

1. INTRODUCTION

The demand for making air traveling more 'pleasant, secure and productive for passengers is one of the winning factors for airlines and aircraft industry. Current trends are towards high data rate communication services, in particular Internet applications. In an aeronautical scenario global coverage is essential for providing continuous service. Therefore satellite communication becomes indispensable, and together with the ever increasing data rate requirements of applications, aeronautical satellite communication meets an expansive market.

Wireless Cabin (IST -2001-37466) is looking into those radio access technologies to be transported via satellite to terrestrial backbones . The project will provide UMTS services, W-LAN IEEE 802.11 b and Blue tooth to the cabin passengers. With the advent of new services a detailed investigation of the expected traffic is necessary in order to plan the needed capacities to fulfill the QoS demands. This paper will thus describe a methodology for the planning of such system.

In the future, airliners will provide a variety of entertainment and communications equipment to the passenger. Since people are becoming more and more used to their own communications equipment, such as mobile phones and laptops with Internet connection, either through a network interface card or dial-in access through modems, business travelers will soon be demanding wireless access to communication services.

2.WIRELESS CABIN ARCHITECTURE

So far, GSM telephony is prohibited in commercial aircraft due to the uncertain certification situation and the expected high interference levels of the TDMA technology. With the advent of spread spectrum systems such as UMTS and W-LAN, and low power pico-cell access such as Blue tooth this situation is likely to change, especially if new aircraft avionics technologies are considered, or if the communications technologies are in line with aircraft development as today

When wireless access technologies in aircraft cabins are envisaged for passenger service, the most important standards for future use are considered to be: UMTS with UTRAN air interface, Blue tooth, and W-LAN IEEE 802.11 b. Of course, these access technologies will co-exist with each other, beside conventional IP fixed wired networks. The wireless access solution is compatible with other kinds of IFE, such as live TV on board or provision of Internet access with dedicated installed hardware in the cabin seats. Hence, it should not be seen as an alternative to wired architecture in an aircraft, but as a complementary service for the passengers.

The Wireless Cabin architecture and its components are conceptually depicted in figure 1.

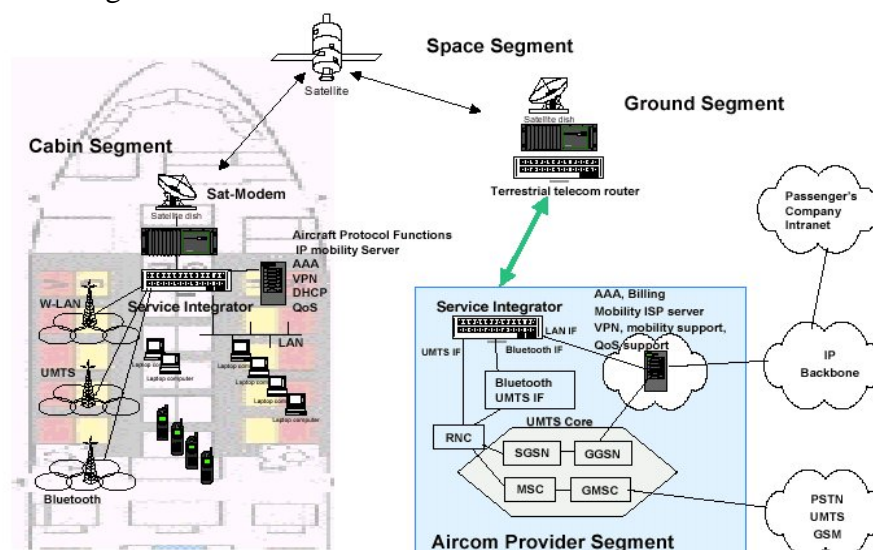


Figure 1.wireless cabin architecture

Several wireless access segments in the aircraft cabin, namely a wireless LAN according to IEEE 802.11 b standard for IP services, an UMTS pico-cell for personal and data communications, and Bluetooth1.1, as well as a standard wired IP LAN.

A satellite segment for interconnection of the cabin with the terrestrial telecom networks. The different cabin services must be integrated and interconnected using a service integrator, that allows the separation and transportation of the services over a single or several satellite bearers. Peculiarities, such as limited bandwidth, asymmetric data rates on satellite up- and down-link, and dynamic traffic demand between the different services and handover between satellite bearers need to be addressed. In order to minimize the cost (satellite resources) for a given QoS efficient interworking between the service integrator and the satellite segment will be required.

