Profit-Function of Two- Identical Cold Standby System subject to lung failure and pneumonia (bacterial secondary infection) caused by H1N1 virus due to swine flu.

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Abstract **- Swine flu deaths at 663, people affected cross 10,000**

PTI | Feb 18, 2015, 08.35 PM IST

NEW DELHI: Swine flu deaths have soared to 663 across the country while number of people affected by it breached the 10,000 mark as the virus spread to new places like Nagaland.

The figures show that there is no let-up in the impact of the virus as it claimed 39 more lives between February 16-17.

Four factors that gave the swine flu virus more teeth

Health minister J P Nadda said there was no dearth of medicines and hospitals were equipped to deal with swine flu. The ministry said states have also not made any demand regarding drugs, diagnostic kits and other wherewithal to deal with the issue.

Central government figures show that 10025 people have suffered from H1N1 virus so far this year, a new high in recent years.

There also appears to be some anomaly in figures reported by the Centre and reports coming from states. While the central data shows only three persons contracted the virus in Jammu & Kashmir this year, a senior health official from the state said at least one person had died due to it while over 70 people have tested positive.

"There have been two deaths so far of patients who were infected with the H1N1 virus and 71 more patients have tested positive for the virus and are undergoing treatment," director, Sher-e-Kashmir Institute of Medical Sciences (SKIMS), Showkat Zargar told reporters in Srinagar.

He said while one death was confirmed to have occurred due to the virus, another female patient had critical cardiac ailments as well and may have died of those ailments.

Nagaland reported its first confirmed case with a woman testing positive for the flu.

Rajasthan, Gujarat and Madhya Pradesh are the worst-hit states with 183, 155 and 90 deaths reported from there respectively. In Punjab, the toll has risen to 24 while in neighbouring Haryana, the total number of deaths is 17.

Six people have died in Uttar Pradesh where the number of positive cases has touched 114. Meanwhile, AMU authorities said eight confirmed cases have been reported from the varsity's community, thus justifying the suspension of all classes and academic activity at the campus till February 25.

Stepping up its efforts, health ministry has started a new testing facility at AIIMS while a round-the-clock monitoring cell is in operation at the National Centre for Disease Control (NCDC).

"Teams of experts from the health ministry have visited states of Telangana, Gujarat and Rajasthan to extend technical support. Two such teams are being sent today to Madhya Pradesh and Maharashtra," it said in a statement today.

The ministry has asked states to study patterns in mortality such as which areas, age groups and section of people have been most affected, in addition to deaths due to co-morbid conditions.

Meanwhile, the Delhi government ordered all private medical labs not to charge more than Rs 4,500 to carry out tests for the viral disease. The move comes following complaints of several patients that tests are being conducted at exorbitant rates in the city's private labs.

In this paper we have taken lung failure and pneumonia (bacterial secondary infection) caused by H1N1 virus due to swine flu .When the main unit fails then cold standby system becomes operative. Pneumonia (bacterial secondary infection) caused by H1N1 virus due to swine flu cannot occur simultaneously in both the units and after failure the unit undergoes Type-I or

Type-II or Type-III repair facility immediately. Applying the regenerative point technique with renewal process theory the various reliability parameters MTSF, Availability, Busy period, Benefit-Function analysis have been evaluated.

Keywords: Cold Standby, lung failure, pneumonia (bacterial secondary infection) caused by H1N1 virus due to swine flu, first come first serve, MTSF, Availability, Busy period, Benefit -Function.

INTRODUCTION

What are the symptoms of swine flu?

Symptoms of swine flu are similar to most influenza infections: fever (100 F or greater), cough, nasal secretions, fatigue, and headache, with fatigue being reported in most infected individuals. Some patients may also get a sore throat, rash, body aches, headaches, chills, nausea, vomiting, and diarrhea. In Mexico, many of the initial patients infected with H1N1 influenza were young adults, which made some investigators speculate that a strong immune response, as seen in young people, may cause some collateral tissue damage.The incubation period from exposure to first symptoms is about one to four days, with an average of two days. The symptoms last about one to two weeks and can last longer if the person has a severe infection.

