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# Performance analysis of mobility procedures in a hybrid space terrestrial IP environment

P.M.L. Chan <sup>a</sup>, R.A. Wyatt-Millington <sup>a</sup>, A. Svigelj <sup>b</sup>, R.E. Sheriff <sup>a,\*</sup>,  
Y.F. Hu <sup>c</sup>, P. Conforto <sup>d</sup>, C. Tocci <sup>d</sup>

<sup>a</sup> Department of Electronics and Telecommunications, University of Bradford, Richmond Road, Bradford, UK BD7 1DP

<sup>b</sup> Institut Jožef Stefan, Jamova 39, SI-1000 Ljubljana, Slovenia

<sup>c</sup> Department of Cybernetics, Internet and Virtual Systems, University of Bradford, Richmond Road, Bradford, UK BD7 1DP

<sup>d</sup> Alenia Spazio, Via G.V. Bona 85, 00156 Rome, Italy

## Abstract

The emphasis of this paper is on investigating the performance of signalling protocols designed for a mobility management scheme, which uses Mobile IP for inter-segment mobility in a hybrid space and terrestrial environment. Initially, the system architecture, which consists of three wireless access networks attached to an IP backbone, is presented. This is followed by a description of the proposed mobility procedures employed in the system, which aim at minimising modifications to existing satellite and terrestrial network protocols. The mobility procedures are simulated in order to evaluate their performance and determine their effectiveness in an operational environment. Results verify the efficiency of the protocols and show that the additional signalling time introduced by the procedures is minimal. © 2001 Elsevier Science B.V. All rights reserved.

*Keywords:* Mobility management; Mobile IP; Performance evaluation; Protocol design; Hybrid networks

## 1. Introduction

The last decade proved to be a turbulent time for the mobile-satellite industry. Original market predictions for the demand for mobile-satellite services have proven to be somewhat optimistic, following the widespread, phenomenal take-up of second-generation cellular communication services, such as GSM. Consequently, there has been a drastic re-alignment of the mobile-satellite industry, towards serving smaller, niche markets.

The start of the nineties was very much geared towards global, non-geostationary satellite solutions. However, by the start of the new millennium, the introduction of regional geostationary satellite networks, notably by ACeS [26] and THURAYA, plus the announcement of the new generation of INMARSAT-4 satellites, has seen the technological pendulum swing back towards the geostationary satellite solution.

We are now on the verge of the introduction of the third-generation (3G) of mobile communications, which will be known in Europe as the UMTS. The introduction of 3G technologies by 2002 will open up new market opportunities for the mobile-satellite industry. The nature of service

\* Corresponding author. Tel.: +44-1274-234053; fax: +44-1274-391521.

E-mail address: r.e.sheriff@bradford.ac.uk (R.E. Sheriff).

### Nomenclature

3GPP	Third Generation Partnership Project	ITU	International Telecommunications Union
ACeS	Asia Cellular Satellite system	IWU	Interworking unit
ACTS	Advanced Communications Technologies and Services	LAN	local area network
AT	Attention command	M-ESW	Mobile-EuroSkyWay
CN	corresponding node	MAC	medium access control
CoA	care-of-address	MMT	multimode terminal
CR	core router	MS	mobile station
DECT	Digital Enhanced Cordless Telecommunications	MSC	Mobile Services Switching Centre
DHCP	Dynamic Host Configuration Protocol	MT	mobile terminal
DN-IWU	distributed network—IWU	NOC	network operation centre
ER	edge router	QoS	quality of service
ETSI	European Telecommunications Standards Institute	RAN	radio access network
FE	functional entity	S-UMTS	satellite—UMTS
FES	fixed earth station	SAT	satellite network
GGSN	gateway GPRS support node	SGSN	servicing GPRS support node
GPRS	General Packet Radio Service	SIU	satellite interface unit
GSM	Global System for Mobile Communications	SN	service node
HLR	home location register	SS-MT	segment specific—MT
IMT-2000	International Mobile Telecommunications—2000	T-IWU	terminal—IWU
IPV4 (6)	Internet protocol version 4 (6)	TCP	Transmission Control Protocol
		TE	terminal equipment
		UDP	User Datagram Protocol
		UMTS	Universal Mobile Telecommunications System

delivery will change with the introduction of 3G networks from existing circuit-switched to a combination of packet- and circuit-switched delivery. Eventually, an all packet-oriented environment can be envisaged, in time for the introduction of fourth-generation (4G) technologies, sometime towards the end of the decade [20].

Demand for voice services is likely to remain dominant over data-services in the short-term. However, as users become more au fait with the mobile multimedia environment, there will come a time when data, transmitted in the form of packets in a Mobile IP environment, will dominate the available resources of the network. This, of course, will require more bandwidth per user.

The broadcast nature of geostationary satellites makes them ideally suited for the delivery of par-

ticular, mobile multimedia services, such as video-on-demand, tele-conferencing, and so on. As services evolve, the anticipated demand for higher data rate, broadband services will render the need to move up in transmission frequency from the allocated S-UMTS L/S-bands to the next suitable band available for broadband transmission, the Ka-band.

However, one disadvantage of mobile-satellite systems is their inability to provide sufficient coverage to urban areas and indoor environments due to severe shadowing of the signal and power limitations. This is particularly the case at Ka-band, where the mobile channel takes on an on-off characteristic [22] with fades in excess of 20 dB. This problem can be alleviated if the satellite system is complemented by a terrestrial system in

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