An aircom service provider segment supporting the integrated cabin services. The aircom provider segment provides the interconnection to the terrestrial personal and data networks as well as the Internet backbone. For the UMTS cabin service, a subset of the UMTS core network must be available.

The provision of such a heterogeneous access network with collectively mobile users requires the development of new protocol concepts to support

- The integrated services with dynamic bandwidth sharing among the services and asymmetrical data rate;
- IP mobility and virtual private networks (VPN) for the individual passengers in the mobile network; authentication, admission and accounting (AAA) in the mobile network, especially taking into account the necessity to support different pricing concepts for each passenger in the mobile network and the interaction of airline, satellite provider, aircom service provider and terrestrial service providers.

3. SATELLITE CONNECTION

Connection to telecom networks is considered to be achieved by satellites with large coverage areas especially over oceanic regions during long-haul flights. The service concept needs to take into account today's peculiarities of satellite communications, thus it must cope with the available or in near future available satellite technology, and interworking must be performed at aircraft interface level with the satellite segment,

- Only restricted satellite data rates will be available in the near future; thus the bandwidth that is requested by standard interfaces of the wireless standards needs to be adapted to the available bandwidth (typically: 432 kb/s in down-link, 144 kb/s up-link (Inmarsat B- GANTM), or 5 Mb/s in down-link, 1.5 Mb/s in up-link (Connexion by Boeing)). Furthermore, dynamic bandwidth management is needed to allocate higher bit rates from temporarily unused services to other service-
- Currently, few geostationary satellites such as the Inmarsat fleet are available for two-way communications, that cover the land masses and the oceans. Ku-band may be used on a secondary allocation basis for aeronautical mobile satellite services (AMSS) but bandwidth is scarce and coverage is mostly provided over continents. K/Ka-band satellites will be launched in the near future, again here continental coverage is mainly intended. The scenario must thus consider
 - the use of different satellite systems, which will probably force the support of different service bearers, and
 - handover between satellite systems.

It is assumed that each satellite segment is connected via terrestrial wide area networks or via the IP backbone to the aircom service provider.

- Asymmetrical data rates in satellite up- and down-links, that may also be caused to operate in conjunction with different satellites systems for up- and down-link. The service portfolio in the cabin and the service integration needs to cope with this possibility.

