CHAPTER 2

LITERATURE REVIEW

2.1 INTEGRATION OF CELLULAR AND WLAN

There exist several studies in the literature, to address the integration of existing wireless system. Yeh (2002) proposed Ad-hoc CELLular NETwork (ACENET) architecture for 3.5G and 4G mobile systems. The heterogeneous MAC protocol is used to integrate IEEE 802.11, Bluetooth and HiperLAN/2 with cellular architectures. The coordination between transmissions of different access protocols is provided using beacons from the base stations. ACENET consists of a cellular network and ad hoc network. They used an Integrated Wireless MAC Scheme (IWMS) for ACENET.

It consists of the integrated mode and the heterogeneous CDMA (H-CDMA) mode. The integrated mode is used of Internet-oriented traffic. The H-CDMA mode is used for mobile phone-oriented traffic. It provides a smooth transition from 3G wireless systems to 4G ACENET. Their main purpose is not to exhaust all possible designs, techniques, and solutions for such heterogeneous wireless architectures and their protocols. Even though ACENET improves the throughput performance, it needs many modifications in the base stations in order to achieve this.

A unified framework for the channel assignment problem in time, frequency, and code domains is proposed by Ramanathan (1997). The unified (T/F/C) DMA algorithm consists of labeling and coloring phases. Using the
graph theory solutions, channel assignment problems in heterogeneous network structures have been addressed. It proposed a Unified algorithm for (T/F/C) DMA channel assignment and it is referred to as Algorithm UxDMA. For a graphical representation of a wireless network, the algorithm UxDMA produces an assignment of positive integers i.e. colors, to vertices or edges of G, subject to a set of constraints on the assignment.

This algorithm consists of two phases. One is the labeling phase and another is the coloring phase. In the labeling phase, each vertex in the graph is assigned a unique label between 1 and n, where n is the total number of vertices. The coloring phase follows the labeling phase. Here, vertices are considered in decreasing order of labels, and if it is edge coloring, then the edges incident to the considered vertex are colored, or if it is vertex coloring, the considered vertex itself is colored. The color is chosen in a greedy fashion.

That is, the least color (integer) that can be assigned without violating any of the constraints is chosen. After the vertex labeled 1 is colored, the algorithm terminates. The crux of the algorithm lies in how the labeling is done. Several ordering heuristics are possible, but this paper studied only three. They are random, minimum neighbors first, and progressive minimum neighbors first.

Huang and Zhuang (2002) presented a MAC protocol with Fair Packet Loss Sharing (FPLS) scheduling for the fourth generation wireless multimedia communications. The MAC protocol exploits both time-division and code division multiplexing. FPLS is a QoS requirement based packet scheduling algorithm. The main aim is to provide QoS guarantees in terms of transmission delay, accuracy, and to maximize system resource utilization. The proposed MAC protocol is shown to provide QoS guarantees in hybrid
TD/CDMA systems. However, the proposed protocol necessitates a new wireless network infrastructure with new base stations for fourth generation communications. The main features of the FPLS scheduler are as follows:

1. According to each and every user QoS requirements, the packet losses are shared fairly among all the users.
2. Both the number of users supported by the system and the resource utilization are maximized.

The bandwidth is shared among all the users in such a way that, when the QoS requirements are guaranteed for one user, they are also guaranteed for all other users at the same time. A hybrid time-division multiple access (TD/CDMA) wireless system is considered for packetized transmission. This system operates in the Time Division Duplex (TDD) mode. This TDD is the best accommodated asymmetric traffic between the uplink and downlink. Here time is partitioned into frames of a constant duration. Each of the frames is divided into time slots. Each time slot has multiple accesses which are accomplished by assigning unique pseudo-random noise (PN) code sequence(s) to each user.

A joint session admission control scheme for multimedia traffic is introduced by Yu and Krishnamurthy (2007). In this, they maximize the overall network revenue with good Quality of Service (QoS). They integrate two different networks, a Wireless Local Area Network (WLAN) and a wideband Code Division Multiple Access Network (CDMA). They designed an integrated WLAN/CDMA network architecture in two different ways. One way is tight coupling and another way is loose coupling internetworking. In the tightly coupled system, a WLAN is connected to a CDMA core network in the same manner as other CDMA radio access networks.
In the loosely coupled system, a WLAN is not connected directly to CDMA network elements. Instead, it is connected to the Internet. A novel concept of effective bandwidth is used in the CDMA network to derive the unified radio resource usage, taking into account both physical layer linear minimum mean square errors (LMMSE) receivers and characteristics of the packet traffic. However, the integration requires modifications in the existing base stations.