Some patients develop severe respiratory symptoms and need respiratory support (such as a ventilator to breathe for the patient). Patients can get pneumonia (bacterial secondary infection) if the viral infection persists, and some can develop seizures. Death often occurs from secondary bacterial infection of the lungs; appropriate antibiotics need to be used in these patients. The usual mortality (death) rate for typical influenza A is about 0.1%, while the 1918 "Spanish flu" epidemic had an estimated mortality rate ranging from 2%-20%. Swine (H1N1) flu in Mexico had about 160 deaths and about 2,500 confirmed cases, which would correspond to a mortality rate of about 6%, but these initial data were revised and the mortality rate worldwide was estimated to be much lower. Fortunately, the mortality rate of H1N1 remained low and similar to that of the conventional flu (average conventional flu mortality rate is about 36,000 per year; projected H1N1 flu mortality rate was 90,000 per year in the U.S. as determined by the president's advisory committee, but it never approached that high number).

Fortunately, although H1N1 developed into a pandemic (worldwide) flu strain, the mortality rate in the U.S. and many other countries only approximated the usual numbers of flu deaths worldwide. Speculation about why the mortality rate remained much lower than predicted includes increased public awareness and action that produced an increase in hygiene (especially hand washing), a fairly rapid development of a new vaccine, and patient self-isolation if symptoms developed.

Delhi-NCR records first swine flu death of year 2014

By: Press Trust of India | New Delhi | Posted: December 26, 2014 3:35 pm | Updated: December 26, 2014 10:08 pm

The National Capital Region (NCR) today reported the first death due to swine flu this year with a 51-year-old woman from Ghaziabad succumbing to the HINI virus at a private hospital here in Delhi.

According to the Directorate of Health Services, six cases of swine flu have been reported in the national capital and its neighbouring region till now this month.

“This is the first death due to Swine flu this year. A total 32 positive cases of swine flu have been reported in Delhi and NCR since January 1 till date.

“However, this death will be regarded as a death of swine flu outside Delhi as the patient is from Ghaziabad and was detected with the virus there itself.

So going by the records, there has been no death in the national capital so far this year,” said Dr Dalveer Singh, State Epidemiologist, also holding the additional charge of Public Health in the absence of Additional Director Dr Charan Singh.

The deceased identified as Sheel Goel, resident of East Model Town in Ghaziabad was admitted to the ICU of Ganga Ram Hospital in a serious condition on December 21.

“At the time of admission, the patient was in a critical state. She had lung failure and was on high frequency ventilator support. Her diagnosis at Ghaziabad and Sir Ganga Ram Hospital confirmed it to be a case of swine flu,” Hospital Spokesperson Ajoy Sehgal said.

“Inspite of the best efforts of doctors, the patient expired on the morning of December 24,” he said.

The woman was earlier treated at Yashoda Hospital in Ghaziabad and then shifted to Columbia Asia Hospital in Gurgaon before she was shifted to Ganga Ram hospital.

According to records maintained by DHS, one case of swine flu was recorded in Jan and seven in Feb in Delhi.

All government hospitals in Delhi have been put on alert by the Delhi Government’s health department. Hospitals have been asked to take appropriate measures to treat swine flu cases. Delhi had recorded 1,511 cases and 16 deaths in 2013.

The disease had last created a panic-like situation in Delhi in 2009-10 as till May 2010, as many as 1,035 people had died of the disease in India and more than 10,000 were infected. More than 40 people have died of the disease, caused by the H1N1 virus, across India this year.

“Swine influenza A (H1N1) virus spreads in the same way as the seasonal flu and even the symptoms are similar to the symptoms of regular flu which includes fever, cough, sore throat, body aches, headache, vomiting and fatigue…," said a Health Ministry official.

