

Performance Evaluation of MAC DCF Scheme in WLAN

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Developed as a simple and cost-effective wireless technology for best effort services, IEEE 802.11 has gained popularity at an unprecedented rate. However, due to the lack of built-in Quality of Service (QoS) support, IEEE 802.11 experiences serious challenges in meeting the demands of real-time multimedia services and applications. QoS is a key consideration for wireless networks and implementation of QoS for supporting voice, video, and multimedia services in general bring a number of difficulties that have to be resolved. In particular, because network bandwidth, timely delivery of multimedia data and wireless fading and high bit error rate (BER) in IEEE 802.11 wireless LAN (W-LAN) applications and services is a challenging problems, various researches and trials have been made to enhance the quality of W-LAN application services. In this article we have analysis the performance of MAC DCF under infrastructure and Ad-hoc mode with help of NS2.

INTRODUCTION

Quality of service (QoS) is referred as the capability to provide resource assurance in a network, which is a critical requirement in order that new wireless based applications can operate within well-defined parameters. More is the applications and services used by different users; the worse is the status and quality of wireless network services. In consideration of QoS, it is very difficult to achieve the level of desired quality for AV transmission and Voice over IP.

As the MAC schemes do not support any service differentiation, unlike the PCF is designed to support time-bounded applications, this mode has some major problems,

which lead to poor QoS performance. In particular the central pooling scheme is inefficient and complex and causes deterioration of the performance of PCF high-priority traffic under load. Where the transmission time of a polled station is difficult to control. But in DCF as it uses only a single queue for all the flows. It is capable to provide best-effort service, not any QoS guarantee. Which cannot capable to provide any service differentiation or priority to for the stations sending any real time multimedia traffic such as voice or video conferencing. The time-bound services such as Voice over IP, or –audio/video conferencing require specified bandwidth, delay and jitter,

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but can tolerate some loss This leads to a lot of research in wireless LAN.

IEEE 802.11 WLAN STANDARD:

IEEE 802.11 is the leading standard for wireless LAN(Zhu, Li, Chlamtac and Prabhakaran, 2007), (Baghali and Hunt, 2001), (Mangold, Choi, May Klein, Heirtz and Stibor, 2002). A wireless local area network (W-LAN) uses radio frequency (RF) technology to transmit and receive data over the air medium. The Institute of Electrical and Electronics Engineers (IEEE) have established the IEEE 802.11 standard, which is the predominant standard for wireless LANs. Any LAN application, network operating system, or protocol including TCP/IP, will run on 802.11- compliant W-LANs as they would over Ethernet. The primary difference between WLANs and wired networks is the limited bandwidth and the ever-changing topology due to node mobility. WLAN transmits on unlicensed spectrum as agreed upon by the major regulatory agencies. The IEEE 802.11 WLAN standard covers the MAC sub-layer and the physical layer of the Open System Interconnection (OSI) network reference model. This architecture provides a

transparent interface to the higher layer users: stations (STAs) may move, roam through 802.11 WLAN and still appear as stationary to 802.2 LLC sub-layer and above. This allows existing TCP/IP protocol to run over IEEE 802.11 WLAN just like Ethernet deployed (Gu and Zhang, 2003) (Zhu, Chlamtae and Prabhakaran, 2004).

The different standardization activities associated with IEEE 802.11 Physical and MAC layers are shown in Figure-2.1 (Zhu, Chlamtae and Prabhakaran, 2004). In comparison to TCP/IP, the IEEE 802.11 protocol suit also has five layers. In application layer, it deals with the users. In transport layer it deals with either transfer control protocol (TCP) or with user datagram protocol (UDP). In network layer it deals with the routing protocols like destination sequence distance vector (DSDV), ad-hoc on demand distance vector (AODV), dynamic source routing (DSR), temporary ordered routing algorithm (TORA). The data-link layer again divided in to two parts that is logical link control (LLC) and medium access control (MAC). The LLC uses the standard defined by 802.2 but the MAC uses the standard specified by 802.11.