Wei et al (2011) presented a radio resource allocation in a heterogeneous wireless access medium. A novel algorithm is developed for the resource allocation. The coordination among different available wireless access networks base stations are established via the MT multiple radio interfaces in order to provide the required bandwidth to each MT. A priority mechanism is employed, so that each network gives a higher priority on its resources to its own subscribers as compared to other user. Numerical results demonstrate the validity of the proposed algorithm. The application of this framework requires major modifications in the NG wireless network components.

They integrated Wi-Fi/WiMAX networks. The users are equipped with dual-radio interfaces that can connect to either a Wi-Fi or a WiMAX network. They consider the integration gain that comes from the better utilization of the resource rather than the increase of the resource. The heterogeneity of the two networks is the fundamental reason for the integration gain. They design a generic framework that supports different performance objectives to qualify the integration gain. The focus is on the max-min throughput fairness and proportional fairness metric. A heuristic algorithm is presented to measure the max-min throughput fairness and the proportional fairness metric.
Yan et al (2008) proposed a handover decision method based on the prediction of travelling distance within an IEEE 802.11 Wireless Local Area Network (WLAN) cell. They use a method of two thresholds which are calculated by the mobile terminal (MT) as it enters the WLAN cell. The prediction of travelling distance is compared against these thresholds to make handover decision. This will minimize the probability of handover failure or unnecessary handovers from a cellular network to a WLAN.

Lee et al (2005), and Yang et al (2007), used the available bandwidth as main criterion for a mobile terminal. Chi et al (2007), Xiaohuan Yan et al (2012), used both bandwidth and received signal strength (RSS) information in the decision process. Depending on whether RSS or bandwidth is the main criterion considered, an algorithm is classified either as RSS based or bandwidth based. Although the proposed scheme is designed for both cellular networks and the satellite-based networks, it requires modifications in the base station. Hence, the existing cellular networks cannot be used for integration.

Jie Zhang et al (2006), proposed a novel vertical handoff decision algorithm based on dynamic programming, by utilizing the location information of mobile users. A general framework is proposed for evaluating user satisfaction by means of a utility function. Based on this framework, they propose a novel vertical handoff decision scheme utilizing the above positioning technique. The key is to predict the mobility pattern of the mobile terminal based on its movement and location topology. They utilize this information for handoff decisions based on the user satisfaction framework.

A location service server (LSS) is introduced to facilitate MTs access to different networks. Periodically, each MT notifies the LSS its position, and in turn the LSS replies with information on available BWNs
around the MT. These messages include the essential information such as the identity of BWNs and their service parameters, namely bandwidth, security, and coverage area. An optimal handoff decision problem is formulated as a Markov decision process and it is solved by using a dynamic programming.

Hai Jiang et al (2007) proposed a next generation wireless networks which is expected to have a simple infrastructure with distributed control. A generic distributed network model for future wireless multimedia communications is considered with a code-division multiple access (CDMA) air interface. The medium access control (MAC) of the network model provides an overview of recent research efforts on distributed code assignment and interference control.

It identifies the limitations when applied in next generation wireless networks supporting multimedia traffic. It also proposes a novel distributed MAC scheme to address these limitations, where active receivers determine whether a candidate transmitter should transmit its traffic or defer its transmission to a later time. However, the MAC scheme only deals with the transmission from a source node to one of its neighboring nodes.

Subba Rao et al (2011) present a survey on medium access control protocols for wireless multimedia networks. They discussed the overview of MAC protocol concepts and developed a framework for comparisons. The MAC protocols covered in this article include random access protocols, contention less protocols, TDMA, CDMA, third-generation WCDMA schemes and hybrid protocols for wireless multimedia networks. The operation of each protocol is explained, and its advantages and disadvantages are presented. A qualitative comparative outline of the discussed protocols is provided.
Mobile communications has become ubiquitous these days. Wireless Multimedia is becoming increasingly popular as they provide users the convenience of access to information and multimedia services any time. With the advent of multimedia applications, there is a need for higher bandwidth and faster data rates. The upcoming wireless cellular infrastructures such as third generation (3G) and fourth generation (4G) are deemed to support bandwidth requirements, faster data rates with different quality of services for multimedia applications. Wideband Code Division Multiple Accesses (WCDMA) have emerged as one of the most promising multiple access techniques for future wireless multimedia networks and have been selected for IMT-2000 systems by standardization bodies all around the world.