"However, it can be serious for elderly or children with low immunity or people who have health complications like heart diseases, cancer, HIV, diabetes or pregnant women, elderly or children with low immunity. Infected people can pass the infection to others a day before symptoms develop and up to seven or more days after becoming sick.

"There is no vaccine available to protect against swine flu. But early detection and treatment of infection can control fatal situations,"

Stochastic behavior of systems operating under changing environments has widely been studied. Dhillon , B.S. and Natesan, J. (1983) studied an outdoor power systems in fluctuating environment . Kan Cheng (1985) has studied reliability analysis of a system in a randomly changing environment. Jinhua Cao (1989) has studied a man machine system operating under changing environment subject to a Markov process with two states. The change in operating conditions viz. fluctuations of voltage, corrosive atmosphere, very low gravity etc. may make a system completely inoperative. Severe environmental conditions can make the actual mission duration longer than the ideal mission duration. In this paper we have taken lung failure and pneumonia (bacterial secondary infection) caused by H1N1 virus due to swine flu .When the main unit fails then cold standby system becomes operative. Pneumonia (bacterial secondary infection) caused by H1N1 virus due to swine flu cannot occur simultaneously in both the units and after failure the unit undergoes repair facility of Type-I or Type- II by doctor called here ordinary repairman or Type III by multispecialty doctor called here multispecialty repairman in case of failure caused by swine flu immediately. The repair is done on the basis of first fail first repaired.

Assumptions

1. λ_1, λ_2 are constant failure rates for failure caused by lung failure and pneumonia (bacterial secondary infection) caused by H1N1 virus due to swine flu respectively. The CDF of repair time distribution of Type I, Type II and multispecialty repairmen Type-III are $G_1(t)$, $G_2(t)$ and $G_3(t)$.

1. The failure due to Pneumonia (bacterial secondary infection) caused by H1N1 virus due to swine flu is non-instantaneous and it cannot come simultaneously in both the units.

2. The repair starts immediately after failure caused by Lung failure caused by H1N1 virus due to swine flu and failure due to Pneumonia (bacterial secondary infection) caused by H1N1 virus due to swine flu and works on the principle of first fail first repaired basis.

3. The repair facility does no damage to the units and after repair units are as good as new.

4. The switches are perfect and instantaneous.

5. All random variables are mutually independent.

6. When both the units fail, we give priority to operative unit for repair.

7. Repairs are perfect and failure of a unit is detected immediately and perfectly.

8. The system is down when both the units are non-operative.

Notations

λ_1 . λ_2 - failure rates for failure caused by Lung failure caused by H1N1 virus due to swine flu , failure due to Pneumonia (bacterial secondary infection) caused by H1N1 virus due to swine flu respectively.

$G_1(t)$, $G_2(t)$, $G_3(t)$ – repair time distribution Type –I, Type-II, Type III due to Lung failure caused by H1N1 virus due to swine flu, repair by the multispecialty repairman respectively.

p, q - probability of failure caused by Lung failure caused by H1N1 virus due to swine flu and failure due to Pneumonia (bacterial secondary infection) caused by H1N1 virus due to swine flu respectively such that p+ q=1

$M_i(t)$ System having started from state i is up at time t without visiting any other regenerative state

A_i (t) state is up state at instant t

R_i (t) System having started from state i is busy for repair at time t without visiting any other regenerative state.

B_i (t) the server is busy for repair at time t.

