International Journal of Electronics and Communication Engineering and Technology (IJECET)
Volume 9, Issue 3, May-June 2018, pp. 52–61, Article ID: IJECET_09_03_007
Available online at
http://www.iaeme.com/ijecet/issues.asp?JType=IJECET&VType=9&IType=3
ISSN Print: 0976-6464 and ISSN Online: 0976-6472

RELIABILITY AVAILABILITY AND PERFORMANCE ANALYSIS OF WIRELESS NETWORKS

Y. S. Thakur
Department of Elect. & Comm. Engineering, Ujjain Engineering. College, Ujjain, India

D. K. Sakravdia
Department of Electrical Engineering, Ujjain Engineering. College, Ujjain, India

ABSTRACT

Reliability is the paramount concern in wireless networks. Consequently, evaluating reliability has become the essential in systems. Many subsisting wireless network routing protocols postulate the availability of reliable nodes. This, however, is not an authentic postulation given the dynamics of wireless networks. Withal, due to frequent vicissitudes in topology, link failures and node failures are possible. Consequently, an authentic method is needed to evaluate reliability of wireless networks in case of such uncertainties. The reliability of a wireless network is tenacious by certain factors such as delay, throughput, latency and overhead. For experimental analysis the network performance feature that will be utilized in the experimental set up will be the throughput of the network. Throughput can be relegated as the volume or amount of data or traffic that can permeate a network at a given time. Throughput can be habituated to quantify network efficiency and reliability. Highly reliable contrivances, equipment, and infrastructure are required for high caliber of reliability.

Key words: Reliability, Analysis, Wireless, Network.

Cite this Article: Y. S. Thakur and D. K. Sakravdia, Reliability Availability and Performance Analysis of Wireless Networks. *International Journal of Electronics and Communication Engineering and Technology*, 9(2), 2018, pp. 52–61.
http://www.iaeme.com/ijecet/issues.asp?JType=IJECET&VType=9&IType=3

1. INTRODUCTION

The area of wireless networks has received an abundance of attention in the research community over the past several years. The world is becoming more dependent on wireless service, but the facility of wireless network infrastructures to handle the growing demand is controvertible. Reliability is a network's faculty to perform a designated set of functions under certain conditions for designated operational times. Reliability has long been paramount area of research for wireless networks [1,2]. This has resulted in many amendments in incremented regulator, carrier, and vendor fixate on the design and implementation of serviceable switching, transmission, and signaling systems.

Wireless Networks used infrared or radio frequency signals to apportion information and resources between contrivances. Wireless networks have connection between nodes without utilization of wires. Theses network development are cost efficacy and it can be applicable to environments where wiring is not possible or it is a preferable solution as compared to wired networks. There are four types of wireless standards for wireless networking and these types are engendered by Institute of Electrical and electronics Engineers. They have established variant of transmission standards: 802.11, 802.11a, 802.11b, 802.11g [3, 4].

Authentic transmission speeds may vary and depends on such factors as number and size of the physical barriers in the network and any interference in the radio transmissions. These networks are reliable, but when interference occurs it reduce the range and the quality of the signal. Interference can be caused by other contrivances operating on the same radio frequency and it is very hard to control the additament of incipient contrivances on the same frequency [3,4] Many types of wireless contrivances are available The emerging third generation cellular networks have enables a variety of higher speed mobile data service.

2. COMPONENT FAILURES

As Figure 2 shows, a communications service network infrastructure consists of a number of components, any of which could fail, affecting different numbers of users:

- A base station accommodates hundreds of mobile users in a given area (cell) by allocating resources that sanction users to make incipient calls or perpetuate their calls if they pergrinate to the cell.
- A base station controller provides switching support for several neighboring base stations, accommodating thousands of users.
- A mobile switching center is a more immensely colossal switch that is capable of accommodating more than 100,000 users.
- Home location & visiting location registers keep track of users who are sempiternally registered or just visiting area.
- Signaling system 7 performs call setup between mobile switching centers & withal to the PSTN.
- High-capacity trunks carry calls between mobile switching centers & PSTN.