Compared to the narrow-band CDMA, wideband CDMA can support services with much higher rate. It is also flexible to deliver multimedia traffic. Many multimedia applications are packet oriented, hence optimized third generation techniques that support variable bit rate and packet capabilities with quality of service requirements will be needed. In a wireless system consisting of a number of mobile terminals or nodes that transmit traffic of any type on a shared medium to a centralized base station, a procedure must be used for effective utilization of network resources and for quality of service requirements. This procedure is known as a Medium Access Control (MAC) protocol. MAC protocols are classified into three main groups. These are Contention less protocols and contention protocols. The contention less protocols is polling, random address polling, and token passing. The Contention protocols are random access protocols such as Aloha, slotted Aloha, and CSMA. The Channelization protocols are FDMA, TDMA and CDMA. In contention less protocols the scheduling is done in a fixed fashion and each node is allocated a part of the resource. In contention
protocols no node is superior to another node and none is assigned control over another. These protocols utilize direct, asynchronous competition to determine access rights for transmission. The contention protocols that suffered from hidden terminal interference and instability (i.e., throughput breakdown) at high network loads.

In frequency-division multiple access (FDMA), the available bandwidth is divided into frequency bands. Each station is allocated a band to send its data. Each band is reserved for a specific node and it belongs to the node all the time. In time-division multiple accesses (TDMA), schemes resource is divided into the time slots and the node transmits its data in its assigned time slot. Finally, Code-division multiple accesses (CDMA) divide the resource into a collection of codes through which assigned users can coexist on the same channel. CDMA allows multiple transmissions to occupy the channel at the same time without interference by using spatial coding techniques which spread the information bits over a broadened channel, allowing the information retrieval from the combined signal.

2.2 NETWORK UTILIZATION

Qadeer et al (2003) developed an integrated approach for the management of power and performance of mobile devices in heterogeneous wireless environments. It decides what wireless network interface (WNIC) to employ for a given application and how to optimize the WNIC usage. And it enhances the QoS by maximizing the power savings in heterogeneous wireless systems. The decision is governed by the current power and performance needs of the system. If the data communication requirements and/or network conditions changes, then the policy dynamically switches between interfaces during program execution. They have experimentally characterized Bluetooth and IEEE 802.11b wireless interfaces to verify the
power and performance management algorithm. They have implemented their policy on HP’s iPAQ portable device that is communicating with HP’s Hot Spot server. They tested the applications which range from MPEG video to email.

Fallah et al (2008) designed a new adaptive MAC based on OFDMA technology. In Wireless Local Area Network (WLAN), the existing Medium Access Control (MAC) scheme lacks scalability when the network is crowded. It is due to the use of random multiple access techniques in the MAC layer. It provides a new opportunity for devising more efficient MAC protocols. Data transmission opportunities are assigned through an access point that can schedule traffic streams in both time and frequency domains.

Zahra Zarei et al (2012) presented a reliable environment monitoring and information collection with an energy efficiency mechanism in new wireless sensor network applications. Reliability and delay are two important and vital parameters in some applications. Lifetime improvement in wireless sensor networks is also a challenging issue. As a result, they proposed a new protocol for solving these problems.

The proposed Energy-Aware QoS Provisioning Protocol (EAQPP) is a development of CSMA/CA protocols and RMAC in MAC layer and is similar with TinyOS MAC protocol. The proposed protocol uses CSMA/CA basic algorithm. And also they use some simple mechanisms to improve energy-efficiency and network reliability with reasonable end-to-end delay. Wireless Sensor Networks (WSNs) have been proposed for monitoring the physical phenomena with little or no human attendance. Inherent to such concept is one of the basic assumptions. Each and every node in a wireless sensor node is equipped with a battery. It has usually been assumed that the battery is irreplaceable.
A research in wireless sensor network has been focused on providing energy-efficient operation of each node that provides a long lifetime of Wireless Sensor Network as possible. However, recent advances in research on sensing technologies, e.g. sensor cameras, multimedia applications in sensor networks, e.g. target tracking in battlefield for military application, and various mission critical applications, e.g. in networked control systems have introduced delay or packet-loss sensitive traffic in wireless sensor networks. Since sensor networks are generally deployed in inhospitable terrains and consist of a dense deployment of sensor nodes. Furthermore, wireless communication is inherently unpredictable and error-prone. Hence, it becomes essential to employ a MAC protocol that efficiently shares the wireless channel.