$H_i(t)$ Expected number of visits by the server for repairing given that the system initially starts from regenerative state i

Symbols for states of the System

Superscripts O, CS, LF, BSIF,

Operative, Cold Standby, Lung failure caused by H1N1 virus due to swine flu, failure due to Pneumonia (bacterial secondary infection) caused by H1N1 virus due to swine flu respectively

Subscripts nlf, lf, bsif, ur, wr, uR

No Lung failure caused by H1N1 virus due to swine flu , Lung failure caused by H1N1 virus due to swine flu , failure due to Pneumonia (bacterial secondary infection) caused by H1N1 virus due to swine flu **,** under repair, waiting for repair, under repair continued from previous state respectively

Up states – 0, 1, 2, 3, 8,9 ; Down states – 4, 5, 6, 7

regeneration point – 0,1,2, 3, 8, 9

States of the System

$0(O_{nlf}, CS_{nlf})$

One unit is operative and the other unit is cold standby and there is no by Lung failure caused by H1N1 virus due to swine flu in both the units.

1($LF_{lf, urI}$, O_{nlf})

The operating unit fails caused by Lung failure caused by H1N1 virus due to swine flu and is under repair immediately of Type- I and standby unit starts operating with no Lung failure caused by H1N1 virus due to swine flu.

2($BSIF_{bsif, urII}$, O_{nlf})

The operative unit fails due to Pneumonia (bacterial secondary infection) caused by H1N1 virus due to swine flu and undergoes repair of type II and the standby unit becomes operative with no Lung failure caused by H1N1 virus due to swine flu.

3($BSIF_{bsif, urIII}$, O_{nlf})

The first unit fails due to Pneumonia (bacterial secondary infection) caused by H1N1 virus due to swine flu and under Type-III multispecialty repairman and the other unit is operative with no Lung failure caused by H1N1 virus due to swine flu.

4($LF_{lf,uR1}$, $LF_{lf,wrI}$)

The unit failed due to LF resulting from Lung failure caused by H1N1 virus due to swine flu is under repair of Type- I continued from state 1and the other unit failed due to LF resulting from Lung failure caused by H1N1 virus due to swine flu is waiting for repair of Type-I.

5($LF_{lf,uR1}$, $BSIF_{bsif, wrII}$)

The unit failed due to LF resulting from Lung failure caused by H1N1 virus due to swine flu is under repair of Type- I continued from state 1and the other unit fails also due to Failure due to Pneumonia (bacterial secondary infection) caused by H1N1 virus due to swine flu is waiting for repair of Type- II.

6($BSIF_{bsif, uRII}$, $LF_{lf ,wrI}$)

The operative unit fails due to Failure due to Pneumonia (bacterial secondary infection) caused by H1N1 virus due to swine flu and under repair continues from state 2 of Type –II and the other unit is failed due to LF resulting from Lung failure caused by H1N1 virus due to swine flu and waiting for repair of Type-I

7($BSIF_{bsif ,uRII}$, $LF_{lf,wrII}$)

The one unit fails due to Failure due to Pneumonia (bacterial secondary infection) caused by H1N1 virus due to swine flu is continued to be under repair of Type II and the other unit failed due to LF resulting from Lung failure caused by H1N1 virus due to swine flu is waiting for repair of Type-II

8($LF_{lf,urIII}$, $BSIF_{bsif, wrII}$)

The one unit fails due to Lung failure caused by H1N1 virus due to swine flu is under multispecialty repair of Type-III and the other unit is failed due to Pneumonia (bacterial secondary infection) caused by H1N1 virus due to swine flu is waiting for repair of Type-II.

9($LF_{lf,urIII}$, $BSIF_{bsif, wrI}$)

The one unit fails due to Lung failure caused by H1N1 virus due to swine flu is under multispecialty repair of Type-III and the other unit is failed due to Pneumonia (bacterial secondary infection) caused by H1N1 virus due to swine flu is waiting for repair of Type-I

Transition Probabilities

Simple probabilistic considerations yield the following expressions:

$p_{01} = \lambda_1 / \lambda_1 + \lambda_2$, $p_{02} = \lambda_2 / \lambda_1 + \lambda_2$, $p_{10} = pG_1^*(\lambda_1)+q\, G_2^*(\lambda_2)$,

