QUEUING SYSTEM IN SYNCHRONOUS OPTICAL NETWORK (SONET)

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ABSTRACT

This paper researches an investigation on Queuing framework in Synchronous Optical Network (SONET). Optical fiber utilized in SONET can blame on various conditions that are capricious, which is a fundamental dependability worry for power lattice interchanges. Different transmission advances have been utilized in whole deal interchanges, for example, optical fiber, microwave, or satellite. Optical fiber can blame on various flighty conditions which make it a noteworthy danger to arrange unwavering quality. Phases of administration in SONET, administration intrusion in this system are well explained. The Queuing issue occurring in this system is very much tackled by strengthening variable methodology and the comparing line execution measures are inferred. The purpose of issue emerged is very much anticipated by this Queuing approach and the administration interference could be limited or to a NIL base. Numerical delineation encourages the model to be defended to an incredible extent. Graphical portrayal unmistakably clarifies the presentation proportions of the Queuing framework in SONET.

KEYWORDS

Batch arrival, Optional First Stage, Compulsory Second Stage, Service Interruption.

1. INTRODUCTION

SONET is utilized to change over electrical sign into optical sign so it can travel longer separations. Synchronous Optical NET work (SONET) is a typical for optical televise communications transport, which was created in the mid-1980s, and stays in boundless use today. Contrasted with Ethernet cabling that traverses separations up to100 meters, SONET fiber ordinarily runs a lot further. Indeed, even short achieve connections range as much as 2 kilometers (1.2 miles); intermediate and long achieve connections spread many kilometers. Along these lines it is appropriate for whole deal transmission, for example, the one in the power lattice correspondences. Wu, Kobrinski, Ghosal, and Lakshman (1994) examined a few DCS design upgrade choices, including a parallel handling/cross-interface DCS engineering, which may improve the administration rebuilding time. Boehm, Ching, Griffith, and Saal (1986) gave an account of the exercises in different benchmarks associations, with accentuation on a synchronous system proposition which is as of now being talked about in the T1 advisory group. Way, Smith, Johnson, and Izadpanah (1992) tentatively confirmed the system idea and talked about various system applications for bursty information traffic and persistent voice/video traffic. Blumenthal *et al.* (2003) explored the sign handling procedures, Hac and Mutlu (1989) researched the B-ISDN convention, guidelines utilized in the Broadband reference model. Lee, Sherali, Han, and Kim (2000) dealt with a system plan issue emerging from the sending of synchronous optical systems (SONET), a standard of transmission utilizing optical fiber innovation. Cosares, Deutsch, Saniee, and Wasem (1995) inspected SONET framework by the Bellcore customer organizations has spared 10 to 30 percent in expenses and requests of greatness in time. Chao, Shtirmer, and Smoot (1989) broke down the physical layer of the system utilizes the synchronous optical system transmission design. Fundamental ideas are talked about and reviewed by Jue, Yang, Kim, and Zhang (2009). Kang, Park, Shin, and Jeong (1995) watched the normal for the system relying on the collected transmission limit of the network. Maragathasundari and Balamurugan (2015) contemplated the presentation examination of bunch landing line with two phases of administration. Maragathasundari and Dhanalakshmi (2018) investigated versatile adhoc systems issue A Queuing approach. Maragathasundari and Srinivasan (2012) made an investigation on M/G/1 input line with three phase and different server get-away. Maragathasundari and Srinivasan (2015) examined a Non-Markovian Multistage Batch entry line with breakdown and reneging. An examination on the investigation of execution proportion of mass information line with N

sort of extra discretionary administration, administration interference and deterministic get-away were inspected by Maragathasundari and Sowmiah (2016).

1.1. ADVANTAGES OF SONET

1) Transmits data to large distances.

2) Low electromagnetic interference.

3) High data rates.

