

## Research Article

# TCP-Call Admission Control Interaction in Multiplatform Space Architectures

Georgios Theodoridis,<sup>1</sup> Cesare Roseti,<sup>2</sup> Niovi Pavlidou,<sup>1</sup> and Michele Luglio<sup>2</sup>

<sup>1</sup>Department of Electrical & Computing Engineering, Aristotle University of Thessaloniki, 54124 Thessaloniki, Greece

<sup>2</sup>Dipartimento di Ingegneria Elettronica, Università degli Studi di Roma Tor Vergata, Via del Politecnico 1, 00133 Rome, Italy

Received 28 September 2006; Revised 3 March 2007; Accepted 18 May 2007

Recommended by Anton Donner

The implementation of efficient call admission control (CAC) algorithms is useful to prevent congestion and guarantee target quality of service (QoS). When TCP protocol is adopted, some inefficiencies can arise due to the peculiar evolution of the congestion window. The development of cross-layer techniques can greatly help to improve efficiency and flexibility for wireless networks. In this frame, the present paper addresses the introduction of TCP feedback into the CAC procedures in different nonterrestrial wireless architectures. CAC performance improvement is shown for different space-based architectures, including both satellites and high altitude platform (HAP) systems.

Copyright © 2007 Georgios Theodoridis et al. This is an open access article distributed under the Creative Commons Attribution License, which permits unrestricted use, distribution, and reproduction in any medium, provided the original work is properly cited.

## 1. INTRODUCTION

The development of network architectures including the space segment (GEO satellites) aims to provide telecommunication services in wide geographical areas. The space segment can complement or even replace the terrestrial infrastructure wherever the latter either fails or is not cost effective. As a matter of fact, along with the evolution of new technological solutions, such as high altitude platforms (HAPs) [1], next generation networks are envisioned as the integration of several different subsystems, unconditionally interoperating among one another [2]. Various architectures including combinations of GEO and HAPs are under continuous study so as to take advantage of each segment's most favorable features in terms of coverage area, easy and quick deployment, robustness to failure and to disaster occurrence, and so forth.

On the other hand, some of the protocols and techniques supporting the communication through this heterogeneous wireless environment could be inadequate, since they are specifically designed for wired networks. Nevertheless, these protocols and techniques are worth being utilized due to their many desirable characteristics and to the fact that the wireless path is usually only a segment of the whole route between the sender and the receiver.

One of these protocols is TCP [3, 4], which is the predominant protocol at the transport layer when dealing with

the very popular Internet-based applications. It presents several impairments when it is implemented in wireless environments [5, 6]. In brief, TCP, originally designed to work well over wired congested network, considers all losses as an explicit indication of network congestion [7]. Therefore, TCP control rate leads to unnecessary rate reductions and then to severe performance degradation without taking into account error-prone wireless links. Communication involving long-delay segments (i.e., geostationary satellites), emphasizes such an impairment slowing down the reversion to the previous transmission rate.

In addition, the presence of asymmetric links may slow down the acknowledgement flow causing problems in the forward channel as well, since TCP misinterprets the overall RTT increase as a congestion notification in the data direction.

In parallel, CAC has evolved into one of the most significant bandwidth management tools in the case of both wired and wireless networks. However, the efficiency of the CAC process is highly dependent on the accuracy of the available info concerning the transmission rate of the serviced connections, not only at the time instant that the CAC algorithm is executed but also for the whole duration of these connections. In particular, the CAC algorithm must be able to make a safe prediction regarding the availability of resources in the long term in order to decide if a new connection can be admitted into the system [8, 9].

In this frame, the present paper investigates the possibility of introducing an interaction between TCP and CAC in several nonterrestrial wireless architectures, in order to improve CAC efficiency by taking TCP dynamics into account. More specifically, the exploitation of TCP feedback as input for the CAC algorithm at regular time intervals has proved to be of primary importance for maximizing the utilization of the network resources [10]. However, as the TCP performance is rather dependent on the characteristics of the communication path, the implementation of the CAC-TCP interaction on different system architectures will introduce meaningful improvements in all the architectures showing such characteristics, demonstrating a more general importance of the concept. Additionally, so far, limited work can be found in the literature on this topic.