$p_{14} = p- pG_1^*(\lambda_1) = p_{11}^{(4)}$,

$p_{15} = q- q\, G_1^*(\lambda_2) = p_{12}^{(5)}$,

$p_{23} = pG_2^*(\lambda_1)+q\, G_2^*(\lambda_2)$, $p_{26} = p- pG_2^*(\lambda_1) = p_{29}^{(6)}$,

$p_{27} = q- qG_2^*(\lambda_2) = p_{28}^{(7)}$, $p_{30} = p_{82} = p_{91} = 1$ (1)

We can easily verify that

$p_{01} + p_{02} = 1$, $p_{10} + p_{14} (=p_{11}^{(4)}) + p_{15} (=p_{12}^{(5)}) = 1$,

$p_{23} + p_{26} (=p_{29}^{(6)}) + p_{27} (=p_{28}^{(7)}) = 1$ (2)

And mean sojourn time is

$\mu_0 = E(T) = \int_0^\infty P[T > t]dt$

Mean Time To System Failure

$Ø_0(t) = Q_{01}(t)[s]\, Ø_1(t) + Q_{02}(t)[s]\, Ø_2(t)$

$Ø_1(t) = Q_{10}(t)[s]\, Ø_0(t) + Q_{14}(t) + Q_{15}(t)$

$Ø_2(t) = Q_{23}(t)[s]\, Ø_3(t) + Q_{26}(t) + Q_{27}(t)$

$Ø_3(t) = Q_{30}(t)[s]\, Ø_0(t)$ (3-6)

We can regard the failed state as absorbing

Taking Laplace-Stiljes transform of eq. (3-6) and solving for

$ø_0^*(s) = N_1(s) / D_1(s)$ (6)

where

$N_1(s) = Q_{01}^*[Q_{14}^*(s) + Q_{15}^*(s)] + Q_{02}^*[Q_{26}^*(s) + Q_{27}^*(s)]$

$D_1(s) = 1 - Q_{01}^* Q_{10}^* - Q_{02}^* Q_{23}^* Q_{30}^*$

Making use of relations (1) & (2) it can be shown that $ø_0^*(0) = 1$, which implies that $ø_0(t)$ is a proper distribution.

$$MTSF = E[T] = \left. \frac{d}{ds} ø_0^*(s) \right|_{s=0}$$

$= (D_1'(0) - N_1'(0)) / D_1(0)$

$= (\mu_0 + p_{01} \mu_1 + p_{02} \mu_2) / (1 - p_{01} p_{10} - p_{02} p_{23})$

where

$\mu_0 = \mu_{01} + \mu_{02}$,

$\mu_1 = \mu_{10} + \mu_{11}^{(4)} + \mu_{12}^{(5)}$,

$\mu_2 = \mu_{23} + \mu_{28}^{(7)} + \mu_{29}^{(6)}$

Availability analysis

Let $M_i(t)$ be the probability of the system having started from state i is up at time t without making any other regenerative state. By probabilistic arguments, we have

$M_0(t) = e^{-\lambda_1 t} e^{-\lambda_2 t}$, $M_1(t) = p \bar{G}_1(t) \; e^{-\lambda_1 t}$

$M_2(t) = q \bar{G}_2(t)$, $M_3(t) = \bar{G}_3(t)$

The point wise availability $A_i(t)$ have the following recursive relations

$A_0(t) = M_0(t) + q_{01}(t)[c]A_1(t) + q_{02}(t)[c]A_2(t)$

$A_1(t) = M_1(t) + q_{10}(t)[c]A_0(t) + q_{12}^{(5)}(t)[c]A_2(t) + q_{11}^{(4)}(t)[c]A_1(t)$,

$A_2(t) = M_2(t) + q_{23}(t)[c]A_3(t) + q_{28}^{(7)}(t)[c]\,A_8(t) + q_{29}^{(6)}(t)]\,[c]A_9(t)$