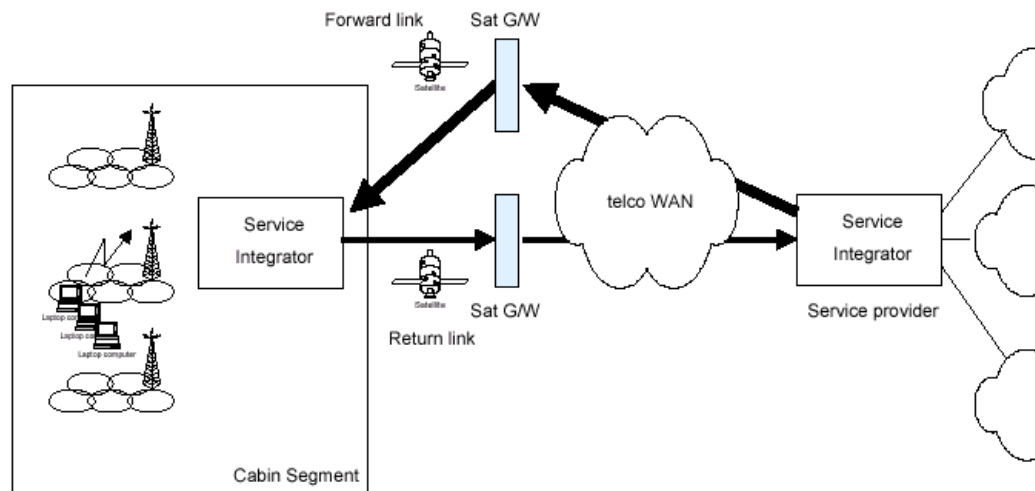


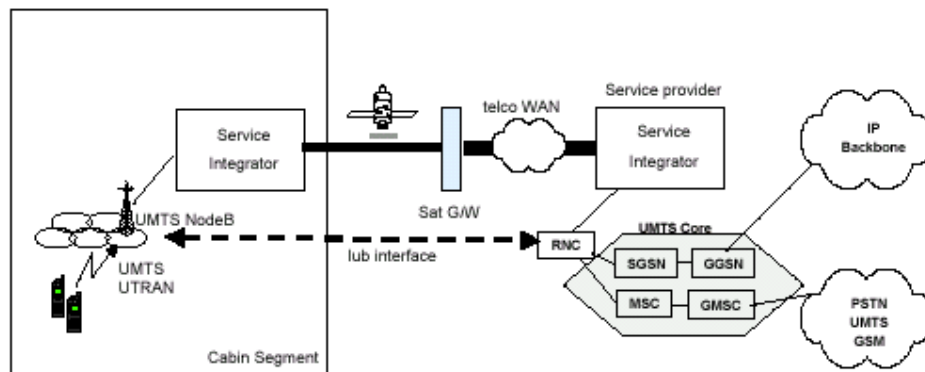
Figure 2: Satellite connection scenario

4. TECHNICAL OVERVIEW

A. UMTS

The Universal Mobile Telecommunication System (UMTS) is the third generation mobile communications system being developed within the IMT -2000 framework. UMTS will build on and extend the capability of today's mobile technologies (like digital cellular and cordless) by providing increased capacity, data capability and a far greater range of services.

In January 1998, ETSI reached an agreement concerning the radio access technique to be used for UMTS. This air interface, named UTRAN (UMTS Terrestrial Radio Access) is applicable in the two existent duplexing schemes for UMTS: UMTS-FDD and UMTS- TTD. UMTS-FDD relies on wideband-CDMA (W-CDMA) access technique, while UMTS- TTD uses the TD-CDMA access technique, a combination of CDMA and TDMA technologies.

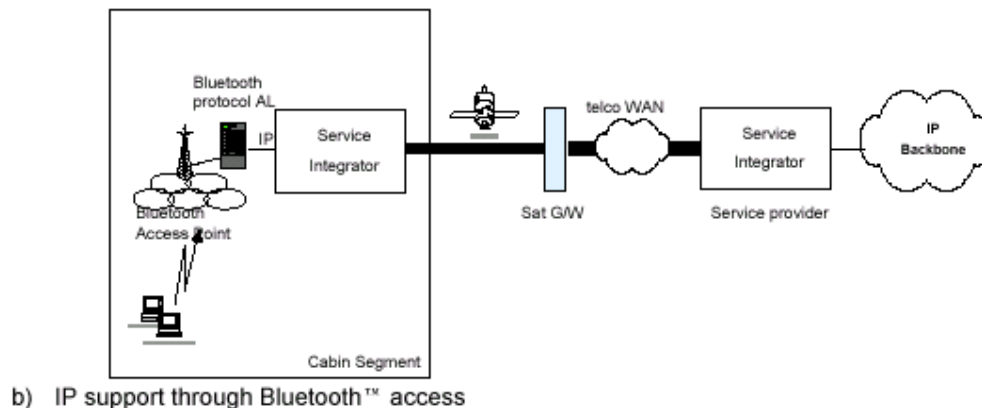


a) Umts Structure

B. BLUETOOTH

Bluetooth operates in the unlicensed 2.4--GHz ISM (industrial, scientific and medical) band and uses a frequency- hopping spread spectrum (FHSS) technique to minimise interference. A Bluetooth unit has a nominal

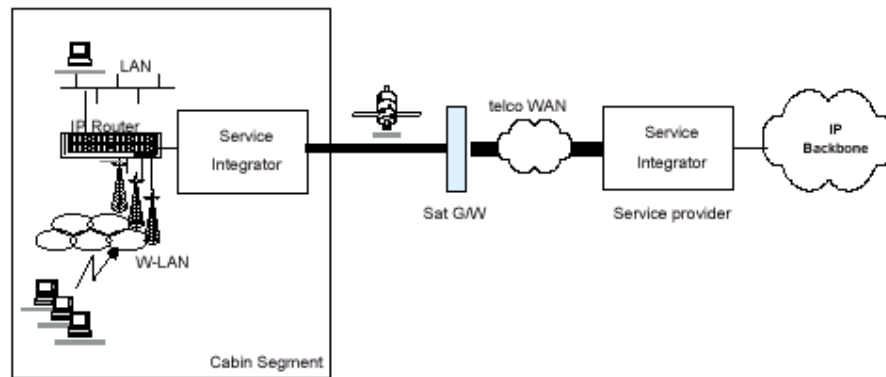
range of approximately 10 meters (in the Class 3 defined in the standard, but which can be enlarged by amplifying the transmit power in Class 2 and Class 1 up to 100 m.). Two or more Bluetooth units sharing the same channel form a piconet. Each piconet consists of a master unit and up to seven active slave units. Furthermore, two or more piconets can be interconnected to form a scatternet. To be a part of more than one piconet a unit called inter-piconet unit (gateway) is required.