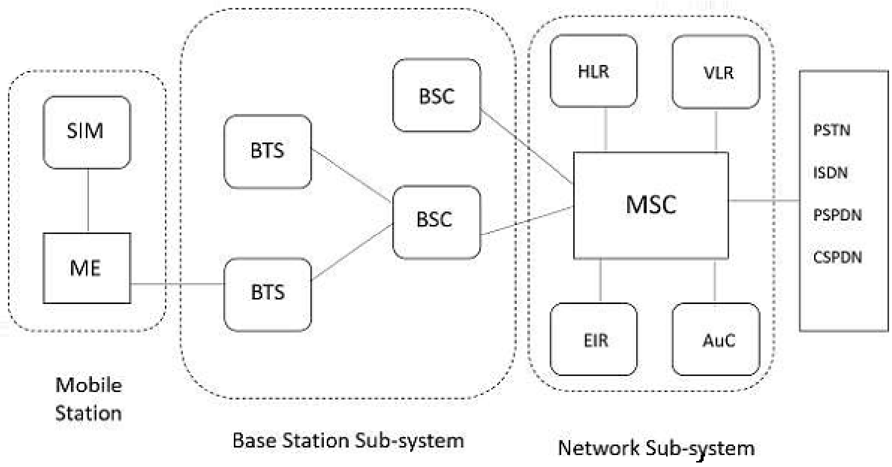

Figure 1 Wireless infrastructure and components.

In this configuration, a failure in a mobile switching center, a habitation location register/visiting location register, a mobile switching center-PSTN link, Signaling system 7, or PSTN trunk could affect proximately all patrons under a mobile switching center. Failure in other components would be less rigorous but still consequential. Even if components are not liable to fail in periods of months or years, failures in astronomically immense networks with thousands of components are liable to occur. Of course, varying degrees of redundancy in these variants of wireless components affect failure frequency.

Utilizer susceptibility to component failure depends on following factors:

- Potential number of wireless users impacted by a particular wireless component failure.
- Mean time to recuperate, which includes fault isolation, repair or supersession, and testing times.

Wireless carriers will naturally fixate on components that impact the most users, but they withal should fixate on incrementing mean time between failures and decrementing mean time to renovate to minimize frequency of failures and to recuperate more resiliently from those failures that do occur. Switch failure will conventionally have a high impact, with most subscribers unable to access accommodation and many utilizer connections severed. A number of central office switches, which are very reliable when opportunely deployed and operated, are configured and deployed as switching centers. Wireless networks, databases, base stations, contrivances, and links can fail. Every wireless network has a database to store, maintain, and update location information for users. To eschew failure, the server can mirror and replicate databases at multiple places in the network. Base station failures can be reduced through redundant components, an overlay architecture.

3. PROBABLE CAUSE OF FAILURES

In the incident reports four categories of root causes have been outlined plus one category that is used in conjunction with one of the other four categories.

3.1. Natural phenomena

This category includes incidents caused by severe weather, earthquakes, floods, pandemic diseases, wildfires, wildlife, and so on.

3.2. Human errors

This category includes incidents caused by errors committed by employees of the provider or outside the provider, during the operation of equipment or facilities, the use of tools, the execution of procedures, etc. E.g. an excavator cutting off a cable.

3.3. Malicious attacks

This category includes incidents caused by a deliberate act by someone or some organization, e.g. a Denial of Service attack disrupting the service, or a cable theft.

3.4. System failures

This category includes incidents caused by technical failures of a system, for example caused by hardware failures, software bugs or flaws in manuals, procedures or policies.

3.5. Third party failures

This category includes incidents caused by a failure or incident at a third party. The category is used in conjunctions with one of the other four root cause categories.

