoughts well and present them in a logical and neat manner. A good quality research paper format is essential because it serves to highlight your research paper and bring to light all necessary aspects of your research.

Informal Guidelines of Research Paper Writing

Key points to remember:

- Submit all work in its final form.
- Write your paper in the form which is presented in the guidelines using the template.
- Please note the criteria peer reviewers will use for grading the final paper.

Final points:

One purpose of organizing a research paper is to let people interpret your efforts selectively. The journal requires the following sections, submitted in the order listed, with each section starting on a new page:

The introduction: This will be compiled from reference matter and reflect the design processes or outline of basis that directed you to make a study. As you carry out the process of study, the method and process section will be constructed like that. The results segment will show related statistics in nearly sequential order and direct reviewers to similar intellectual paths throughout the data that you gathered to carry out your study.

The discussion section:

This will provide understanding of the data and projections as to the implications of the results. The use of good quality references throughout the paper will give the effort trustworthiness by representing an alertness to prior workings.

Writing a research paper is not an easy job, no matter how trouble-free the actual research or concept. Practice, excellent preparation, and controlled record-keeping are the only means to make straightforward progression.

General style:

Specific editorial column necessities for compliance of a manuscript will always take over from directions in these general guidelines.

To make a paper clear: Adhere to recommended page limits.

Mistakes to avoid:

- Insertion of a title at the foot of a page with subsequent text on the next page.
- Separating a table, chart, or figure—confine each to a single page.
- Submitting a manuscript with pages out of sequence.
- In every section of your document, use standard writing style, including articles ("a" and "the").
- Keep paying attention to the topic of the paper.

- Use paragraphs to split each significant point (excluding the abstract).
- Align the primary line of each section.
- Present your points in sound order.
- Use present tense to report well-accepted matters.
- Use past tense to describe specific results.
- Do not use familiar wording; don't address the reviewer directly. Don't use slang or superlatives.
- Avoid use of extra pictures—include only those figures essential to presenting results.

Title page:

Choose a revealing title. It should be short and include the name(s) and address(es) of all authors. It should not have acronyms or abbreviations or exceed two printed lines.

Abstract: This summary should be two hundred words or less. It should clearly and briefly explain the key findings reported in the manuscript and must have precise statistics. It should not have acronyms or abbreviations. It should be logical in itself. Do not cite references at this point.

An abstract is a brief, distinct paragraph summary of finished work or work in development. In a minute or less, a reviewer can be taught the foundation behind the study, common approaches to the problem, relevant results, and significant conclusions or new questions.

Write your summary when your paper is completed because how can you write the summary of anything which is not yet written? Wealth of terminology is very essential in abstract. Use comprehensive sentences, and do not sacrifice readability for brevity; you can maintain it succinctly by phrasing sentences so that they provide more than a lone rationale. The author can at this moment go straight to shortening the outcome. Sum up the study with the subsequent elements in any summary. Try to limit the initial two items to no more than one line each.

Reason for writing the article—theory, overall issue, purpose.

- Fundamental goal.
- To-the-point depiction of the research.
- Consequences, including definite statistics—if the consequences are quantitative in nature, account for this; results of any numerical analysis should be reported. Significant conclusions or questions that emerge from the research.

Approach:

- Single section and succinct.
- An outline of the job done is always written in past tense.
- Concentrate on shortening results—limit background information to a verdict or two.
- Exact spelling, clarity of sentences and phrases, and appropriate reporting of quantities (proper units, important statistics) are just as significant in an abstract as they are anywhere else.

Introduction:

The introduction should "introduce" the manuscript. The reviewer should be presented with sufficient background information to be capable of comprehending and calculating the purpose of your study without having to refer to other works. The basis for the study should be offered. Give the most important references, but avoid making a comprehensive appraisal of the topic. Describe the problem visibly. If the problem is not acknowledged in a logical, reasonable way, the reviewer will give no attention to your results. Speak in common terms about techniques used to explain the problem, if needed, but do not present any particulars about the protocols here.

