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Guest editorial

Recent advances in wireless networks and systems

1. Introduction

Recently, we have seen wireless technology infuses every aspect of our life with applications that range from the wireless mice/keyboards, and the Bluetooth that controls home devices to wireless LANs and MANs. This proliferation of wireless devices was the result of the FCC decision to open the ISM band to the public. Wireless local area networks (WLANs) were among the domains that benefited from this release. This release from licensing motivated many companies and research labs to develop and implement wireless LAN solutions. Wireless communications and networks have experienced impressive growth in recent years due to their mobility, cost-saving, and freedom from cables, among others. The latter advantage enables what is often called the 3A paradigm: communications any where, anytime, and with anyone [1–5].

Recent estimations indicate that more than one million residential people and one hundred thousand institutions are not covered by terrestrial broadband access. Wireless systems when integrated with new technical solutions allow offering an immediate coverage at high data rates. The major challenge is to have broadband wireless technology fill the digital divide at service cost, reliability and quality comparable to terrestrial solutions. Great challenges concerning digital divide are also evident in Africa, Asia and South America and wireless technology has a real chance to play a key role in this regard. Also in the US, the lack of economical access to wired broadband resources at a significant number of facilities will pose a critical hindrance to business operations. Broadband wireless systems will be essential to enable comprehensive broadband services with the performance required to support the mission-critical applications needed by corporate and markets.

Wireless and satellite technology offers many advantages compared to cable networks from the viewpoint of scalability, overcoming geographical obstacles, covering isolated areas, and application in hazardous environments. In many situations such as aerospace services, the wireless choice is a must. In other situations, wireless means resource optimization, as in the case of Wireless LANs. Cable networks and the Internet are not sufficient to support applications in some environments. People may require news on the web in hazardous environments. Moreover, in the presence of infrastructure, traffic bottlenecks of terrestrial networks and traditional links could make the service highly inefficient, if not useful. Therefore, there is an increasing commercial interest to use wireless in modern telecommunications systems such as local area services, interactivity and possibility of building networks adapted to the different needs; tele-learning; managing activity of the Public Administration; bank and financial services; industrial activity located remotely; broadcasting and backbone access; international connections; tele-medicine; data recovery; video-surveillance; application in rural environments; applications for vehicles, trains and planes; and tactical communications, among others. Offering real services with a specific guarantee of Quality of Service (QoS) over wireless systems (including WLAN, radio and satellite systems) is very challenging as it implies the need to solve difficult research and development issues due to the peculiarity of the application environment.

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2. Wireless networks and systems issues

As wireless systems progress with increasing size, applications and performance, there will be a need to integrate them with other systems in order to support mobile computing applications and have them perform as efficiently as fixed (wired) systems. Due to the difficulties posed by the wireless medium and the increase demand for better and cost-effective services, the area of wireless networks and communications is an extremely rich field for research and development [1–3].

There are numerous technical issues related to wireless systems such as WLANs, WMANs, radio networks, 3G and beyond systems, Bluetooth and HomeRF personal area wireless networks (PANs), military tactical and satellite networks. These issues that have risen due to new applications or new interface of such systems either together or to wired systems. Major issues have to do with topologies, protocols, routing, mobility management, security, and performance analysis and evaluation. On one hand, wireless systems allow ubiquitous information dissemination, but on the other hand, wireless infrastructures inherit all the network requirements of wired networks adding intrinsic problems and complexity and challenges.

This special issue of Computers and Electrical Engineering Journal is dedicated to wireless networks and systems and it presents recent research results reported by worldwide experts. The papers cover many issues in wireless networks and the papers have come from all over the world. We have received sixty eight papers for this special issue. Each paper was reviewed at least three qualified reviewers and based on the reviewers' recommendations and space limitation, we only accepted seventeen papers.

3. Scanning the issue

Koletta and Constantinou described a new methodology for the determination of the coordination area around the receivers of the conventional Fixed Service (FS) with respect to mobile Earth Stations on board Vessels operating in frequency bands C and Ku. Their scheme is based upon parameters such as the velocity of the ESVs and their frequency of passage from specific locations within the neighborhood of the FS receiver. The methodology is extracted through a mathematical and statistical analysis of the motion of the ESVs. The scheme resulted in an iterative algorithm, which can be applied for every type of FS link and mobile interferer. The application of the iterative algorithm in real FS links leads to the construction of new types of coordination areas. Simulations performed for realistic interference scenarios prove the validity of the proposed methodology.

Sethom and Afifi presented a new architecture for fast handover and micro-mobility management in wireless systems. The proposed scheme addresses the key problems of transparent vertical and horizontal handoff. In order to reduce the handoff delay and consequently packets loss, the authors proposed to manage the problem at the layer 2.5. By combining the advantage of the virtual interface and the MPLS forwarding mechanism, they proposed a simple solution that covers intranet and Internet connectivity. Moreover, the authors described the implementation for the virtual interface. Simulation results have shown that using W-MPLS can lead to substantial reductions in handover delays.