4) Large Bandwidth.
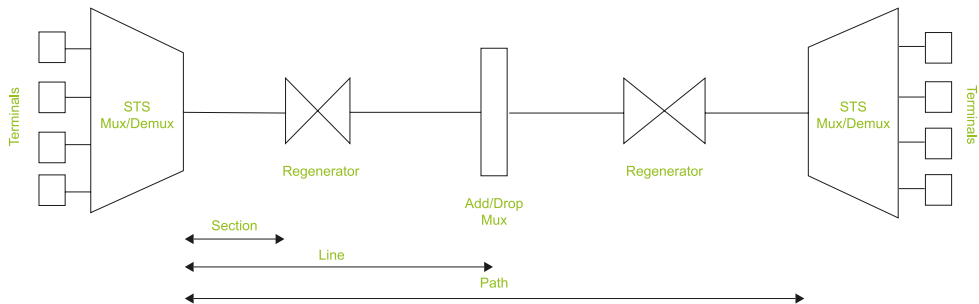
Graphic 1. SONET Network Elements.

1.2. SONET CONNECTIONS

1) Section: Portion of system interfacing two neighboring gadgets.

2) Line: Portion of system interfacing two neighboring multiplexers.

3) Path: End-to-end segment of the system.

*STS Multiplexer:

Performs multiplexing of sign.

 *STS Demultiplexer:

Performs demultiplexing of sign.
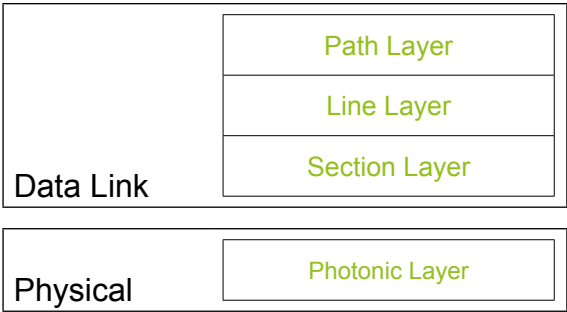
Converts optical sign to electrical sign.

*Regenerator:

It is a repeater, that takes an optical sign and recovers (builds the quality) it.

*Add/Drop Multiplexer:

It permits including sign originating from various sources into a given way or expelling a sign.

1.3. SONET LAYERS

Graphic 2. SONET Layers.

SONET includes four functional layers:

1) Path Layer:

 a. It is in charge of the development of sign from its optical source to its optical goal.

 b. STS Mux/Demux gives way layer capacities.

2) Line Layer:

 a. It is in charge of the development of sign over a physical line.

 b. STS Mux/Demux and Add/Drop Mux give Line layer capacities.

3) Section Layer:

 a. It is in charge of the development of sign over a physical area.

 b. Each gadget of system gives segment layer capacities.

4) Photonic Layer:

 a. It relates to the physical layer of the OSI model.

 b. It incorporates physical determinations for the optical fiber channel (nearness of light = 1 and nonappearance of light = 0).

1.4. PERFORMANCE REQUIREMENTS

We assume the following to describe the queuing model of our study.

1) Batch arrival − Queue - We consider a solitary server line which will give two distinct administrations, an Essential Service and Optional Service.

2) Essential administration − 2 phases: One of the benefits of SONET is that it can pass on gigantic payloads (more than 50 Mbps). To achieve this capacity, the STS SPE can be sub-apportioned into more diminutive sections or structures, known as VTs (Virtual tributaries)

   *Optional First Stage: Except for connected sign, all data sources are at last changed over to a base setup of a synchronous STS−1 signal (51.84 Mbps or higher). Lower-speed information sources, for instance, DS−1s are first piece or byte-multiplexed into VTs. Several synchronous STS−1s are then multiplexed together in either a singular or two-mastermind system to outline an electrical STS−N signal (N >= 1).

   * Compulsory Second Stage: Any kind of organization, running from voice to quick data and video, can be recognized by various types of organization connectors. An organization connector maps the sign into the payload envelope of the STS−1 or VT. New organizations and sign can be transported by including new organization connectors at the edge of the SONET sort out.

3) Optional administration − Service Interruption happens − Optical Cable Failures are considered here as Service Interruption during this Optional Service.

Three kinds of optical strands have been utilized in the whole deal transport of information.

- Buried fiber optic links have a higher disappointment rate than the two overhead links.