The paper is organized as follows: Section 2 provides a brief analysis of the TCP driven CAC concept, while Section 3 includes an overview of possible architectures. Section 4 presents a description of the reference architectures and the simulation scenario, along with results comparing the efficiency of the proposed algorithm in the several space architectures. Finally, Section 5 summarizes the conclusions.

## 2. THE CONCEPT OF A TCP-BASED CAC

TCP is a transport layer protocol based on sending data packets upon reception of acknowledgement of previously sent packets, thus guaranteeing high reliability. When the network is characterized by significant round trip time (RTT), as in the case a satellite path is included, this process can significantly slow down data transfer.

TCP can exploit congestion control either through an ACK counting mechanism (the actions on the sliding window are just based on the number of received ACKs) [3] or through the byte-counting scheme (the actions on the sliding window are based on the actual number of bytes acknowledged) [11].

When the communication path is not error-free (usual in wireless networks) TCP misinterprets the data loss due to the harsh wireless reception conditions as congestion occurrence. As a consequence, for every packet loss, TCP reduces the actual transmission rate, limiting the bandwidth utilization of the connection far below its nominal value.

This inefficiency is meaningful in wireless networks since the radio resource is usually scarce and expensive. Particularly in GEO satellite, the large footprints limit the implementation of frequency reuse, thus reducing system capacity. Therefore, achieving maximum utilization of the available bandwidth must be the primary goal of every network configuration.

On the other hand, CAC is implemented by the network manager as a preventive congestion control scheme. CAC algorithms decide upon the admittance/rejection of new connections based on the network conditions (traffic load, link capacity, buffer size, etc.) as well as the traffic characteristics and the QoS objectives of both the candidate and the already active users. In this framework, the aim of CAC is twofold: (i) to guarantee that the QoS requirements of all the admitted

users are met, and (ii) maximize revenue from the network's perspective, that is, optimize the utilization of the available resources [8]. However, achieving these objectives is rather difficult, since CAC is inherently an "in advance" procedure and no traffic model can offer a priori a completely accurate prediction, in particular considering the heterogeneity of multimedia telecommunication traffic sources. Therefore, real-time measurements of each connection's load and conditions are considered essential for the CAC's effectiveness [9].

CAC functionality is based on the concept that the used bandwidth plus the bandwidth of the upcoming user should be lower or equal to the total capacity. As a matter of fact the following condition must be always respected:

$$\sum_{i=1}^N B_i + B_f \leq c. \quad (1)$$

Since always  $B_j\text{-TCP\_datarate} \leq B_j\text{-nominal\_datarate}$ , the exploitation of the TCP feedback leads to a decrease in the system overall blocking probability. Moreover, the bandwidth assigned to each connection is equal to the real data rate of the connection monitored via the TCP performance. Therefore, having maximized the average number of the users simultaneously active in the network and having minimized the over-assignment of resources, the throughput of the network, defined as the percentage of the aggregate capacity that is actually occupied by the set of active connections, is radically improved.

In this frame, the possibility to get feedback information about TCP congestion window actual evolution would be of primary importance in order to efficiently drive CAC scheme. In fact, since the CAC algorithm, by taking into account the actual amount of capacity necessary to exploit all the TCP connections, could prevent the over provision of bandwidth to the aforementioned connections, a better utilization of the network resources would be achieved. In this way, the admission/rejection of the new user would be based on the actual occupancy of the channel by the active users at the time instant of a new user arrival, computed according to the TCP congestion window state of the connections instead of their nominal data rate. The above scheme is depicted in the flow chart of Figure 1.

## 3. SUITABLE ARCHITECTURES FOR CAC-TCP INTERACTION

The potential improvement introduced by the implementation of the integrated CAC-TCP scheme is addressed in various nonterrestrial wireless architectures, where either the high propagation delay and/or the occurrence of transmission errors negatively impact TCP performance by leading to an unjustified decrease of the transmission data rate.

In particular, four different architectures are introduced and described, focusing on the potential drawbacks concerning optimal TCP working.