c. IEEE802.11b

Wireless local area networking (WLAN) radio technology provides superior bandwidth compared to any cellular technology. The IEEE 802.11 b standard offers a maximum throughput of 11 Mbps (typical 6.5 Mbps) working in the same 2.4- GHz ISM band as Bluetooth by the use of direct sequence spread spectrum (DSSS). WLANs were originally intended to allow local area network (LAN) connections where premises wiring systems were inadequate to support conventional wired LANs, but they were later identified with mobility.

A WLAN cell is formed by an AP and an undefined number of users in a range from approximately 20 to more than 300 m (100 m. in indoor environments) that access the AP through network adapters (NAs), which are available as a PC card that is installed in a mobile computer.



a) IP support through fixed cabling or W-LAN

Table 1 summarizes the main parameters of each standard, where only Class 3 of the Bluetooth standard has been considered, as long as the Bluetooth version 1.0 specification focuses primarily on the 10- meter ranger standard radio. Notice that the coverage range in the UMTS case is capacity dependent and it can vary from 200 m. up to 1.4 Km., a phenomena known as "cell breathing".

	Bit rates		Bw.(MHz)	Band(GHz)	Coverage Range(m.)	Duplexing Scheme	Tx.P. (dBm)	Modulation
	Max	Typ						
UMTS	2Mbps	144Kbps	5,10,20	FDD: 1.92-1.90(uL) 2.11-2.17(dL) TDD: 1.90-1.92 2.01-2.025	Depends on capacity	FDD/TDD	20	QPSK(dL) BPSK (uL)
Bluetooth	1Mbps	728 Kbps	1	2.4-2.4835	10	TDD	0	GFSK
IEEE 802.11b	11Mbps	6,5Mbps	26	2.4-2.4835	20-100	TDD	20	Depends on bit rate

5. SERVICE INTEGRATOR

The different wireless access services of UMTS, W-LAN and Bluetooth require an integration of the services over the satellite. The central part of the service portfolio provisioning is the service integrator (SI), cf. Figure 3. The service integrator will provide the interfaces for the wireless and wired service access points in the cabin, as well as the interface to the terrestrial networks at aircom provider site. All services will be bundled and transported between a pair of Service Integrators. It performs the encapsulation of the services and the adaptation of the protocols.

The SI multiplexer is envisaged to assign variable capacities to the streams, controlled by a bandwidth manager that monitors also the QoS requirements of the different service connections. Changes in capacity assignment must be signaled to the SI at the other communication end. The heterogeneous traffic stream is then sent to streaming splitter/combiner. This unit is envisaged to support several satellite segments and to perform handover between them. Asymmetrical data rates in inbound and outbound directions can be managed here. Adaptation to the supported satellite segments are done by medium access controllers (MAC) in a modular manner. Towards the terminal side, the interfaces of the wireless access standards need to interwork with the transport streaming of the SI by specific adaptation layers (AL). These ALs have to be designed according to the analysis of the impact of delay, jitter and restricted / variable bandwidth on the protocol stack. Buffering (to compensate delay jumps at handover) and jitter compensation for real-time services (e.g., voice) must be also provided here.