- Optical ground wire links and introduced overhead on posts or transmission towers.

- All dielectric self-supporting cables introduced overhead on posts or transmission towers.

Two sorts of disappointments are being considered,

  (a) "cable cut" disappointments which will influence both the working strand and the assurance strand, and

  (b) "Strand disappointments" which will bomb just one strand inside the link.

4) Completion of Both administrations– Dissatisfied Customers (not ready to utilize the multiplexing procedure successfully) can join the tail of the first line to get a Feedback administration.

2. MATHEMATICAL PORTRAYAL OF THE QUEUING MODEL

The arithmetical portrayal of the Queuing frame work has the option to be described by the resulting proposition:

Customers meet up at the structure in clusters of variable size in a compound strategy pursues Poisson conveyance. Let $\lambda d_j dt (j = 1, 2, 3 \dots)$ be the first order probability that a batch of j customers arrives at the system during a short duration of time $(t, t+dt)$ where $0 \leq d_j \leq 1$ and $\sum\limits_{j=1}^{n} d_j = 1$ and $\lambda > 0$ is the mean landing rate of the batches.

The administration time pursues general(arbitrary) circulation. First stage of essential service follows distribution function as $L_{e_1}(x)$ and density function $l_{e_1}(x)$. Let $\mu_{(e_1)}(x)\,dx$ be the conditional density function. Hence, we have:

$$\mu_{(e_1)}(x) = \frac{l_{e_1}(x)}{1-L_{e_1}(x)} \ , \quad l_{e_1}(x) = \mu_{(e_1)}(x)\, e^{-\int\limits_0^s \mu_{(e_1)}(s)ds} \tag{a}$$

For second stage of essential service,

$$\mu_{(e_2)}(x) = \frac{l_{e_2}(x)}{1-L_{e_2}(x)} \quad , l_{e_2}(x) = \mu_{(e_2)}(x)\, e^{-\int\limits_0^s \mu_{(e_2)}(s)ds} \tag{b}$$

For optional service,

$$\mu_k(x) = \frac{l_k(x)}{1-L_k(x)} \quad , l_k(x) = \mu_k(x)\, e^{-\int\limits_0^s \mu_k(s)ds} \tag{c}$$

Service interruption follows Poisson distribution with mean rate $\beta > 0$.

3. GOVERNING EQUATIONS OF THE MODEL

$$\frac{d}{dx}P_n^{(e_1)}(x) + \left(\lambda + \mu_{(e_1)}(x)\right) P_n^{(e_1)}(x) = \lambda \sum_{j=1}^{n} d_j P_{n-j}^{(e_1)}(x) \tag{1}$$

$$\frac{d}{dx}P_0^{(e_1)}(x) + \left(\lambda + \mu_{(e_1)}(x)\right) P_0^{(e_1)}(x) = 0 \tag{2}$$

$$\frac{d}{dx}P_n^{(e_2)}(x) + \left(\lambda + \mu_{(e_2)}(x)\right) P_n^{(e_2)}(x) = \lambda \sum_{j=1}^{n} d_j P_{n-j}^{(e_2)}(x) \tag{3}$$

$$\frac{d}{dx}P_0^{(e_2)}(x) + \left(\lambda + \mu_{(e_2)}(x)\right) P_0^{(e_2)}(x) = 0 \tag{4}$$

$$\frac{d}{dx}K_n(x) + (\lambda + \mu_k(x) + \beta) K_n(x) = \lambda \sum_{j=1}^{n} d_j K_{n-j}(x) \tag{5}$$

$$\frac{d}{dx}K_0(x) + (\lambda + \mu_k(x) + \beta) K_0(x) = 0 \tag{6}$$

$$\frac{d}{dx}M_n(x) + (\lambda + \mu_m(x)) M_n(x) = \lambda \sum_{j=1}^{n} d_j M_{n-j}(x) \tag{7}$$

$$\frac{d}{dx}M_0(x) + (\lambda + \mu_m(x)) M_n(x) = 0 \tag{8}$$

$$\lambda Q = \int_0^\infty M_0(x) \mu_m(x)\, dx + (1-m)\int_0^\infty P_0^{(e_2)}(x) \mu_{(e_2)}(x)\, dx + (1-r)Q\int_0^\infty K_0(x) \mu_k(x) \tag{9}$$