Application	Application
Transport Layer	Transport Protocols (TCP, UDP)
Network Layer	Routing Protocols (DSDV, AODV, DSR, TORA)
Data Link Layer	802.2 Logical Link Control (LLC)
	802.11 Medium Access Control (MAC) (PCF, DCF)
Physical Layer	Infrared, FHSS, DSSS, OFDM, HR-DSS

Figure-2.1: The Layered Structure of TCP/IP and IEEE 802.11 W-LAN

It adopts the standard 802.2 LLC protocol but provides optimized physical layer and MAC sub-layers for wireless communications. The physical layer uses specifications defined by 802.11 are Infrared, frequency hopping spread spectrum (FHSS), direct sequence spread spectrum (DSSS), orthogonal frequency division multiplexing (OFDM), and high rate direct sequence spread spectrum (HR-DSS) (Gu and Zhang, 2003). As is a wireless environment the security is a major problem. For this a secure wireless LAN (SWAN) (Malli, Ni, Turletti and Barakat, 2001) architecture is needed, which tries to address both the problems pertaining to Malicious Node Behavior (information security and privacy, traffic volume and QoS) and Network Health.

IEEE 802.11 SPECIFICATIONS

IEEE 802.11 refers to a family of specifications developed by the IEEE for wireless LAN technology in 1997 (Aad and Castelluccia, 2001). This base standard allowed data transmission of up to 2 Mbps. As this standard goes on enhancing, these extensions are recognized by the addition of a letter to the original 802.11 standard, including 802.11a and 802.11b. Table-2.1.1 shows the family of the IEEE 802.11 W-LAN specifications and features

associated with them (Heegard, Coffey, Gummed, Murphy, Provencio etc., 2001) (Zhu, Li etc., 2004) (Baghei and Hant, 2004).

802.11a operates at radio frequencies between 5.15 and 5.875 GHz and a modulation scheme known as orthogonal frequency division multiplexing (OFDM) makes data speeds as high as 54 Mbps possible. The 802.11b specification was ratified by the IEEE in July 1999 [6] and operates at radio frequencies in the 2.4 to 2.497 GHz bandwidth of the radio spectrum. The modulation method selected for 802.11b is known as complementary direct sequence spread spectrum (DSSS) using complementary code keying (CCK) making data speeds as high as 11 Mbps. The 802.11a specification was also ratified in July 1999, but products did not become available until 2001 so it isn't as widely deployed as 802.11b (Choi, Park, Lee, Ryu, 2006) (Baghaei, Hunt, 2004) (Ni, Romdhani, Turletti, 2004) (Zhu, Li etc., 2004).

The 802.11g specifications were ratified in June 2003. While 802.11g operates at radio frequencies in the 2.4 GHz to 2.497 GHz range, it utilizes the same OFDM modulation allowing for throughput up to 54 Mbps.

Table- 2.1.1: Family of IEEE 802.11 W-LAN Specifications

Specification	Description & Features
802.11	The original WLAN Standard. Supports 1 Mbps to 2 Mbps.
802.11a	High speed WLAN standard for 5 GHz band. Supports 54 Mbps, unlicensed radio band by utilizing OFDM.
802.11b	WLAN standard for 2.4 GHz band. Supports 11 Mbps, unlicensed radio by utilizing HR/DSSS.
802.11c	Provides required information to ensure proper bridge operations, which is required when developing access points.
802.11d	Covers additional regulatory domains, which is especially important for operation in the 5GHz bands because the use of these frequencies differ widely from one country to another. As with 802.11c, 802.11c standards mostly applies to companies developing 802.11 products.
802.11e	Address quality of service requirements for all IEEE WLAN radio interfaces. MAC enhancement for QoS such as HCF and EDCF.
802.11f	Defines inter-access point communications to facilitate multiple vendor-distributed WLAN networks.
802.11g	Establishes an additional modulation technique for 2.4 GHz band. Intended to provide speeds up to 54 Mbps, unlicensed radio band with OFDM
802.11h	Defines the spectrum management of the 5 GHz band for use in Europe and in Asia Pacific.
802.11i	Address the current security weaknesses for both authentication and encryption protocols. The standard encompasses 802.1X, TKIP, and AES protocols.

MAC SCHEMES OF IEEE 802.11 W-LAN

The MAC (medium access control) layer of 802.11 wireless LAN supports two basic access methods: that is contention-based distributed coordination function (DCF) and optional point coordination function (PCF) (Choi, Park, Lee, Ryu, 2006) (Baghaei, Hunt, 2004) (Ni, Romdhani, Turletti, 2004) (Malli, Ni, etc., 2004) (Garg, Doshi, etc., 2003). DCF is designed for the best-effort data transmission by using carrier sense multiple access with collision avoidance (CSMA/CA) (Aad, and Castelluccia, 2001) (Mangold, Choi, etc.