In the proposed protocol, they have some reasonable assumptions. Each node has one ID and knows its neighbors IDs. The network topology is static. The sensor nodes are static. The only possible change in the network topology is due to discharge of sensor nodes. The layer 3 protocols are responsible of building routing tables in order to send packets to their destinations. If some duplicated packets are transmitted with an assumption of using aggregation mechanism, they are dropped. To achieve improved reliability, they assumed that Bit Error Rate (BER) is specific. With this parameter, they obtained the packet error rate. In this proposed protocol (EAQPP), energy efficiency is implemented using the transceiver’s sleep and wakeup mode.

Hou and O’Brien (2006) and Giupponi et al (2005) used fuzzy logic and neural networks as tools in a RAT selection algorithm. They can both minimize the number of unnecessary HOs and maximize the percentage of satisfied users. These solutions take into consideration both user
preferences as well as operator’s policies. Their disadvantage is that they increase the overall system complexity and in the case of neural networks a pre-training session of the system is required.

Murray et al (2003) and Zhuang et al (2003) proposed a policy-based scheme which is based on a set of rules that manage the execution of appropriate actions based on specific events. When these rules are simple, they provide a fast and easily implemented solution at the expense of non-optimal resource utilization. To cope with the later, more sophisticated policies can be introduced, but they increase the system complexity.

Special care is needed in order to avoid conflicts between different policies, especially when these policies reside in different network nodes. These schemes may be combined with one of the previous mechanisms in order to make the final decision. A point to consider when using policy based schemes is that strict rules do not provide for scalability and flexibility to cope up with all the contradicting parameters involved.

Lichun Bao (2009) says Large-scale wireless LAN systems based on the IEEE 802.11 standards have become the most successful wireless networks. These wireless networks are deployed in large organizations, such as educational campuses and corporate warehouses. On the other hand, the suite of IEEE 802.11 MAC protocols, including DCF, PCF and EDCA mechanisms, was unable to meet the challenges to provide collision freedom and differentiated quality of services. They proposed a channel access scheduling protocol based on Latin squares, called DCLASS (Distributed Coordination based on LAting Squares), that provisions a set of highly desirable features to large scale wireless networks with stringent performance demands.
The proposed DCLASS is scalable, fair, and co-exists with IEEE 802.11 nodes with traditional DCF mechanisms. The performance of DCLASS is evaluated in distributed WLAN systems. The experiment results show the near-optimum performance of DCLASS in contrast to IEEE 802.11 DCF under various scenarios.

The channel access control function is mainly categorized into the following channel access and packet multiplexing schemes:

- Random channel access and statistical multiplexing, such as CSMA, CSMA/CA, pure and slotted ALOHA, which were most extensively used and studied. For instances, MACA, MACAW, IEEE 802.11 DCF, PAMAS. However, the commonly used random back off mechanism along with CSMA/CA has constantly failed the performance goals in highly demanding environments, such as real-time and multimedia applications.

- The scheduled channel access and fixed multiplexing, using FDMA, TDMA, CDMA mechanisms in wireless cellular networks are GSM, UMTS and CDMA2000 systems. Scheduled channel access problems are commonly modeled as graph coloring problems, which is a well-known NP-complete problem. The polynomial algorithms exist for graph coloring problems using centralized computations or in-band signaling mechanisms. There are several topology-independent channel access mechanisms which provide constant-time algorithms. This algorithm combat collision by repetitions. RRMS have been proposed to apply pseudo random number generators to create node orders for channel access. Although the scheduled
channel access guarantees the transmission reliability, the waste of unused resource allocations is a perplexing problem.

- In the hybrid reservation based packet transmission scheme, the channel is separated in two virtual components. One is for control purpose to allocate channels using random access mechanisms, and the other is for data packet transmissions. However, in a distributed wireless network, negotiation based channel resource allocation and channel access often incur overhead and cannot completely eliminate conflicts.