4. BOUNDARY CONDITIONS

The following boundary conditions are used to solve the above equations:

$$P_n^{(e_1)}(0) = \int_0^\infty M_{n+1}(x) \mu_m(x)\, dx + (1-m)\int_0^\infty P_{n+1}^{(e_2)}(x) \mu_{(e_2)}(x)\, dx + r\int_0^\infty K_n(x) \mu_k(x)\, dx + \lambda D_{n+1}Q \tag{10}$$

$$P_n^{(e_2)}(0) = \int_0^\infty P_n^{(e_1)}(x) \mu_{(e_1)}(x)\, dx \tag{11}$$

$$K_n(0) = \int_0^\infty P_n^{(e_2)}(x) \mu_{(e_2)}dx \tag{12}$$

$$M_n(0) = \beta \int_0^\infty K_n(x) \tag{13}$$

5. QUEUE LENGTH DISTRIBUTION

Usage of Supplementary variable technique

We multiply (1) by z^n and sum over n from 1 to ∞ and add it to (2).

We get,

$$\frac{d}{dx} P^{(e_1)}(x,z) + \left(\lambda - \lambda D(z) + \mu_{(e_1)}(x) \right) P^{(e_1)}(x,z) = 0 \tag{14}$$

Again integrating the above from 0 to n, we get

$$P^{(e_1)}(x,z) = P^{(e_1)}(0,z) \, e^{-(\lambda - \lambda D(z))x} \int_0^x \mu_{(e_1)}(t)\, dt \tag{*}$$

Again integrating (*) by parts with respect to x yields,

$$P^{(e_1)}(z) = P^{(e_1)}(0,z) \left[\frac{1 - L_{(e_1)}(\lambda - \lambda D(z))}{(\lambda - \lambda D(z))} \right] \tag{15}$$

Multiplying both sides of the (*) by $\mu_{(e_1)}(x)$ and integrating over x, we get:

$$\int_0^\infty P^{(e_1)}(x,z)\, \mu_{(e_1)}(x) = P^{(e_1)}(0,z)\, L_{(e_1)}(\lambda - \lambda D(z)) \tag{16}$$

Applying the same concept for the second stage (optional) in essential service $[\, P_n^{(e_1)}(x)\,]$, optional service $[\, K_n(x)\,]$, and repair process $[\, M_n(x)\,]$, we get,

$$\text{i)} \quad P^{(e_2)}(z) = P^{(e_2)}(0,z) \left[\frac{1 - L_{(e_2)}(\lambda - \lambda D(z))}{(\lambda - \lambda D(z))} \right]$$

$$= P^{(e_1)}(0,z)\, L_{(e_1)}(\lambda - \lambda D(z)) \left[\frac{1 - L_{(e_2)}(\lambda - \lambda D(z))}{(\lambda - \lambda D(z))} \right] \tag{17}$$

Also we have,

$$\int_0^\infty P^{(e_2)}(x,z)\, \mu_{(e_2)}(x)\, dx = P^{(e_1)}(0,z)\, L_{(e_1)}(\lambda - \lambda D(z))\, L_{(e_2)}(\lambda - \lambda D(z)) \tag{18}$$

$$\text{ii)} \, K(z) = \, K(0,z) \left[\frac{1 - L_k(\lambda - \lambda D(z) + \beta)}{(\lambda - \lambda D(z) + \beta)} \right] = P^{(e_1)}(0,z)\, L_{(e_1)}(\lambda - \lambda D(z))$$

$$L_{(e_2)}(\lambda - \lambda D(z)) \left[\frac{1 - L_{(e_2)}(\lambda - \lambda D(z))}{(\lambda - \lambda D(z))} \right] \tag{19}$$

$$\int_0^\infty K(x,z)\,\mu_k(x)\,dx = P^{(e_1)}(0,z)\,L_{(e_1)}(\lambda - \lambda D(z))\,L_{(e_2)}(\lambda - \lambda D(z))\,L_k(\lambda - \lambda D(z) + \beta) \tag{20}$$