2002) (Engelstad, Osterbo, 2005). The DCF scheme does not provide any means of service differentiation and thus assumes that all flows have equal priority. The main concern of DCF is to reduce the collision among the flows that are competing for access to the wireless medium. The PCF (point coordination function) targets that the transmission of real time traffic as well as the best-effort data traffic where it differentiates between traffic of different priorities and allow frames of high priority a faster access to the wireless medium. The PCF access

method is based on a central polling scheme controlled by an access point (AP) (Engelstad, Osterbo, 2005). In summary, we can view 802.11 wireless LAN as a wireless version of the wired Ethernet, which supports best-effort services (Choi, Park, Lee, Ryu, 2006) (Baghaei, Hunt, 2004) (Ni, Romdhani, Turletti, 2004) (Mico, Cuenca, and Orozco-Barbosa, 2004) (Gu, and Zhang, 2003).

Characteristics of PCF and DCF

In general, IEEE 802.11 wireless LAN standard covers the MAC sub-layer and the physical layer of the OSI network reference model. The IEEE 802.11 MAC protocol supports two types of transmission: Asynchronous and Synchronous. Asynchronous transmission is provided by the DCF, which implements the basic access method for the IEEE 802.11 MAC protocol. DCF is based on the Carrier Sense Multiple Access with Collision Avoidance (CSMA/CA) protocol, and is the default implementation. Synchronous service is provided by PCF and implements a polling-based access method. The PCF uses a centralized polling approach that requires an AP to act as a point coordinator. The AP cyclically polls stations to give them the opportunity to transmit packets. Unlike the DCF, the implementation of the PCF is not mandatory. Furthermore, the PCF itself relies on the underlying asynchronous service provided by the DCF. Although providing different service functions, neither DCF nor DCF+PCF have the ability to offer true QoS over the wireless LAN applications.

QoS in PCF

PCF mode can deliver a certain level of guaranteed QoS service to the centralized

polling mechanism (Mico, Cuenca, and Orozco-Barbosa, 2004). The QoS mechanisms associated with PCF can be divided into three categories:

- Classification: there is no classification mechanism or service differentiation provided.
- Channel access: polling-based media access control mechanism using an access point (AP).
- Packet scheduling: packet scheduler uses FIFO mechanism directly related to the polling mechanism.

QoS limitations in PCF

Though PCF has been designed to support time-bounded applications, this mode has some major problems, which lead to poor QoS performance (Malli, Ni, Turletti, and Barakat, 2004). In particular the central pooling scheme is inefficient and complex and causes deterioration of the performance of PCF high-priority traffic under load (Mico, Cuenca, and Orozco-Barbosa, 2004). The transmission time of a polled station is difficult to control, when a pooled station is allowed to send a frame of any length between 0 and 2346 bytes, it introduces the variation of transmission time. In addition all communications have to pass through the AP, which degraded the bandwidth performance. Also the transmission time of the polled station is unknown. QoS in DCF mode.

As its name suggests distributed coordinated function, here all the stations share the same queue in a round robin manner without any priority. Packets go to the queue and operate in a FIFO (first in first out) mechanism; no scheduling of packets is done. QoS mechanisms associated with DCF is can

be divided in to following categories: (as shown in Figure-3.2.1)

- Classification: there is no classification mechanism or service differentiation provided.
- Channel access: contention-based media access control mechanism.
- Packet scheduling: packet scheduler uses FIFO mechanism.
- It follows the schemes CSMA/CA or RTS/CTS.