The current WLAN systems are mostly based on the IEEE 802.11 standards, which have grown to encompass the most advanced communication technologies. They also introduced a CS-graph clustering algorithm for multi-channel communication capabilities in DCLASS. They have shown that DCLASS have superior performance in contrasts to IEEE 802.11 DCF in large scale WLAN system environments.

Vladimir Atanasovski, Valentin Rakovic, Liljana Gavrilovska (2012) The RIWCoS approach to RM relies on the notion of MIH User defined within the IEEE 802.21 standard. The MIH User uses the services of the lower MIH Function (MIHF) in a standardized way. In order to encompass all possible user scenarios envisioned in the RIWCoS paradigm, the RM approach requires both network and terminal side RM modules. However, the implementation of network RM modules is more intriguing and requires many assumptions and prerequisites from the network side. Therefore, RIWCoS at the current stage defines and evaluates only the terminal side RM module.
Liang et al (2007) aimed to select the most suitable access network, where the users QoS requirements can be satisfied and the cost that user paid for is the lowest. It only considered roaming and vertical handoff, but how to improve the overall system revenue optimally has not been studied. The main aim is to provide the mobile users with seamless wireless access and guaranteed quality of service (QoS) anywhere and anytime. It is a trend to integrate CDMA cellular networks and wireless local area networks (WLANs) into heterogeneous networks in next generation all-IP wireless networks. They proposed a net utility-based network selection algorithm.

They use a utility function to reflect the user satisfaction level to QoS and to use the cost function to reflect the cost for service. They introduce a call admission control algorithm of CDMA and WLAN system to aid the network selection. The goal of their proposed scheme is to guide users to select the most suitable access network. In this the user’s QoS requirements can be satisfied and the cost that user paid for is the lowest.

Shen and Zeng (2006) consider a dynamic decision strategy which handles the performance of the whole system. It takes the Vertical Handover decisions by meeting individual needs. This decision strategy selects the best network based on the highest received signal strength (RSS) and lowest Variation of received signal strength (VRSS). It ensures the high system performance by reducing the unnecessary handoffs.

### 2.3 QUALITY OF SERVICE

A dynamic access probability protocol is proposed by Naor and Levy (2001) for cellular Internet and satellite-based networks. The network computes an access probability. This access probability depends on the load, and announces it, as a broadcast message, to the user. The basic idea is that
when a user wishes to send a message, it transmits with a probability $p_{access}$. This $p_{access}$ depends on the load on the channel.

Under conditions of low load, the probability $p_{access}$ approaches 1. At high load $p_{access}$ is relatively low. The media access control protocol guarantees high channel utilization at high load, as well as low delay at low load periods. The load is estimated with certain uncertainty using the statistical usage of the shared channel. However, the QoS requirements of the application are not addressed.

McNair and Zhu (2004) suggested a cost functions which uses a numerical functions to calculate the cost of alternative Radio Access Technologies (RATs), based on several weighted metrics and parameters. Such functions provide a simple way to make a Hand off (HO) decision and a comparative measure on the suitability of one RAT against others.

It should be noted that there is an issue to consider when mixing different parameters of different measurement units in a single equation. The measures are monetary cost with signal strength and QoS type. Furthermore, there are parameters that cannot be directly measured by a certain unit. They are namely, user preferences and security. It is not always clear in which way they can be incorporated in such mechanisms.

Navarro et al (2007) presented a vertical handoff decision algorithm for heterogeneous wireless networks. For vertical handoff decision, the connection duration and the signaling load are incurred on the network. The algorithm is based on the Markov Decision Process (MDP) formulation with the objective of maximizing the expected total reward of a connection. The MDP model consists of five elements. They are decision epochs, states, actions, transition probabilities, and rewards. The mobile terminal has to
make a decision whenever a certain time period has elapsed. A stationary
deterministic policy is obtained, when the connection termination time is
gometrically distributed.

Yung-Han Chen et al (2009) introduced an admission control by a
fuzzy Q-learning technique for WCDMA/WLAN heterogeneous network
with multimedia traffic. It is composed of a neural-fuzzy inference system
(NFIS) admissibility estimator, and a decision maker. The NFIS admissibility
estimator takes an essential system measures into account to judge how each
reachable sub network can support the admission request's required QoS and
then output admissibility costs.