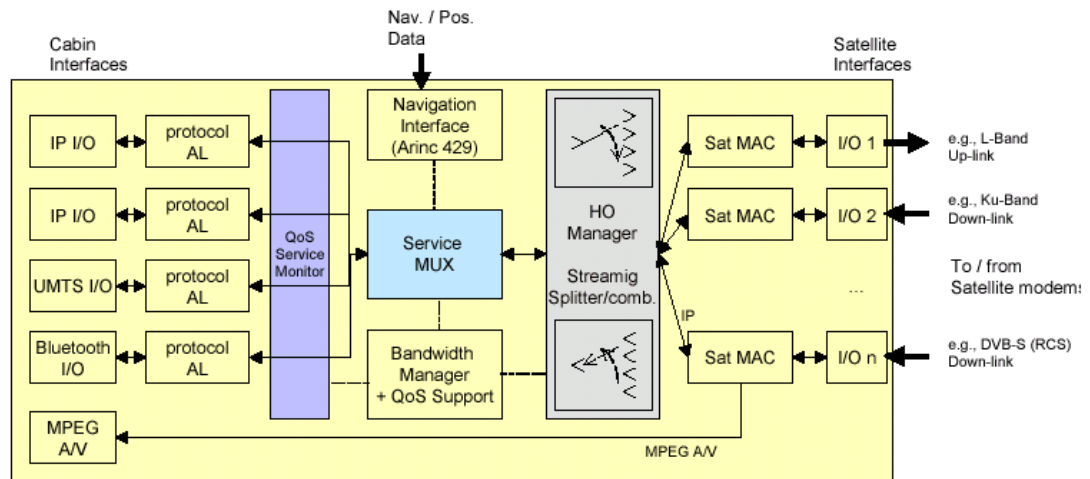


Fig. 3 Service Integrator

6. SERVICE DIMENSIONING

This section provides an overview of key issues and steps for the systematic system dimensioning of Wireless Cabin aircom satellite communications system. We will tackle the satellite constellations as potential candidates for aircom services as well as the gross traffic calculation and assignment process.

Different market entry options and reference business cases must be taken into account in an initial stage of a system design. The evolutionary path leads from existing L-band systems such as inmarsat GAN (see Figure 5) or B-Gan in few years up to C/Ku band and existing GEO transponders, whereas the “revolutionary” path may target from the beginning at advanced K/Ka band technology and the design of a tailor-made, potentially non-GEO system.

The system dimensioning process can be structured in several steps:

- Determination of gross traffic per aircraft using the multi-service model
- Determination of the timely and locally varying traffic, depending on the flight path and flight schedule, assuming also a service roll-out scenario for different airlines and aircraft types.
- Identification of potential serving satellites and their coverage areas.
- Mapping and traffic allocation of the aircom traffic to the satellite systems.

Two key observations concerning the “geographic market” are 1) the pronounced asymmetry of market opportunities between northern and southern hemisphere (partly just a result of our earth’s “continental layout”), and the fact that a significant share of the addressable market is at higher (northern) latitudes, especially with the important long-haul intercontinental flight routes between the European, North American and East Asian regions. Both observations are illustrated in figure 6, although its view is Europe-centric; the underlying flight route investigations have been performed within the European ACTS project ABATE and have been used for design and dimensioning studies of an aeronautical subsystem of the EuroSkyWay satellite communications system

7. INTERFERENCE

Once the above described measurements finish. four types of interferences within the CMHN have to be studied: the co-channel interference among the terminals of the same wireless access segment, the inter- segment interference between terminals of different wireless networks, the cumulative interference of all simultaneous active terminals with the aircraft avionics equipment and the interference of the CMHN into terrestrial networks.

From the co-channel interference analysis the re-use distance and the re-use frequency factor for in-cabin topology planning will be derived. For this reason it is important to consider different AP locations during the measurements.

It is not expected to have major problems due to interference from UMfS towards WLAN and Bluetooth, thanks to the different working frequency. On the other hand, particular interest has to be paid in the interference between Bluetooth and WLAN .Due to the market acceptance of Bluetooth and WLAN, there is a special interest of designers and portable data devices manufacturers to improve the coexistence of the two standards. There are many studies showing the robustness and the reliability of Bluetooth in presence of WLAN and vice versa.

A description of the electromagnetic behaviour of conventional aircraft equipment is necessary to analyse the interference and the EMC of the new wireless network with the avionics systems. The allowed radiated field levels are regulated and must be respected if certification is desired. So far, GSM telephony is prohibited in commercial aircraft due to the uncertain certification situation and the expected high interference levels of the TDMA technology. With the advent of spread spectrum systems such as

8. COLLECTIVELY MOBILE HETEROGENEOUS NETWORK

The concept of having several users, which are collectively on the move forming a group with different access standards into this group, is called Collectively Mobile Heterogeneous Network (CMHN). In such a scenario [5] one can find two types of mobility and two types of heterogeneity: the mobile group itself and the user mobility inside the group from one side, and heterogeneous access segments and heterogeneous user access standards from the other side. The aircraft cabin represents a CMHN (see Fig. 1) supporting three types of wireless (user mobility) access standards (heterogeneous user access) inside an aircraft (the mobile group) using one or more satellite access segments. The CMHN may cross coverage areas and then inter-/ intra- satellite handover will be required.