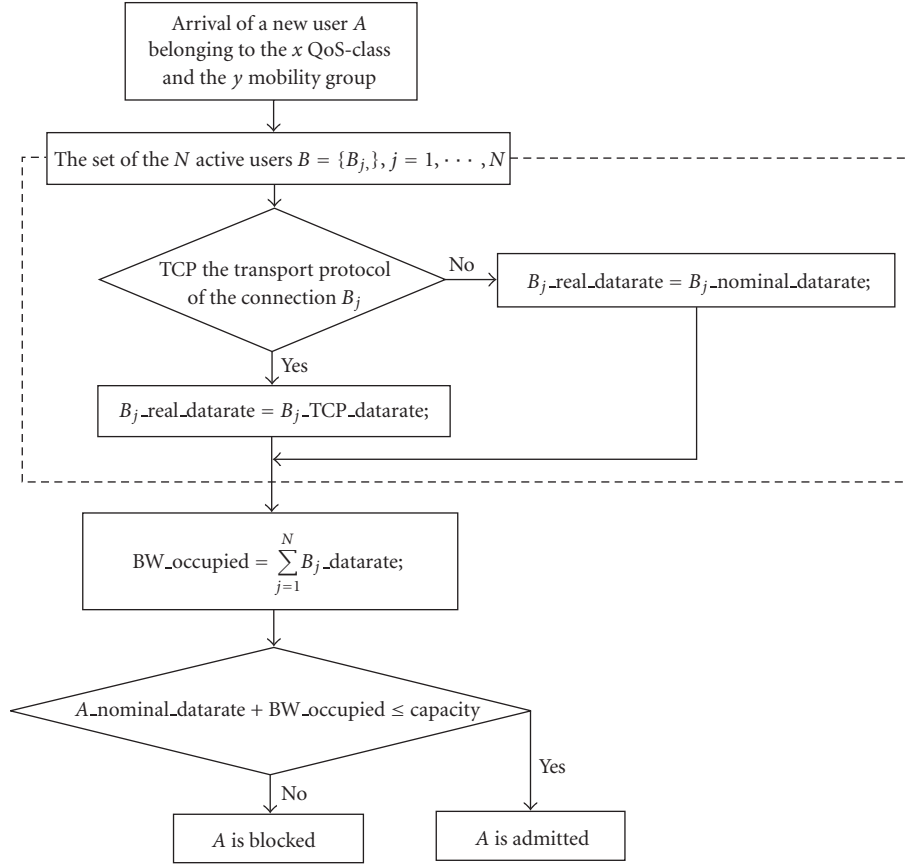


FIGURE 1: Cross-layer CAC-TCP flow chart.

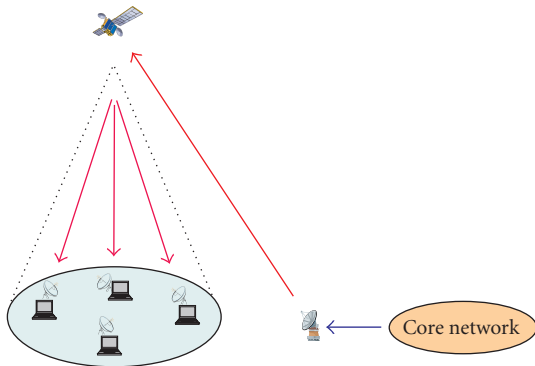


FIGURE 2: Stand-alone GEO satellite.

### 3.1. Stand-alone GEO satellite

A system architecture based on a stand alone GEO satellite (Figure 2) implies a rather challenging environment for TCP performance. Such an architecture presents a *long propagation path* (in average about 80 000 km end to end) along with *transmission errors* quantified in terms of BER (depending on propagation channel conditions) and link unavailability, par-

ticularly meaningful in case of use of high frequencies and/or terminal mobility.

The large latency-bandwidth product could cause two harmful effects:

- (i) the pipe size, indicating the amount on unacknowledged data that can be “in-flight” in a given instant, could exceed the buffer limits in the existing implementations resulting in a suboptimal maximum throughput;
- (ii) the high latency entails a considerable time interval to open the TCP sliding window, when a new connection starts (slow-start algorithm). Similarly, in the case of losses, the reaction of TCP is very slow, increasing the time needed to return to high transmission rates.

### 3.2. Stand-alone HAP

HAPS are characterized by the utilization of a platform located in the stratosphere (about 20 km from ground), allowing very fast deployment, low cost, less critical communication parameters, flexible architecture but limited coverage (Figure 3). The proximity of the HAP to the ground minimizes the propagation delay, being distances comparable to the ones in terrestrial wireless systems [1, 12].