$$M(z) = \beta z P^{(e_1)}(0,z)\,L_{(e_1)}(\lambda - \lambda D(z))\,L_{(e_2)}(\lambda - \lambda D(z)) \left[\frac{1 - L_k(\lambda - \lambda D(z) + \beta)}{(\lambda - \lambda D(z) + \beta)} \right] \left[\frac{1 - H(\lambda - \lambda D(z))}{(\lambda - \lambda D(z))} \right] \tag{21}$$

$$\int_0^\infty M(x,z)\,\mu_m(x)\,dx = \beta z P^{(e_1)}(0,z)\,L_{(e_1)}(\lambda - \lambda D(z))\,L_{(e_2)}(\lambda - \lambda D(z)) \left[\frac{1 - L_k(\lambda - \lambda D(z) + \beta)}{(\lambda - \lambda D(z) + \beta)} \right] H(\lambda - \lambda D(z)) \tag{22}$$

Now $\sum\limits_{n=0}^{\infty} z^n$ (10), using (9) and further using (18), (20), (22) we get,

$$P^{(e_1)}(0,z) = \frac{\lambda Q(D(z) - 1)}{z - L_{(e_1)}(a) L_{(e_2)}(a) \left[\beta z H(a) \left[\frac{1 - L_k(b)}{b} \right] + (1-m) + r L_k(b) \right]} \tag{23}$$

Substituting (23) in (15), (17), (19), (21) we get,

$$P^{(e_1)}(z) = \frac{\left[L_{(e_1)}(a) - 1 \right] Q}{z - L_{(e_1)}(a) L_{(e_2)}(a) \left[\beta z H(a) \left[\frac{1 - L_k(b)}{b} \right] + (1-m) + r L_k(b) \right]} \tag{24}$$

$$P^{(e_2)}(z) = \frac{L_{(e_1)}(a) \left[L_{(e_2)}(a) - 1 \right] Q}{z - L_{(e_1)}(a) L_{(e_2)}(a) \left[\beta z H(a) \left[\frac{1 - L_k(b)}{b} \right] + (1-m) + r L_k(b) \right]} \tag{25}$$

$$K(z) = \frac{a L_{(e_1)}(a) L_{(e_2)}(a) \left[L_k(b) - 1 \right]}{b \left[z - L_{(\ )}(a) L_{(\ )}(a) \left[\beta z H(a) \left[\frac{1 - L_k(b)}{b} \right] + (1-m) + r L_k(b) \right] \right]} \tag{26}$$

$$M(z) = \frac{\beta z L_{(e_1)}(a) L_{(e_2)}(a) \left[L_k(b) - 1 \right] \left[1 - H(a) \right]}{b \left[z - L_{(e_1)}(a) L_{(e_2)}(a) \left[\beta z H(a) \left[\frac{1 - L_k(b)}{b} \right] + (1-m) + r L_k(b) \right] \right]} \tag{27}$$

Where, $a = \lambda - \lambda D(z)$, $b = \lambda - \lambda D(z) + \beta$

6. PROBABILITY CAPACITY FUNCTION OF THE QUEUE LENGTH

Let $J_q(z)$ be the PGFof the queue length

$$J_q(z) = P^{(e_1)}(z) + P^{(e_2)}(z) + K(z) + M(z)$$

Adding (24) to (27), we get,

$$J_q(z) = \frac{Q\left\{b\left[L_{(e_1)}(a)L_{(e_2)}(a)-1\right]+L_{(e_1)}(a)L_{(e_2)}(a)\left[L_k(b)-1\right]\left[a+\beta z[1-H(a)]\right]\right\}}{b\left[z-L_{(e_1)}(a)L_{(e_2)}(a)\left[\beta z H(a)\left[\frac{1-L_k(b)}{b}\right]+(1-m)+rL_k(b)\right]\right]} \tag{28}$$

7. IDLE TIME AND UTILIZATION FACTOR

Idle time is determined using the condition:

$$J_q(1) + Q = 1 \tag{29}$$

Applying LH rule we get,

$$J_q(z) = \frac{N'(1)}{D'(1)} \tag{30}$$

$$Q = \frac{D'(1)}{D'(1)+N'(1)} \tag{31}$$

From the idle factor Q, the utilization rate is calculated.