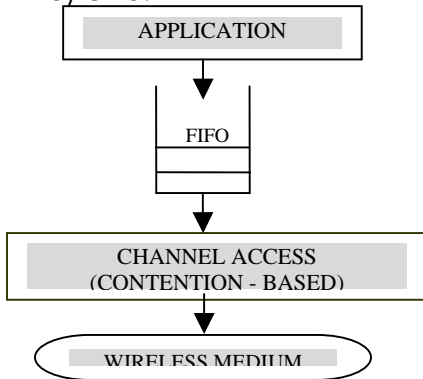


Figure-3.2.1: DCF QoS Architecture

PERFORMANCE ANALYSIS OF MAC DCF

Simulation have made in order to evaluate the performance of 802.11 MAC DCF, using NS-2 (McCanne and Floyed). Simulation topology consists of up to 15 stations operates at IEEE 802.11 physical mode and transmits two types of traffics (general and multimedia) to each other and the stations are mobile. The packet size of general is equal to 512 bytes and the inter packet arrival interval is 30ms. The multimedia packet size is 1024 bytes and the inter packet arrival interval is 50ms as shown in the Table-4.1 Simulation time is 10 simulated seconds and all traffics are CBR sources. We varying load by increasing the no of stations from 2 to 15. Stations having drop tail queue with maximum capacity 50. Each connection uses a constant bit

rate (CBR) generator as a traffic source, and each traffic flow has assigned traffic CBR1 or CBR3.

Traffic Type	CBR1 (General)	CBR3 (Multimedia)
Packet-size	512	1024
Interval (ms)	30	50

Table-4.1: Traffic Settings for Simulation

Other simulation parameters DIFS (Distributed Interframe space), SIFS (Shortest Interframe Space), CW_{min} and CW_{max} (Contention Window minimum and maximum), RTS (Request to Send), CTS (Clear to Send), ACK (Acknowledgement) are mentioned in Table-4.2.

Parameter	Value
Nodes	2 to 15
SIFS	10µs
DIFS	50µs
Slot Time	20µs
CW_{min}	31
CW_{max}	1023
Frame Types	Size in byte
RTS	20
CTS	14
ACK	14
MAC Header	28

Table-4.2: Simulation parameters and its values

Simulation is done in Infrastructure and Ad-hoc mode, which consists of different Service Sets (such as BSS, ESS and IBSS (or Ad-hoc))

I. SIMULATION OF DCF UNDER BSS MODE

As it is BSS it contains one access point (AP), which connected to the wired backbone and the nodes or mobile station move inside the region of the AP, and nodes increases from 2 to 15. At the time of transmission at shares the common AP, through which all the communication has been made.