The communication infrastructure to support the cabin CMHN is depicted in Fig 2. The architecture consists of (i) several wireless access segments in the aircraft cabin which can coexist with the standard wired IP LAN, (ii) a satellite segment for interconnection of the cabin with the terrestrial telecom networks, and (iii) an aircom service provider segment supporting the integrated cabin services.

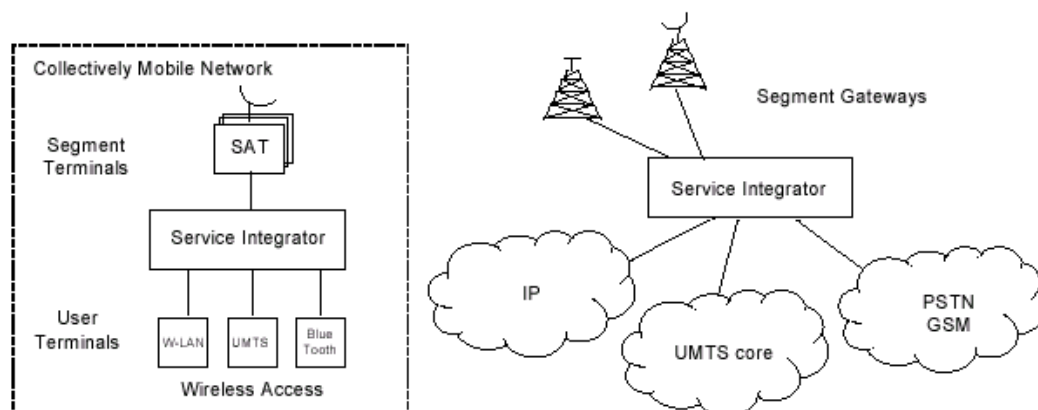


Figure 4. CMHN system architecture

9.CONCLUSION

Go meet the increasing and ever changing needs of the most demanding passengers a solution in which passengers, both business and economy, could use their own wireless equipment must be developed. This approach has many advantages. From the users point of view, their service acceptance will be increased by the following facts: they can be reached under their usual telephone number, they may have available telephone numbers or other data stored in their cell phones or PDAs, their laptops have the software they are used to, the documents they need and with their personalized configuration (starting web site, bookmarks, address book). In addition, since users in an aircraft are passengers, the electronic devices they carry with them is wireless, like laptops with WLAN interface. From the airlines point of view there is a huge saving of the investment that would suppose the installation of terminals (screens, stations, wired telephones), the consequent software licenses (in case of PCs) and the further investment due to hardware updating to offer always last technology to their customers. Currently, one of the major IFE costs is due to film copies and delivery expenses of new movies. This could be reduced if other broadband services were offered to passengers via satellite. Anyway, the wireless access solution is not replacing other kinds of IFE, such as TV on board or provision of Internet access with dedicated installed hardware in the cabin seats. Hence, it should not be seen as an alternative to a wired architecture in aircraft, but as an added service for passengers.

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ABSTRACT

In the future, airlines will provide a variety of entertainment and communications equipment to the passenger. Since people are becoming more and more used to their own communications equipment, such as mobile phones and laptops with Internet connection, either through a network interface card or dial-in access through modems, business travellers will soon be demanding wireless access to communication services. Specifically it focus on wireless services such as UMTS and W-LAN in aircraft cabins that connect the passenger via satellite to terrestrial infrastructure. Current trends are towards high data rate communication services, in particular internet applications. In an aeronautical scenario global coverage is essential for providing continuous service. Therefore satellite communication became indispensable, and together with ever increasing data rate requirements of applications, aeronautical satellite communication meets an expensive market. Certain features of UMTS and W-LAN that helps to provide these services are also explained.

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ACKNOWLEDGMENT

I express my sincere thanks to **Prof. M.N Agnisarman Namboothiri** (Head of the Department, Computer Science and Engineering, MESCE), **Mr. Sminesh** (Staff incharge) for their kind co-operation for presenting the seminar.

I also extend my sincere thanks to all other members of the faculty of Computer Science and Engineering Department and my friends for their co-operation and encouragement.

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