Several challenges related to the seamless interworking of wireless
LAN and 3G cellular networks are discussed. Feasible conditions and
restrictions under which seamless continuity of video sessions across the two
networks are evaluated. A number of practical interworking scenarios are
formulated. The main objective is to evaluate the conditions and restrictions
under which seamless continuity of video sessions across the two networks is
feasible. For that purpose, they formulated a number of practical interworking
scenarios.

The UMTS subscriber with ongoing real-time video sessions is
handovers to WLAN. They particularly quantify the maximum number of
UMTS subscribers that can be admitted to the WLAN, subject to maintaining
the same level of UMTS QoS and respecting the WLAN policies of Apostolis

Chuanxiong Guo et al (2004) proposed a novel seamless and
proactive end-to-end mobility management system to roam across
heterogeneous wireless networks. The proposed system has two components,
the Connection Manager (CM) and Virtual Connectivity (VC). The Connection Manager uses a novel Media Access Control (MAC) layer and physical layer sensing techniques to obtain an accurate network condition. At the same time it reduces the unnecessary handoff and ping-pong effect. The Virtual Connector makes mobility which is transparent to applications.

This is done by using a Local Connection Translation (LCT) without the support of additional network-layer infrastructure. It handles mobility well in Network Address Translator (NAT). The primary functionality of Connection Manager (CM) is to intelligently sense and detect the network conditions. The network conditions are such as network type, signal strength, bandwidth and delay. Motivated by the fact that the handoff in CM between WLAN and WWAN is vertical and asymmetrical, they introduce a new handoff metrics for roaming between WLAN and WWAN.

Specifically, from WWAN to WLAN roaming, they present MAC-layer sensing by taking into account the QoS of WLAN system for better connectivity from WLAN to WWAN roaming. They proposed a Fast Fourier Transform (FFT) decay detection algorithm for timely detecting unavailability of WLAN. However this system considers only the quality of service (QoS) and not the resource utilization.

Xijin Li et al (2010) presented an efficient joint session admission control scheme. It maximizes overall network revenue with QoS constraints over both the WLAN and the TD-SCDMA cellular networks. The new arrival sessions are modeled as a continuous time Markov chain. To simplify, it is done by dividing the continuous network states into discrete levels. The architecture integrates WLAN/TD-SCDMA system.
The integrated network is comprised of multiple WLAN (Wireless Local Area Network) wireless access points and TD-SCDMA (Time Division Synchronous Code Division Multiple Access) base-stations. They assumed that, the new calls in a cell arise at an average rate according to a Poisson process. Call duration has a negative exponential probability distribution. These two wireless access networks have different coverage area and load-carrying capability, and overlap coverage the same wireless areas.

Ismail and Weihua Zhuang (2012), studied a radio resource allocation in a heterogeneous wireless access medium. Mobile terminals (MTs) are assumed to have multi-homing capabilities. Both constant bit rate and variable bit rate services are considered. A novel algorithm is developed for the resource allocation. Unlike existing solutions in literature, the proposed algorithm is distributed in nature, such that each network base station / access point can perform its own resource allocation to support the MTs according to their service classes.

The coordination among different available wireless access networks’ base stations is established via the MT multiple radio interfaces in order to provide the required bandwidth to each MT. A priority mechanism is employed, so that each network gives a higher priority on its resources to its own subscribers as compared to other users. Numerical results demonstrate the validity of the proposed algorithm.

2.4 SCHEDULING

Garcia et al (2006) proposed a novel Common Radio Resource Management (CRRM) algorithm for heterogeneous wireless network. The proposed CRRM algorithm is applied in a heterogeneous wireless scenario with CDMA and TDMA radio access networks to schedule the downlink
transmissions of a delay-constrained service. The scheduling algorithm ensures that the total bandwidth is efficiently used. While at the same time it takes into account the time-out requirements of the different packets to ensure an optimal allocation.

The bit rate allocation is executed by means of an optimal mechanism based on Hopfield Neural Network (HNN) through the minimization of a properly defined Energy Function. The HNN is a heterogeneous scenario which is considered as a combinational problem where radio resources is to be allocated to several users at each frame subject to certain restrictions in terms of Quality of Service (QoS) and of total amount of available resources.