Chen, Lei and Wang proposed an adaptive guard capacity scheme for soft hando® calls by means of a predictive multiple access interference (MAI) temporal structure, so as to improve soft hando® users performance simultaneously with an acceptable QoS guarantee for ongoing users. They also applied feedback control methodology to formulate the adaptive guard capacity adjustment as an adaptive real-time control problem. The performance evaluation results reveal that their solution not only has excellent stability behavior, but also meets zero steady state error and settling time requirements. The simulation results also indicated that their adaptive guard capacity scheme can guarantee the predetermined soft hando® failure probability and new call blocking probability by comparing with conventional fixed guard capacity scheme.

Chu and Frank Yeong-Sung Lin investigated the survivability of mobile wireless communication networks in the event of base station (BS) failure. The authors employed the Lagrangean relaxation as a solution approach and analyzed the experiment results in terms of the blocking rate, service rate, and CPU time. The results have indicated that the total call blocking rate (CBR) is much less sensitive to the call blocking probability (CBP) threshold of each BS when the load is light rather than heavy; therefore, the more traffic loaded,

the less service rate will vary. The proposed model can fit the requirement of capacity expansion by locating mobile/portable BSs to the places they are most needed.

Papadaki, Friderikosy, and Aghvamiz proposed a power control scheme that can enhance the efficiency of a node improving its survivability and the quality of communications. Their proposed MGCh algorithm utilizes mobility information to influence the rate allocation vector. The simulation results have indicated that for vehicular environments and depending on the mobility pattern, the algorithm can provide significant gains in power efficiency that cannot be achieved by mobility agnostic schemes. The authors reported power efficiency gains of almost 40%.

Chang and Mai proposed a cross-layer framework and the Hierarchical Multicast Session Initiation Protocol (HMSIP), which extends the IETF Session Initiation Protocol (SIP) with the concept of multicast SIP session and integrates the underlying IP Multicast QoS routing protocol and the RSVP resource reservation technique, to support mobile multimedia multicasts. Such a structure significantly reduces handoff delays and deployment costs and therefore, achieves end-to-end QoS support for MHs on heterogeneous wireless networks. The authors analyzed analytically the handoff delays of the HRS, BT-MOM and HMSIP schemes. The simulation results have shown that the HMSIP can significantly achieve much more stable and lower handoff delays than those of the BT-MOM and HRS only with a small proportion of extra bandwidth than the bandwidth-optimal HRS, thereby supporting higher numbers of handoffs without interrupting multimedia playback of the mobile multicast activity. The paper also discusses the tradeoffs between costs for deploying HMSIP Proxies in the framework and corresponding performances of the HMSIP families.

Lu, Wu and Liu proposed the mobility-aided adaptive resource reservation (MARR) with admission control (AC) to provide better usage of scarce resource in wireless multimedia networks. In this scheme, the area of a cell is divided up into: the reservation zone and the non-reservation zone. A target cell is predicted by extrapolating the trajectory of mobile stations (MSs). In order to reduce signalling overhead, bandwidth is reserved only in the target cell as MSs move into the reservation zone and leave the serving base station (BS). The amount of bandwidth to be reserved is dynamically adjusted according to the instantaneous variation of mobility ratio, location, and direction of MSs. The authors investigated two scenarios of the MARR scheme using OPNET simulation package. The simulation results obtained by authors have shown that employing the MARR scheme can indeed reduce connection dropping and blocking probability, and make better bandwidth utilization when appropriate parameters are chosen.

Zhang and Wang proposed an adaptive multi-user frequency-time domain radio resource allocation model for the downlink Orthogonal Frequency Division Multiplexing (OFDM) systems, which efficiently exploits the time diversity, frequency diversity as well as multiuser diversity in the time, frequency and user domain, respectively. They presented a detailed capacity analysis of the proposed frequency-time domain radio resource allocation. The analysis results have shown that the proposed scheme can achieve much higher capacity than the conventional frequency-domain resource allocation scheme. The authors devised two complexity adaptive resource allocation algorithms—algorithm A and algorithm B—that adopt a two-step allocation method to reduce the scheduling complexity and meanwhile improve the scheduling performance. The simulation results have shown that though the performance of algorithm A and B is slightly different, both of them yield much higher spectral efficiency and much lower outage probability than conventional OFDM–TDMA scheme or random allocation without any scheduling policy.

Shen and Wang proposed the Fuzzy Hopfield Neural Network (FHNN) for better channel assignment in wireless cellular system. In this scheme, each channel is regarded as a data sample and every cell is taken as a cluster. Channels are adequately distributed to the dedicated cells while satisfying the interference constraints such as co-site constraints, adjacent channel constraints, and co-channel constraints. The author's aim is to avoid the interference and serve the expected traffic, which is to minimize used spectrum. The proposed FHNN scheme can guarantee that the neural network will skip local minima, and in all cases will converge to the optimum arrangement of the channels. The simulation conducted by the author has indicated that the FHNN can provide an alternative approach of solving this class of channel assignment problems.