The following approach can create a valuable beginning:

- Explain the value (significance) of the study.
- Defend the model—why did you employ this particular system or method? What is its compensation? Remark upon its appropriateness from an abstract point of view as well as pointing out sensible reasons for using it.
- Present a justification. State your particular theory(-ies) or aim(s), and describe the logic that led you to choose them.
- Briefly explain the study's tentative purpose and how it meets the declared objectives.

Approach:

Use past tense except for when referring to recognized facts. After all, the manuscript will be submitted after the entire job is done. Sort out your thoughts; manufacture one key point for every section. If you make the four points listed above, you will need at least four paragraphs. Present surrounding information only when it is necessary to support a situation. The reviewer does not desire to read everything you know about a topic. Shape the theory specifically—do not take a broad view.

As always, give awareness to spelling, simplicity, and correctness of sentences and phrases.

Procedures (methods and materials):

This part is supposed to be the easiest to carve if you have good skills. A soundly written procedures segment allows a capable scientist to replicate your results. Present precise information about your supplies. The suppliers and clarity of reagents can be helpful bits of information. Present methods in sequential order, but linked methodologies can be grouped as a segment. Be concise when relating the protocols. Attempt to give the least amount of information that would permit another capable scientist to replicate your outcome, but be cautious that vital information is integrated. The use of subheadings is suggested and ought to be synchronized with the results section.

When a technique is used that has been well-described in another section, mention the specific item describing the way, but draw the basic principle while stating the situation. The purpose is to show all particular resources and broad procedures so that another person may use some or all of the methods in one more study or referee the scientific value of your work. It is not to be a step-by-step report of the whole thing you did, nor is a methods section a set of orders.

Materials:

Materials may be reported in part of a section or else they may be recognized along with your measures.

Methods:

- Report the method and not the particulars of each process that engaged the same methodology.
- Describe the method entirely.
- To be succinct, present methods under headings dedicated to specific dealings or groups of measures.
- Simplify—detail how procedures were completed, not how they were performed on a particular day.
- If well-known procedures were used, account for the procedure by name, possibly with a reference, and that's all.

Approach:

It is embarrassing to use vigorous voice when documenting methods without using first person, which would focus the reviewer's interest on the researcher rather than the job. As a result, when writing up the methods, most authors use third person passive voice.

Use standard style in this and every other part of the paper—avoid familiar lists, and use full sentences.

What to keep away from:

- Resources and methods are not a set of information.
- Skip all descriptive information and surroundings—save it for the argument.
- Leave out information that is immaterial to a third party.

Results:

The principle of a results segment is to present and demonstrate your conclusion. Create this part as entirely objective details of the outcome, and save all understanding for the discussion.

The page length of this segment is set by the sum and types of data to be reported. Use statistics and tables, if suitable, to present consequences most efficiently.

You must clearly differentiate material which would usually be incorporated in a study editorial from any unprocessed data or additional appendix matter that would not be available. In fact, such matters should not be submitted at all except if requested by the instructor.

Content:

- Sum up your conclusions in text and demonstrate them, if suitable, with figures and tables.
- In the manuscript, explain each of your consequences, and point the reader to remarks that are most appropriate.
- Present a background, such as by describing the question that was addressed by creation of an exacting study.
- Explain results of control experiments and give remarks that are not accessible in a prescribed figure or table, if appropriate.
- Examine your data, then prepare the analyzed (transformed) data in the form of a figure (graph), table, or manuscript.

What to stay away from:

- Do not discuss or infer your outcome, report surrounding information, or try to explain anything.
- Do not include raw data or intermediate calculations in a research manuscript.
- Do not present similar data more than once.
- A manuscript should complement any figures or tables, not duplicate information.
- Never confuse figures with tables—there is a difference.

Approach:

As always, use past tense when you submit your results, and put the whole thing in a reasonable order.

Put figures and tables, appropriately numbered, in order at the end of the report.

If you desire, you may place your figures and tables properly within the text of your results section.

Figures and tables:

If you put figures and tables at the end of some details, make certain that they are visibly distinguished from any attached appendix materials, such as raw facts. Whatever the position, each table must be titled, numbered one after the other, and include a heading. All figures and tables must be divided from the text.

Discussion:

The discussion is expected to be the trickiest segment to write. A lot of papers submitted to the journal are discarded based on problems with the discussion. There is no rule for how long an argument should be.