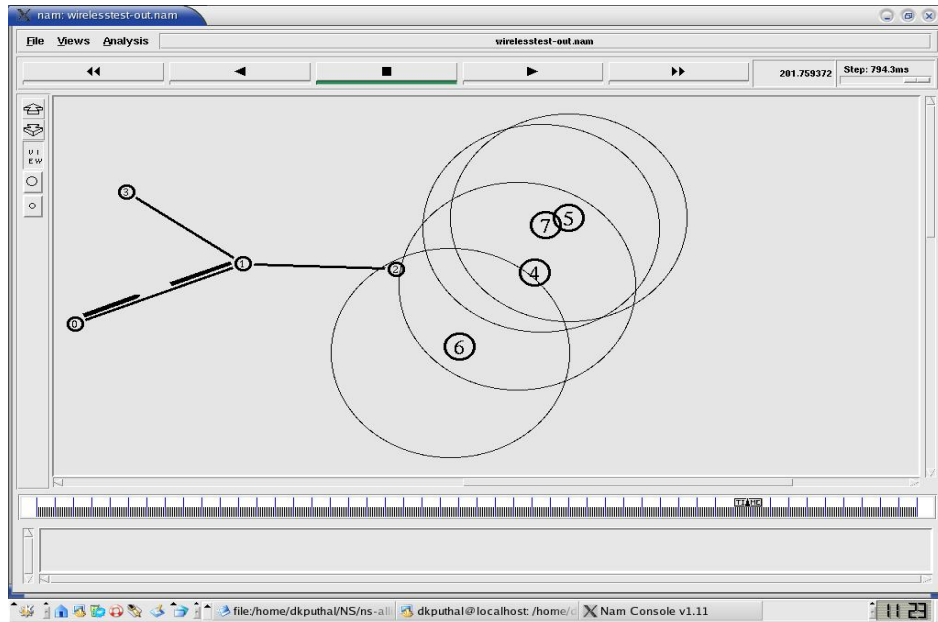


Figure-4.1: Screen shot of BSS

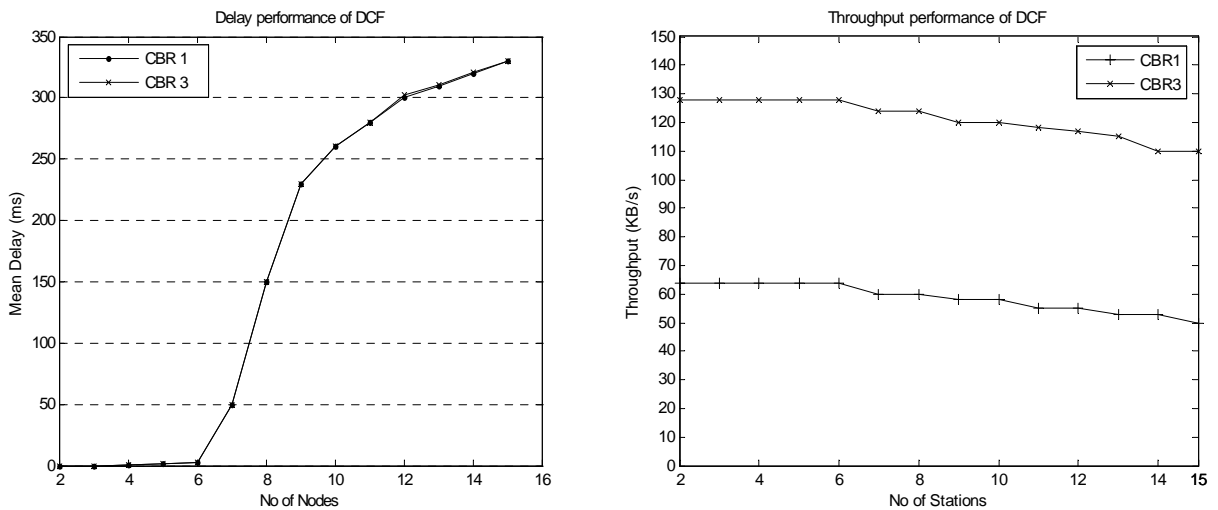


Figure-4.2: Delay and Throughput analysis of DCF in BSS mode.

II. SIMULATION OF DCF UNDER ESS MODE

Here it contains two APs that are connected to the wired backbone and one among them known as home agent (HA) where other one is known as foreign agent. (FA) Nodes or mobile stations move from HA to FA, from FA to HA or within the APs.