To find L_q the length of the Queue and the Queue performance measures.

We have $L_q(z) = \frac{d}{dz}J_q(z)|z = 1 = \frac{0}{0}$ (indeterminate form)

$$L_q = \lim_{z\to 1}\frac{D'(z)N''(z)-N'(z)D''(z)}{2(D'(z))^2} \tag{32}$$

Here $J_q(z) = \frac{N(z)}{D(z)}$ where N(z) and D(z) are the numerator and denominator of (28).

$$N'(1) = \lambda E(I)\left[E(L_{(e_1)})+E\left(L_{(e_2)}\right)+1+\beta E(H)\left(L_k(\beta)-1\right)\right]$$

$$N''(1) = 2\left(-\lambda E(I)\right)^2\left[E(L_{(e_1)})+E\left(L_{(e_2)}\right)\right]$$

$$+\beta\left(\lambda E(I)\right)^2\left[E(L_{(e_1)}{}^2)+E(L_{(e_2)}{}^2)+2\left[E(L_{(e_1)})E\left(L_{(e_2)}\right)\right]\right]\left(-\lambda E(I)\right)^2\left[-E(H)\left[E(L_{(e_1)})+E\left(L_{(e_2)}\right)+L'_k-\beta\right]\right.$$

$$+\beta E(H)\left(L_k(\beta)+\left(-\lambda E(I)\right)\left(E(L_{(e_1)})+E\left(L_{(e_2)}\right)+L_k'\right)\right)+\left(-\lambda E(I)\right)^2\beta E(H^2)L_k(\beta)\right] \tag{33}$$

$$D'(1) = \left(-\lambda E(I)\right)\left[1-\left(1-L_k(\beta)+(1-m)+rL_k(\beta)\right)\right]$$

$$+\beta\left\{1+\left(-\lambda E(I)\right)\left[E(L_{(e_1)})+E\left(L_{(e_2)}\right)\right]\left[\left(1-L_k(\beta)\right)+(1-m)+rL_k(\beta)\right]\right.$$

$$-\left[\left(1-L_k(\beta)\right)+\lambda E(I)E(H)\left(1-L_k(\beta)\right)+\beta\lambda E(I)L'_k+rL'_k\lambda E(I)\right]\right\}$$

$$D''(1)=-\lambda E(1)2\{1+(-\lambda E(I))[E(L_{(e_1)})+E(L_{(e_2)})][(1-L_k(\beta))+(1-m)+rL_k(\beta)]$$
$$-[(1-L_k(\beta))+ \lambda E(I)E(H)(1-L_k(\beta))+ \beta\lambda E(I)L'_k+ rL'_k\lambda E(I)]\}$$
$$+ \beta\{-(-\lambda E(I))^2(E(L_{(e_1)}^2)+ E(L_{(e_2)}^2)+2E(L_{(e_1)})E(L_{(e_2)}))[1-L_k(\beta)$$
$$+(1-m)+ rL_k(\beta)]+(-\lambda E(I))L'_k(E(L_{(e_1)})+ E(L_{(e_2)}))$$
$$-(\lambda E(1))(E(L_{(e_1)}+E(L_{(e_2)}))[1-L_k(\beta)+ E(H)\ \lambda E(I)(1-L_k(\beta))$$
$$-\lambda E(I)\ L'_k+r\lambda E(I)L'_k]$$
$$-[(\lambda E(I))E(H)(1-L_k(\beta))+ \beta\ L'_k+ E(H)\ \lambda E(I)(1-L_k(\beta))$$
$$+E(H^2)(-\lambda E(I))^2(1-L'_k(\beta))+\beta E(I)E(H)\ L'_k+\beta(-\lambda E(I))\ L'_k$$
$$-\beta(-\lambda E(I))^2L'_kE(H)+ \beta E(L_k^2)(\lambda E(I))^2+rE(L_k^2)(-\lambda E(1))^2]\}$$

(33)

Substituting (33) in (32) we obtain L_q in closed form.