Shan Chu and Xin Wang (2009) presented a holistic distributed scheduling algorithm. This algorithm adaptively selects different transmission strategies. The selection is based on the node types and channel conditions. This is to effectively relieve the bottleneck effect caused by nodes with smaller antenna arrays. And avoid transmission failure due to violation of channel constraint. They considered a distributed channel resource allocation among an ad hoc network of nodes. These nodes have different number of antenna elements and experience different channel conditions.

To address the challenges, the algorithm groups transmissions into two types. One is transmissions to poor nodes using P-slots and another is to rich nodes using R-slots. This distributed scheduling algorithm consists of two phases, namely transmitter node selection / slot request and stream allocation. In the first phase, a set of nodes are first selected as a transmitter nodes. Each node differentiates its packets as poor nodes and rich nodes in order to determine its current preference of transmission slot type. In the second phase, stream allocation is performed to allocate the data packets of
the transmitter nodes to a selected set of antennas with an appropriate Multiple Input Multiple Output (MIMO) strategy.

Dian et al (2009) proposed an adaptive Joint Session Scheduling (JOSCH) based on layer-encoded streaming in heterogeneous wireless networks. The adaptive JOSCH is designed for real-time multimedia transmitting. It deals with the traffic scheduling issues in simultaneous transmission. An innovative skew scheduling algorithm and effective data dispatching method are applied. Thus the network change can be overcome, by which it provides a high-qualified multimedia service.

The adaptive JOSCH is designed for real-time multimedia service simultaneously transmitted by several heterogeneous radio access technologies (RATs). By understanding the characteristics of the layer-encoded streaming, an adaptive JOSCH mechanism is designed along with the supporting network architecture. Which is an efficient usage of the heterogeneous wireless resources and also it adapt to the dynamic network changes. They used an innovative skew scheduling algorithm to preprocess the layer-encoded streaming.
Gamal et al (2002) considers the problem of minimizing the energy which is used to transmit packets over a wireless link. This transmission is through lazy schedules that judiciously vary packet transmission times. They consider packet transmission schedules that minimize energy subject to a deadline or a delay constraint. Particularly, they use an optimal offline schedule for a node operating under a deadline constraint. An inspection of the form of this schedule naturally leads us to an online schedule. They relax the deadline constraint and provide an exact probabilistic analysis of our offline scheduling algorithm. They devised a lazy online algorithm that varies transmission times according to backlog. They prove that it is more energy efficient than a deterministic schedule that guarantees stability for the same range of arrival rates.

The statistics of the arrival process is mainly used to design online algorithms that are energy efficient on average. They assumed a Poisson arrival for the analysis. Since the Poisson arrivals are unrealistic in the wireless LAN environment, the arrivals are tending to
be bursty. They have observed that, when the arrival is bursty, the lazy scheduling performs even better than in the Poisson case.

Huang and Zhuang (2000) proposed a Hybrid Medium Access Control (MAC) protocol with packet a scheduling algorithm. It supports a wide variety of traffic types in TDD wideband CDMA wireless system. The proposed MAC protocol can efficiently accommodate two-rate such as on-off voice, variable data video and bursty data traffic.

They consider a hybrid Time/Code Division Multiple Access Control protocol. The basic idea behind the hybrid techniques is to control interference in the CDMA system using TDMA type multiplexing. In Time division multiplexing, the packet flows are generated and transmitted to the mobile users on spread spectrum. In code space, the packet transmissions are scheduled to control interference among the users in each time slot. This achieves satisfactory transmission accuracy.

Lu et al (1999) introduced a new model for wireless fair-scheduling based on the adaptation of Fluid Fair Queuing (FFQ). It mainly handles a location-dependent error bursts. They describe an ideal wireless fair-scheduling algorithm. It provides a packetized implementation of the fluid mode, by assuming full knowledge of the current channel conditions. They derive a practical wireless scheduling algorithm which approximates the ideal algorithm and derive the worst-case throughput and delay bounds.

Daeseob Lim (2007) proposed a distributed hybrid multi-cell scheduling algorithm for heterogeneous wireless sensor network. The scheduling algorithm consists of two parts. One is cell-level scheduling and another is node-level scheduling. The first part, cell-level scheduling
algorithm describes which cells are active so that the interference between the active cells is reduced drastically. The node-level scheduling algorithm decreases the contention among the wireless nodes accessing a wireless channel. They combine the above two scheduling algorithms to reduce energy consumption of communication devices on mobile nodes. It improves the aggregate throughput in multi-cell wireless networks.