$A_3(t) = M_3(t) + q_{30}(t)[c]A_0(t)$

$A_8(t) = q_{82}(t)[c]A_2(t)$

$A_9(t) = q_{91}(t)[c]A_1(t)$ (7-11)

Taking Laplace Transform of eq. (7-11) and solving for $\hat{A}_0(s)$

$$\hat{A}_0(s) = N_2(s) / D_2(s) \quad (12)$$

where

$N_2(s) = \hat{M}_0 [\{1 - \hat{q}_{11}^{(4)}\}\{1 - \hat{q}_{28}^{(7} \hat{q}_{82}\} - \hat{q}_{12}^{(5)} \hat{q}_{29}^{(6)} \hat{q}_{91}] + \hat{q}_{01}[\hat{M}_1\{1 - \hat{q}_{28}^{(7)} \hat{q}_{82}\} + \hat{q}_{12}^{(5)} \hat{q}_{23} \hat{M}_3] + \hat{q}_{02}[\{\hat{q}_{23} \hat{M}_3 + \hat{M}_2\}\{1 - \hat{q}_{11}^{(4)}\} + \hat{q}_{29}^{(6)}) \hat{q}_{91} \hat{M}_1]$

$D_2(s) = \{1 - \hat{q}_{11}^{(4)}\}\{1 - \hat{q}_{28}^{(7} \hat{q}_{82}\} - \hat{q}_{12}^{(5)} \hat{q}_{29}^{(6)} \hat{q}_{91} - \hat{q}_{01}[\hat{q}_{10}\{1 - \hat{q}_{28}^{(7)} \hat{q}_{82}\} + \hat{q}_{12}^{(5)} \hat{q}_{23}] - \hat{q}_{02}[\{\hat{q}_{23} \hat{q}_{30}\{1 - \hat{q}_{11}^{(4)}\} + \hat{q}_{29}^{(6)} \hat{q}_{91} \hat{q}_{10}]$

(Omitting the arguments s for brevity)

The steady state availability

$A_0 = \lim_{t\to\infty}[A_0(t)]$

$= \lim_{s\to 0}[s\,\hat{A}_0(s)] = \lim_{s\to 0} \frac{s\,N_2(s)}{D_2(s)}$

Using L' Hospitals rule, we get

$$A_0 = \lim_{s\to 0} \frac{N_2(s) + s\,N_2'(s)}{D_2'(s)} = \frac{N_2(0)}{D_2'(0)} \quad (13)$$

The expected up time of the system in (0,t] is

$\lambda_u(t) = \int_0^{\infty} A_0(z)\,dz$

So that $\bar{\lambda}_u(s) = \frac{\hat{A}_0(s)}{s} = \frac{N_2(S)}{SD_2(S)}$ (14)

The expected down time of the system in (0,t] is

$\lambda_d(t) = t - \lambda_u(t)$

So that $\bar{\lambda}_d(s) = \frac{1}{s^2} - \bar{\lambda}_u(s)$ (15)

Similarly, we can find out

1.The expected busy period of the server when there is failure due to Pneumonia (bacterial secondary infection) caused by H1N1 virus due to swine flu and Lung failure caused by H1N1 virus due to swine flu in (0,t] - R_0

2.The expected number of visits by the repairman Type-I or Type-II for repairing the identical units in (0,t]- H_0

3.The expected number of visits by the multispecialty repairman Type-III for repairing the identical units in (0,t]- W_0

Benefit- Function Analysis

The Benefit-Function analysis of the system considering mean up-time, expected busy period of the system under failure due to Failure due to Pneumonia (bacterial secondary infection) caused by H1N1 virus due to swine flu and Lung failure caused by H1N1 virus due to swine flu , expected number of visits by the repairman for unit failure.