Further, all the other queue performance measures can be found using Little's law

$$W_q = \frac{L_q}{\lambda^+}, \ \ W = \frac{L}{\lambda^+}, \ \ L=L_q + \rho$$
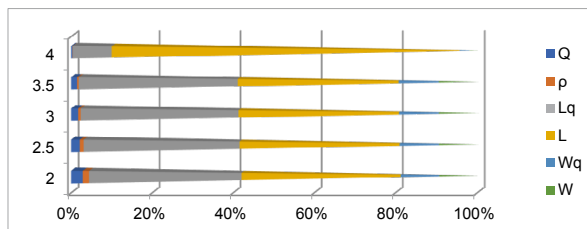
8. NUMERICAL ILLUSTRATION

$$\lambda = 4, \ \beta = 2, \ r = 0\ 6, \ m = 0\ 5, \ \mu_{(e_1)} = 2\ 5, \mu_{(e_2)} = 3\ 5, \ \mu_k = 2\ 8, \ \ \mu_m = 3,$$

$$E(L_{(e_1)}) = \frac{1}{\mu_{(e_1)}}, \ \ E\left(L_{(e_2)}\right) = \frac{1}{\mu_{(e_2)}}, \ \ L'_k = \frac{1}{\mu_k}, \ \ E(H) = \frac{1}{\mu_m}, \ \ L_k(\beta) = \frac{\mu_k}{\mu_k+\beta}, \ \ E(L_k^2) = \frac{2}{\mu_k^2},$$

$$E(H^2) = \frac{2}{\mu_m^2}, \ \ L'_k(\beta) = \frac{\mu_k}{(\beta+\mu_k)^2}$$

Table 1. Effect of change of $(\beta = 2, 2\ 5, 3, 3\ 5, 4)$.

| Q	P	Lq	L	Wq	W
0.6485	0.3515	8.5449	8.8964	2.1362	2.2241
0.6917	0.3083	12.552	12.8602	3.138	3.2151
0.7382	0.2618	16.556	16.8173	4.1389	4.2043
0.7787	0.2213	20.983	21.2043	5.2457	5.3011
0.8190	0.1810	25.237	25.4176	6.3092	6.3544

Graphic 3. Effect of change ofβ.

From Table 1 and Figure 3, it is clear that if the probability in service interruption increases it leads to an increase in all the performance measures. Since the service interruption gets increased   the idle time gets amplified and utilization factor is decreased.

Table 2. Effect of change of .

Q	P	Lq	L	Wq	W
0.6485	0.3515	8.5449	8.8964	2.1362	2.2241
0.645	0.355	8.6013	8.9563	2.1503	2.2399
0.6391	0.3609	8.6967	9.0576	2.1742	2.2644
0.6277	0.3723	8.9197	9.2077	2.2299	2.3019
0.5977	0.4023	9.7597	10.162	2.4399	2.5405
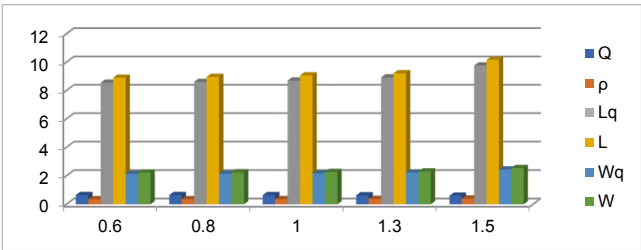
Graphic 4. Effect of change of r.

Table 2 indicates that, as the probability of repair rate gets increased, length of the queue is increased. Since the repair rate increased utilization factor gets increased and idle time gets decreased.

9. CONCLUSIONS

In this paper we have studied a batch arrival, two phases of essential administration and optional administration, service interruption, feedback service. This paper clearly analyses the steady state results and some queuing performance measures.   Further this model can be extended by adding the concept of delay time, reneging, long vacation, short vacation etc.

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