They compare an optimal node-level scheduling algorithm to show that the problem is NP-complete. A heuristic scheduling algorithm is presented and it is converted into distributed node-level scheduling algorithm.

JunSeong Kim (1999) presented a Performance-Based Path Selection (PBPS) scheme. It dynamically selects the best communication path among several to reduce the communication overhead of parallel programs. To increase the available bandwidth, they aggregate multiple physical paths into a single virtual path. This is done by Performance-Based Path Aggregation (PBPA) scheme. They used a Performance-Based Path Determination (PBPD) on a cluster of SGI microprocessors interconnected with Ethernet, Fiber channel and High Performance Parallel Interface (HiPPI) network.

They introduced a network-based computing for an efficient scheduling of shared resources, such as processor, memories and networks. To assist the network-based computing systems, a network status predictor is used. It is a general and extensible network load monitor which provides lower and upper latency prediction bounds.
Higgins and Lastovetsky (2006), presented a model of performance for nodes in a heterogeneous Network of Computers (NOC). This model has number of steps which is built from two components. They are a performance function and a pair of load function. The performance function has a number of experimentally obtained benchmarks for problem of increasing size. And the load function represents the maximum and minimum load experienced by a machine over an increasing period of time.

A dedicated cluster a NOC is made up of machines which have varying levels of integration with the rest of a general purpose network. It is the integration result of different load fluctuations on nodes in the NOC. Their model aims to represent how those routine fluctuations effect performance. And they demonstrated the construction of the model and its use in the design and implementation of a parallel application.

Daeseob et al (2006) proposed a proxy-level scheduler. This scheduler significantly improves the Quality of Service (QoS) in heterogeneous wireless sensor networks. At the same time it reduces the overall power consumption also. The proposed scheduler is transparent to both applications and MAC in order to take the advantage of the standard off-the shelf components. It reduces collisions through a generalized TDMA implementation. Thus it improves the throughput and QoS by activating only a subset of stations at a time. The Power savings is achieved by scheduling transfer of larger bursts of IP packets followed by longer idle periods during which node’s radio can either enter sleep or be turned off.

The proposed proxy-level scheduler is a TDMA-type scheduler. In this, time is divided into slots whose length is $T$ referred as a scheduling decision interval. The scheduler is based on a generalized TDMA scheme.
With this scheme, they reduced the contention by activating only a portion of stations in the network. It improves the throughput.

Fangwen Fu and Van Der Schaar (2012), proposed a systematic solution to the problem of scheduling delay-sensitive media data for transmission over time-varying wireless channels. They formulated the dynamic scheduling problem as a Markov decision process. The scheduling explicitly considered the user’s heterogeneous multimedia data characteristics. For example, delay deadlines, distortion impacts and dependences, and so on. They consider a time-varying channel condition, which are not simultaneously considered in packet scheduling algorithms. This formulation allows them to perform foresighted decisions to schedule multiple data units for transmission at each time in order to optimize the long-term utilities of the multimedia applications.

To express the transmission priorities between the different data units, the heterogeneity of the media data is used. It is represented as a priority graph, which is a directed acyclic graph. This priority graph provides an elegant structure to decompose the multi data unit. They develop a low-complex online learning algorithm to update the value function. The function captures the impact of the current decision on the future utility. This function is developed based on the priori unknown statistical knowledge of the multimedia data characteristics and channel conditions.

2.5 SUMMARY

The literature reviews presented above listed several proposals which address the integration of existing wireless systems. However, the integration requires modifications in the existing access schemes in the base station or a new wireless network infrastructure with new base stations.
Although it improves the throughput performance over the existing networks, many modifications in the base stations are required to achieve this.

These approaches lead to integration problems in terms of implementation costs, scalability and backward compatibility. Few proposals concentrate only on integrating the existing wireless network but not on the Quality of Service. Some proposals discuss the Quality of Service requirement in heterogeneous wireless network. In a heterogeneous wireless network the mobile users must provide a seamless access with a good quality of service. Along with that the network resources in the heterogeneous wireless network should be used efficiently. Based on the reviews from various literatures we identified that the problems as integration of existing wireless network, high network utilization and guarantees Quality of Service requirements.