The expected total cost per unit time in steady state is

$C = \lim_{t\to\infty}(C(t)/t) = \lim_{s\to 0}(s^2 C(s))$

$= K_1A_0 - K_2R_0 - K_3H_0 - K_4W_0$

where

K_1 - revenue per unit up-time,

K_2 - cost per unit time for which the system is busy under repairing,

K_3 - cost per visit by the repairman type- I or type- II for units repair,

K_4 - cost per visit by the multispecialty repairman Type- III for units repair

CONCLUSION

After studying the system, we have analyzed graphically that when the failure rate failure due to Pneumonia (bacterial secondary infection) caused by H1N1 virus due to swine flu and Lung failure caused by H1N1 virus due to swine flu increases, the MTSF, steady state availability decreases and the Profit-function decreased as the failure increases.

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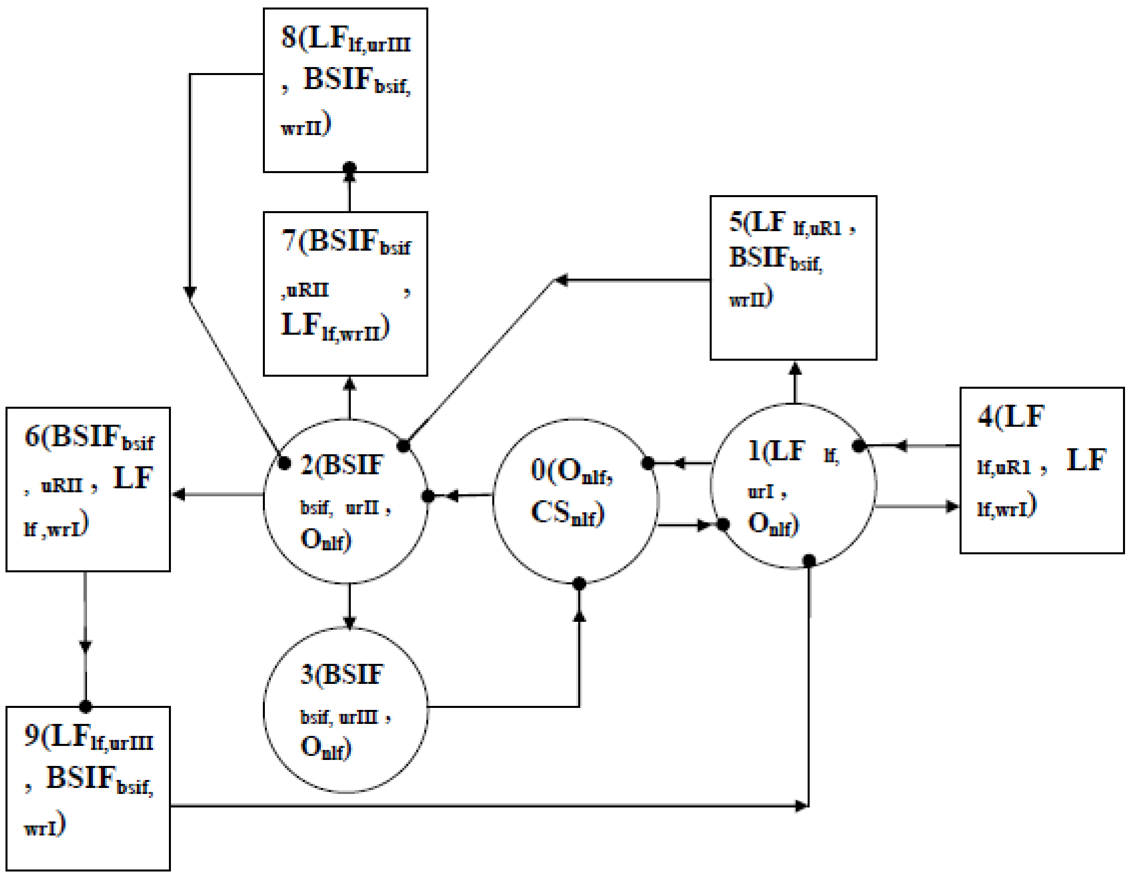

Fig. The State transition Diagram

Up-State Down-State
regeneration point