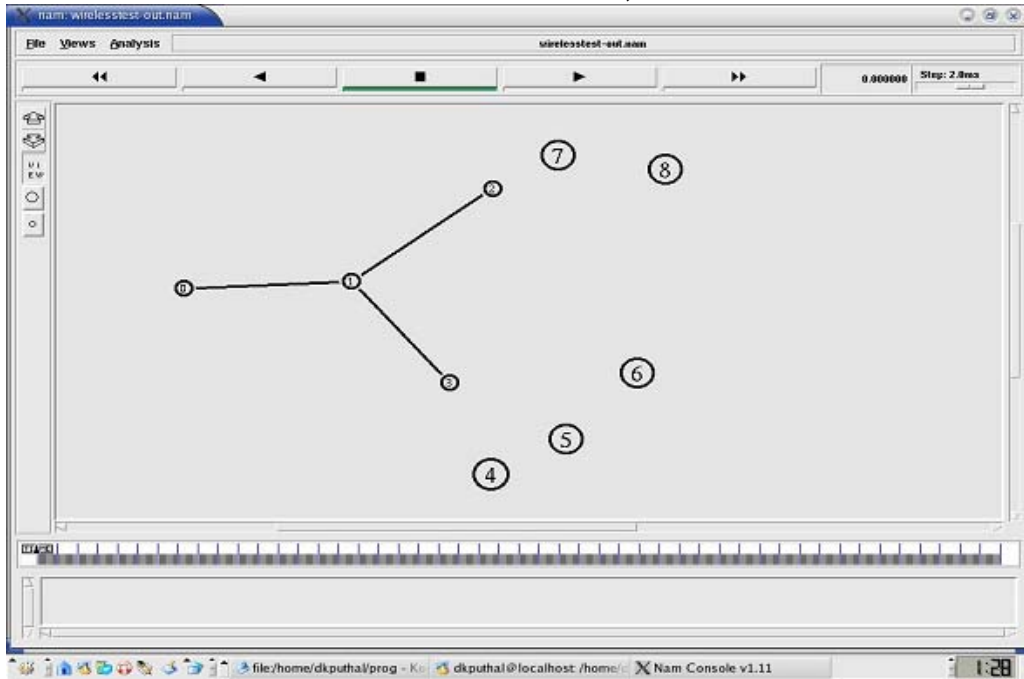


Figure-4.3: Screen shot of ESS

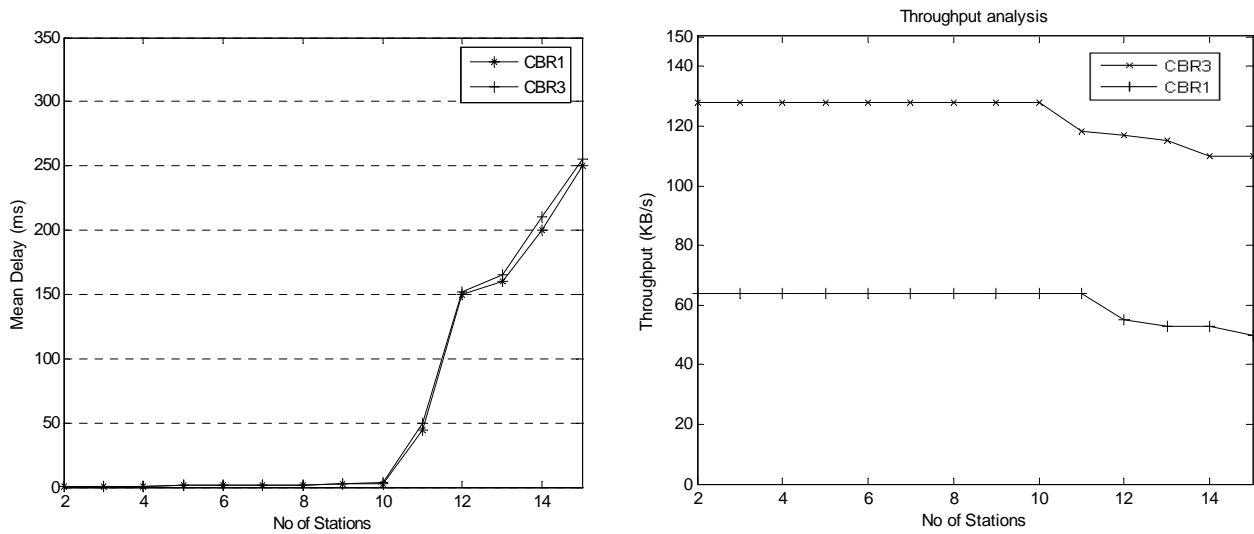


Figure-4.4: Delay and Throughput analysis of DCF in ESS mode

III. SIMULATION OF DCF UNDER IBSS (or AD-HOC) MODE

In Ad-hoc mode all stations are mobile and capable to transmitting and receiving the packets. Nodes are move within a specified region and communicate among themselves through one another. Here the problems associated is hidden station and exposed station problem. Nodes are increases from 2 to 15 in order to increase the network load.