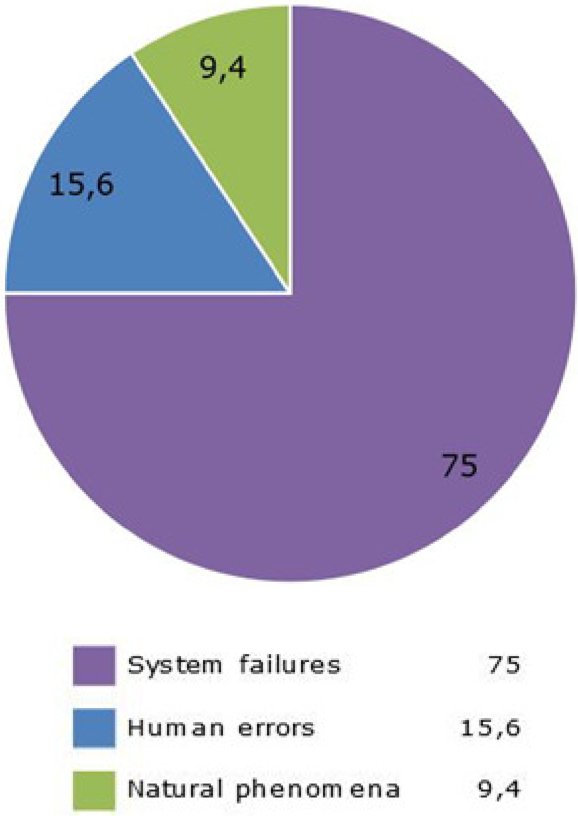

Figure 2 Root cause categories for mobile telephony (percentage).

4. RELIABILITY MEASURE OF NETWORK

There subsist a number of reliability measures for a wireless network depending on the network and its applications. For a telecommunication network it is conspicuously communication issues that meet certain connectivity requisites. Whereas for the sensor network the focus is on information accumulating, processing and communication issues to meet the coverage and connectivity requisites.

Each reliability measure is concerned with the facility of a network to be available to provide the desired accommodation to the cessation utilizer. Different criteria can be considered in order to express or measure the reliability of a network. The main ones are the following:

1. Reliability measure of connectivity falls within any one of the categories, which are 2-terminal reliability, k-terminal reliability, all terminal reliability and many sources to terminal reliability.
2. Hardware reliability measures are MTTR & MTTF;
3. The coverage reliability measure is assured desired level of coverage (at least k-coverage) of event or target at all times formulated by either Boolean sensing model or collaborative sensing model [6];
4. Capacity/Max flow measure is defined as probability that maximum flow of network is not less than given demand.
5. QoS reliability measure is assured date transfer timely and ensured bandwidth data precision timely depends upon utilizer/applications demand [7];
6. Information reliability ascertains that the nodes transmit to the sink only information concerning consequential events or targets.

Reliability and availability parameters: Reliability analysis (Jan-16 to Dec-16) for 3G wireless service providers [19] is given in table 1, table 2, table 3, table 4. Consider the performance of three months (July, August and September) is 3.14 for 3G wireless service providers. Then

Total Time in Hours = 92 x 24 = 2208

Unavailable Time = (2208 x 3.14) / 100 = 69.33

Available Time = 2208 – 69.33 = 2138.66

Mean Up Time (MUT) = 2138.66/3 = 712.88 hrs

Mean Down Time (MDT) = 69.33/2 = 34.66 hrs

Failure Rate (λ) = 1 / MUT = 0.0014027

Repair Rate (μ) = 1/ MDT = 0.0288

The reliability of the network

$R = e^{-\lambda T}$ Eq. (1)

Where T = the total duration of the call (24hrs),

λ = total failure rate.

Table 1 Reliability analysis (Jan-16 to Mar-16) for 3G wireless service providers [19].

Parameter	Sevice Provider	Service Area	Mean Down Time(hrs)	Mean Up Time(hrs)	Reliability	Availability
BTSs and Node-B's Accumulated Downtime(not available for service)(%age)	Aircel	North East	61.05	693.5	0.966	0.919
Worst affected Node B's due to downtime (%age)	Aircel	Assam	126.85	651.43	0.964	0.837
	BSNL	Kolkata	54.87	699.42	0.999	0.927
Worst affected cells having more than 3% Circuit Switched Voice Drop Rate	Aircel	Assam	102.12	667.92	0.965	0.867
	BSNL	West Bengal	83.91	680.06	0.965	0.890

Table 2 Reliability analysis (Apr-16 to Jun-16) for 3G wireless service providers [19].