Position your understanding of the outcome visibly to lead the reviewer through your conclusions, and then finish the paper with a summing up of the implications of the study. The purpose here is to offer an understanding of your results and support all of your conclusions, using facts from your research and generally accepted information, if suitable. The implication of results should be fully described.

Infer your data in the conversation in suitable depth. This means that when you clarify an observable fact, you must explain mechanisms that may account for the observation. If your results vary from your prospect, make clear why that may have happened. If your results agree, then explain the theory that the proof supported. It is never suitable to just state that the data approved the prospect, and let it drop at that. Make a decision as to whether each premise is supported or discarded or if you cannot make a conclusion with assurance. Do not just dismiss a study or part of a study as "uncertain."

Research papers are not acknowledged if the work is imperfect. Draw what conclusions you can based upon the results that you have, and take care of the study as a finished work.

- You may propose future guidelines, such as how an experiment might be personalized to accomplish a new idea.
- Give details of all of your remarks as much as possible, focusing on mechanisms.
- Make a decision as to whether the tentative design sufficiently addressed the theory and whether or not it was correctly restricted. Try to present substitute explanations if they are sensible alternatives.
- One piece of research will not counter an overall question, so maintain the large picture in mind. Where do you go next? The best studies unlock new avenues of study. What questions remain?
- Recommendations for detailed papers will offer supplementary suggestions.

Approach:

When you refer to information, differentiate data generated by your own studies from other available information. Present work done by specific persons (including you) in past tense.

Describe generally acknowledged facts and main beliefs in present tense.

The Administration Rules

Administration Rules to Be Strictly Followed before Submitting Your Research Paper to Global Journals Inc.

Please read the following rules and regulations carefully before submitting your research paper to Global Journals Inc. to avoid rejection.

Segment draft and final research paper: You have to strictly follow the template of a research paper, failing which your paper may get rejected. You are expected to write each part of the paper wholly on your own. The peer reviewers need to identify your own perspective of the concepts in your own terms. Please do not extract straight from any other source, and do not rephrase someone else's analysis. Do not allow anyone else to proofread your manuscript.

Written material: You may discuss this with your guides and key sources. Do not copy anyone else's paper, even if this is only imitation, otherwise it will be rejected on the grounds of plagiarism, which is illegal. Various methods to avoid plagiarism are strictly applied by us to every paper, and, if found guilty, you may be blacklisted, which could affect your career adversely. To guard yourself and others from possible illegal use, please do not permit anyone to use or even read your paper and file.

Criterion for Grading a Research Paper (Compilation) by Global Journals

Please note that following table is only a Grading of "Paper Compilation" and not on "Performed/Stated Research" whose grading solely depends on Individual Assigned Peer Reviewer and Editorial Board Member. These can be available only on request and after decision of Paper. This report will be the property of Global Journals.

Topics	Grades		
	A-B	**C-D**	**E-F**
Abstract	Clear and concise with appropriate content, Correct format. 200 words or below	Unclear summary and no specific data, Incorrect form Above 200 words	No specific data with ambiguous information Above 250 words
Introduction	Containing all background details with clear goal and appropriate details, flow specification, no grammar and spelling mistake, well organized sentence and paragraph, reference cited	Unclear and confusing data, appropriate format, grammar and spelling errors with unorganized matter	Out of place depth and content, hazy format
Methods and Procedures	Clear and to the point with well arranged paragraph, precision and accuracy of facts and figures, well organized subheads	Difficult to comprehend with embarrassed text, too much explanation but completed	Incorrect and unorganized structure with hazy meaning
Result	Well organized, Clear and specific, Correct units with precision, correct data, well structuring of paragraph, no grammar and spelling mistake	Complete and embarrassed text, difficult to comprehend	Irregular format with wrong facts and figures
Discussion	Well organized, meaningful specification, sound conclusion, logical and concise explanation, highly structured paragraph reference cited	Wordy, unclear conclusion, spurious	Conclusion is not cited, unorganized, difficult to comprehend
References	Complete and correct format, well organized	Beside the point, Incomplete	Wrong format and structuring

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