Marias presented a distributed, dynamic frequency selection and multicarrier scheduling scheme, called Distributed QoS-based Dynamic Carrier Reservation (D-QDCR). The scheme allows coexisting IEEE 802.11 access points of different providers to contend and reserve a carrier, based on QoS demands, and to distribute the allocated carrier, as well as the reserved time, to the associated wireless terminals, enabling

the spectrum agility paradigm. The scheme seeks to schedule for transmission an access point when its transfer requirements are at their peak in order to accomplish the QoS contracts and to achieve fairness. Moreover, using self-organized and etiquette policies, it mitigates interference situations, avoiding the waste of the scarce electromagnetic spectrum. Analysis results have indicated that the proposed dynamic frequency selection and scheduling scheme outperforms conventional scheduling in terms of data losses, transfer delays and efficiency.

Ma and Zhu proposed a new MAC protocol with scheduling algorithms to provide integrated service for CDMA based wireless networks. The devised scheme evolves from the distributed queuing random access protocol for CDMA wireless network (DQRAP/CDMA). It was designed to have an ability to accommodate integrated traffic in the network with effective scheduling schemes. The protocol performance was analyzed using simulation modeling. The simulation results have revealed that the proposed protocol with the scheduling can perform effectively to the integrated traffic composed of messages with or without time constraints and achieve fairness among different types of traffic.

Mendez, Panduro, Covarrubias, Dominguez and Romero proposed a scheduling scheme that can provide flexibility in bandwidth allocation and QoS guarantees. The proposed rate scheduling scheme is based on Generalized Processor Sharing (GPS), which has the advantage of being able to treat different traffic types according to their QoS requirements. However, GPS also assumes that multiple traffic with variable traffic rates can be served simultaneously. This is considered as a drawback of GPS because the classical packet-based systems are based in TDMA. The analysis have shown that when comparing the proposed scheme to the existing CDMA–GPS, the results have indicated an improvement in the system performance in terms of dropped packets, delay and increased operational throughputs.

Morgan and Kunz proposed the PYLON-Late QoS model, which deals with the cross-domains QoS connectivity issues. A PYLON-Lite gateway operates between the ad-hoc network, with its unique characteristics on one side, and the fixed topology access network on the other side. The fundamental differences between these two networks form the heterogeneous environment of the PYLON-Lite model. The PYLON-Lite QoS model provides a, seemingly, homogeneous cross-domain QoS solution. PYLON-Lite has a flexible model design that facilitates a lightweight implementation to benefit from the already existing QoS models on each side of the gateway. The paper identified the challenges in designing the cross-domain QoS model. PYLON-Lite presents specific mechanisms to deal with those challenges while maintaining the lightweight approach. It defines methods to interact with other QoS models on both sides of the gateway, methods to police traffic, and conditions to guarantee model scalability. The authors have presented extensive analysis and evaluation of the model performance and behavioural characteristics. It was found that PYLON-Lite, consistently; improves the QoS provided for real-time traffic with limited impact on best-effort traffic.

Elayoubi, Fourestiè and Ben Jamaa presented statistical methods to enhance dynamic simulations in mobile networks. The goal is to perform reliable and fast evaluation of QoS indicators such as blocking and dropping rates. The authors adopted a Trajectory Splitting (TS) method that splits the path of the simulated stochastic process into multiple copies for determined configurations, thus focusing on configurations for which communication problems are likely to occur. The authors have shown that the proposed method significantly reduces the variance of the estimators of both blocking and dropping probabilities, and hence reduces simulation times for the same precision.

De Rango, Gerla and Marano devised a scalable routing protocol for very large and dense ad hoc networks. The proposed protocol, called Geo-LANMAR, inherits the same advantage of LANMAR protocol in terms of group motion support and traffic load scalability and it reflects also the behaviour of geo-routing protocols such as GPSR. The scheme, Geo-LANMAR, is based on the idea of Terminodes routing for the forwarding scheme: long-distance geo-forwarding and low-distance table-driven routing. Its updating scheme, instead, is similar to the Hazy Sighted Link State Routing (HSLS) through a spatial and time update rate differentiation: frequent update rate for short distance and lower update rate for long distance. The performance evaluation of the scheme has shown that Geo-LANMAR is scalable in terms of traffic load, mobility speed, number of nodes and number of groups.

De Cola and Marchese studied the performance analysis of Transport Layer mechanisms applied in military radio environments. They basically, investigated the performance of the reliable transport protocols in wireless tactical infrastructures.

Finally, Boudriga and Obaidat developed an architecture and associated algorithms to build a Self Organizing Wireless Sensor Network (SOWSN) system that is capable of detecting mobile targets using cooperative sensors that are randomly deployed in a physical environment. The system manages sensor mobility, event fusion and correlation, and sensing continuity. It also proposes a communication security scheme for sensors. The system may be utilized in areas including military environmental monitoring, and home applications. In military environments, for example, the rapid deployment, self-organization, and fault tolerance characteristics of our SOWSN make it a very promising sensing tool for military command, control, communications, computing, intelligence, surveillance, reconnaissance, and targeting systems. Simulation analysis has been conducted to validate the performance of the proposed scheme.

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