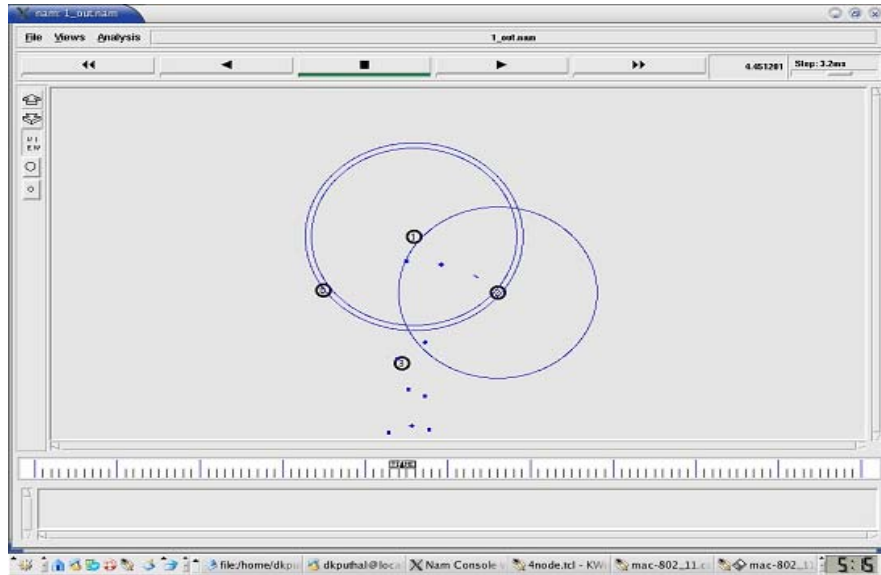


Figure-4.5: Screen shot IBSS or Ad-hoc

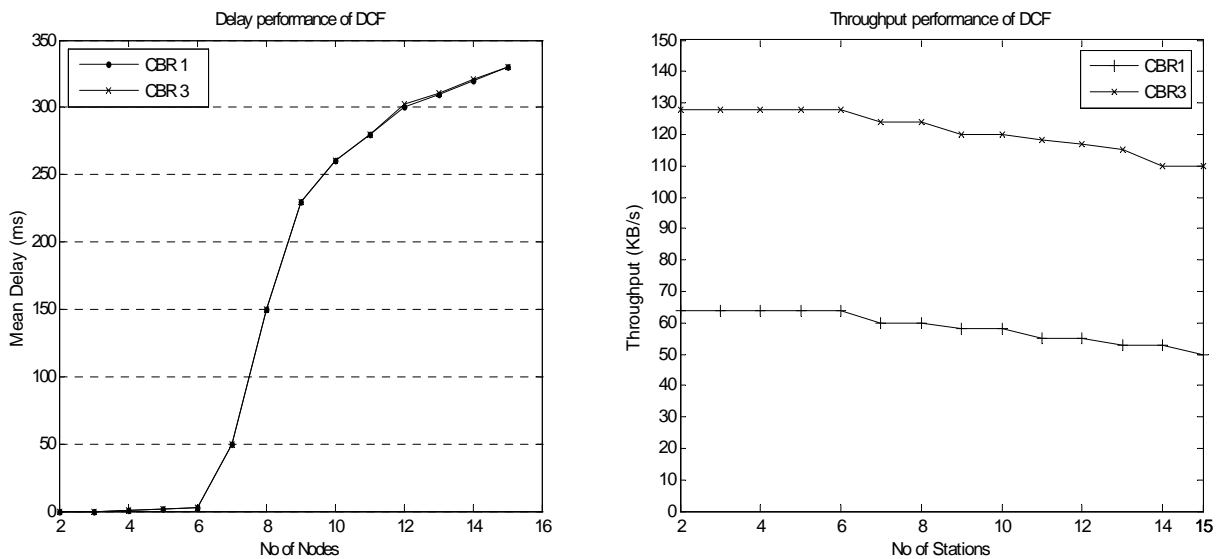


Figure-4.6: Delay and Throughput analysis of DCF in IBSS (or ad-hoc) mode

From the above simulation (i.e. BSS, ESS and Ad-hoc) modes with the mentioned parameters as in Table-4.1 and Table-4.2 using NS-2, it is found that the DCF does not provide any service differentiation in any traffic pattern. The delay performance analysis of three modes for both the traffic pattern is not differentiated as shown in Figure-4.2, 4.4, 4.6. Also the average throughput of the two flows for a station is quasi-stable (i.e. the no of station is up to a limit) and the delay is lower than 5ms. When the no of station increases, the throughput of two flows decreases. So this simulation clearly shows that there is neither throughput nor delay differentiation between the different flows. The reason is that all flow shares the same queue. So DCF cannot provide QoS, rather it provides only best-effort services.

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CONCLUSION:

A framework for DCF has been developed using NS-2 to simulate the performance of DCF. DCF only supports best-effort services but does not provide any QoS guarantee for time bounded applications such as Voice over IP (VoIP), videoconferencing. Our study shows that, it requires specific bandwidth, low delay and jitter, but can tolerate some loss. In DCF all stations compete for the channel with same priorities, also shares the common queue. There is no differentiation mechanism to guarantee bandwidth, packet delay and jitter for high-priority multimedia flows. These are the problem area in WLAN, which needs a greater attention for research. Here no service differentiation has embedded for different flows. The delay for real time multimedia flows should be reduced for better performance. Some parameters can be tunable to achieve the service differentiation is Contention Window, Backoff Algorithm and Inter-frame spacing.

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