Parameter	Sevice Provider	Service Area	Mean Down Time(hrs)	Mean Up Time(hrs)	Reliability	Availability
BTSs and Node-B's Accumulated Downtime(not available for service)(%age)	Aircel	North East	85.23	679.18	0.965	0.888
Worst affected Node B's due to downtime (%age)	Aircel	Assam	239.57	576.29	0.959	0.706
	BSNL	Kolkata	52.66	700.89	0.966	0.930
Worst affected cells having more than 3% Circuit Switched Voice Drop Rate	Aircel	Assam	90.97	675.35	0.965	0.881
	BSNL	West Bengal	92.19	674.54	0.965	0.879

Table 3 Reliability analysis (July-16 to Sep-16) for 3G wireless service providers [19].

Parameter	Sevice Provider	Service Area	Mean Down Time(hrs)	Mean Up Time(hrs)	Reliability	Availability
BTSs and Node-B's Accumulated Downtime(not available for service)(%age)	Aircel	North East	142.86	688.38	0.966	0.828
Worst affected Node B's due to downtime (%age)	Aircel	Assam	246.08	571.95	0.959	0.699
	BSNL	Kolkata	44.16	706.56	0.967	0.941
Worst affected cells having more than 3% Circuit Switched Voice Drop Rate	Aircel	Assam	81.26	681.83	0.965	0.894
	BSNL	West Bengal	81.91	681.39	0.965	0.893

Table 4 Reliability analysis (Oct-16 to Dec-16) for 3G wireless service providers [19].

Parameter	Sevice Provider	Service Area	Mean Down Time(hrs)	Mean Up Time(hrs)	Reliability	Availability
BTSs and Node-B's Accumulated Downtime(not available for service)(%age)	Aircel	North East	51.78	701.48	0.966	0.931
Worst affected Node B's due to downtime (%age)	Aircel	Assam	86.11	678.59	0.965	0.887
	BSNL	Kolkata	30.14	715.91	0.967	0.959
Worst affected cells having more than 3% Circuit Switched Voice Drop Rate	Aircel	Assam	57.85	697.43	0.966	0.923
	BSNL	West Bengal	84.13	679.92	0.965	0.889

5. QUALITY OF SERVICE

The concept of quality of service (QoS) is described in wireless networks in terms of diminutive size, low cost, low puissance, routing and capacity of wireless networks. By providing quality of accommodation support in wireless networks is a hospital budding part of research. Due to exorbitant resources constraint, bandwidth and power sources in wireless networks and additionally cutting-edge emerging challenges of quality of accommodation. There are different protocols required for wireless networks on substratum of subsisting challenges, we can ascertain reliability in wireless networks. Several control mechanism are indispensable in order to assure the reliability, these are load capacity, bandwidth, flow control, end to culminate transmission in the wireless communication networks.

6. PROBLEMS RELATED TO QOS WIRELESS NETWORKS

Because of the resource inhibitions and dynamic nature of wireless networks, it is especially consequential to be able to provide QoS. QoS support in wireless networks includes issues at the application layer, convey layer, network layer, MAC layer and physical layer [8]. In wireless networks, there are several unique issues and difficulties that do not apply to the traditionally wired internet infrastructure. The most paramount issues are listed below.

6.1. Unpredictable Link Properties

Wireless media is very capricious and packet collisions are an ineluctable consequence of wireless networks. Signal propagation faces difficulties such as fading, interference, and multipath abrogation. These properties of the wireless network make quantifications such as bandwidth and delay of the link capricious.

6.2. Node Mobility

Kineticism of nodes in the wireless network engenders a dynamic network topology. Links will be dynamically composed when two nodes moves into transmission range of each other and are torn down when they move out of transmission range.

6.3. Limited Battery Life

There is constrained power of the contrivances that establish the nodes in the wireless network due to inhibited battery life time. Technique utilized in QoS provisioning should be power vigilant & power efficient.

6.4. Hidden & Exposed Terminal Problem

In MAC layer with traditionally carrier sense multiple access (CSMA) protocol, multihop packet relaying introduces “hidden terminal” quandaries. The obnubilated terminal quandary transpires when signal of two nodes, verbally express A and B, that are out of reach of each other’s transmission range, collide at a prevalent receiver, verbally express node C. With the same nodal configuration, an exposed terminal quandary will result from a scenario where node B endeavors to transmit data (to someone other than A or C) while node C is transmitting to node A. Carrier sense multiple access with collision avoidance (CSMA/CA) reduces the effect of obnubilated terminal quandary, but there is no solution for the exposed terminal quandary today. Obnubilated and exposed terminal quandary is not only a QoS quandary, but is a recurring quandary through the aspect of the wireless network.

6.5. Route Maintenance

The dynamic nature of the network topology and the transmuting deportment of the communication medium make the precise maintenance of network state information very arduous. Since nodes can join & leave wireless network environment as they gratify, established routing path may be broken at any time even during process of data transfer. Thus, desideratum arises of routing paths with minimal overhead & delay. Since QoS-vigilant routing would require reservation of resources at the routers (nodes), the quandary of a heavily transmuting topology network might become cumbersome.

6.6. Security

Without adequate security, unauthorized access & utilization may infringe QoS negotiations. The nature of broadcasts in wireless networks potentially results in more security exposure. Because of the arduous properties of mobile wireless networks there has been a suggestion of utilizing soft QoS. The definition of Soft QoS is that after a connection setup, there may subsist transient periods of time when QoS designations is not accolade. However we can quantify the caliber of QoS contentment by the fraction of total disruption time over total connection time. The physical layer should take care of transmutations in transmission quality, for example by adaptively incrementing or decrementing the transmission puissance. Similarly, the link layer should react to the vicissitudes in link error rate, including the utilization of automatic reiterate request (ARQ). A more sophisticated technique involves an adaptive error rectification mechanism that increments or decreases the amount of error rectification coding in replication to transmutations in transmission quality of desired QoS. As the link layer takes care of the variable bit error rate, the main effect observed by network layer will be a transmutation in efficacious throughput (bandwidth) and delay.

7. CONCLUSION

Currently, wireless networks are more prone to failure and loss of access than their wired counterparts. Failure can involve one or more of wireless network's components— switches, base stations, databases, contrivances & wireless links.

The performance for different quarters is given as-

7.1. Performance during Apr to Jun

The performance has improved in quarter (Apr to Jun) as compared to the previous quarter (Jan to Mar) in respect of the following parameters :-

- Worst affected BTSs and Node-B's due to downtime (percentage).
- Call Set Up Success Rate (within licensee's own network).
- SDCCH/Paging Channel and RRC Congestion (percentage).
- TCH and Circuit Switched RAB Congestion (percentage).
- Call drop and Circuit Switched Voice Drop Rate (percentage).
- Worst affected cells having more than 3% TCH drop (call drop) and Circuit Switched Voice Drop Rate:-CBBH

The performance has deteriorated in quarter (Apr to Jun) as compared to the previous quarter (Jan to Mar) in respect of the following parameters:-

- Connection with good voice quality and Circuit Switch Voice Quality (CSV Quality)
- Point of Interconnection (POI) Congestion.

7.2. Performance during July to Sep

The performance has improved in quarter (July to Sep) as compared to the previous quarter (Mar to Jun) in respect of the following parameters :-

- Worst affected BTSs and Node-B's due to downtime (percentage).
- SDCCH/Paging Channel and RRC Congestion (percentage).
- Worst affected cells having more than 3% TCH drop (call drop) and Circuit Switched Voice Drop Rate:-CBBH
- Connection with good voice quality and Circuit Switch Voice Quality (CSV Quality)

The performance has deteriorated in quarter (July to Sep) as compared to the previous quarter (July to Sep) in respect of the following parameters:-

- Fault incidences (No. Of faults/ 100 subs/month)
- Fault repaired by next working day for urban areas
- Mean Time Fault repaired within 5 days (for urban areas)
- Response time to the customer for Assistance- Accessibility of call centre/Customer care.

7.3. Performance during Oct to Dec

The performance has improved in quarter (Oct to Dec)as compared to the previous quarter (Oct to Dec) in respect of the following parameters :-

- BTSs and Node-B's Accumulated downtime (not available for service) (%age)
- Worst affected cells having more than 3% TCH drop (call drop)and Circuit Switched Voice Drop Rate:-CBBH

The performance has deteriorated in this quarter as compared to the previous quarter in respect of the following parameters:-

- Point of Interconnection (POI) Congestion.

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