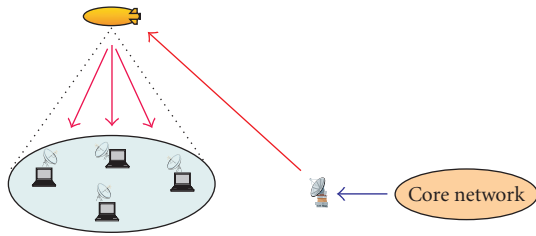


FIGURE 3: Stand-alone HAP.

Nevertheless, since HAP systems work also in millimeter-wave bands (47/48 GHz), in that case rain attenuation and scattering constitute a severe constraint in achieving good TCP performance. Some studies indicate a two-state (good-bad) Markov model as a suitable error model [13]. Therefore, the packet-error rate (PER) experienced by the TCP can be approximated by the probability of the bad channel conditions.

Depending on the PER value, TCP congestion window continuously stops its growth resulting in “fast retransmit and fast recovery” (FR-FR) or even timeout expirations, when due to the loss of a large burst of segments, sender does not receive any feedback (i.e., duplicate ACKs). In the latter case, TCP remains in an idle state for several seconds and resets its window to one segment.

### 3.3. Integrated GEO satellite—HAP

In order to allow HAPS users to communicate with remote locations, a link between the HAPS and the satellite can be envisaged, as depicted in Figure 4.

Being the GEO-HAP segment outside the atmosphere and in line-of-sight (LoS) conditions, errors are due to free space losses and thermal noise and quantified in terms of BER. On the contrary, the PER of the overall link is predominately defined by the HAP-ground segment, where significant transmission errors can occur depending on the utilized frequency and on eventual ground terminal mobility. Thus, from the PER point of view an integrated GEO-HAP architecture is equivalent to the stand-alone HAP case. Moreover, the use of GEO satellite as an intermediate node introduces long RTT, adding the drawbacks in the TCP dynamics detected in the stand-alone GEO satellite scenario.

### 3.4. HAP constellation

Finally, we consider the architecture of Figure 5, where the coverage area is served by a constellation of HAPS; inter-HAP links are also set up [14]. If the data is forwarded to the destination HAP via one (or more) of its neighboring HAPS, although the propagation delay is kept low, the end-to-end reception conditions could possibly become harsher, due to the imperfections of the inter-HAP links. The aforementioned imperfections could be mostly due to the stabilization problems of the platforms, which would result in corresponding pointing difficulties regarding the optical links that are envisioned for such an inter-HAP communication.

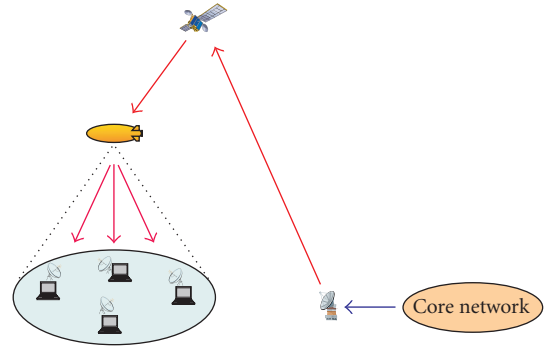


FIGURE 4: Integrated GEO satellite—HAP.

Then, in this scenario, TCP performance suffers mainly from the problems arisen in the stand-alone HAP architecture.

## 4. EVALUATION OF THE CAC-TCP INTERACTION IN SPACE ARCHITECTURES

### 4.1. Reference architectures

Summarizing, TCP performance over radio links, including one or more space systems, relies primarily on two factors:

- (1) the delay imposed by the space segment (RTT),
- (2) the reception error probability of the wireless space-user channel (PER).

The adopted TCP scheme, based on ACK counting, leads to same efficiency as achievable when using the byte-counting algorithm [11], because all the correctly delivered TCP packets are considered immediately acknowledged by the corresponding ACK (ACK are not delayed).

Thus, in order to evaluate the efficiency as well as the necessity of a TCP driven CAC scheme, only three different network architectures, based on the boundary conditions in terms of RTT and PER (or both), are selected to be simulated in the present paper. They are stand-alone GEO (Figure 2), stand-alone HAP (Figure 3), and integrated GEO satellite-HAP (Figure 4). In the following, the most meaningful implemented features concerning the selected architectures, are described. In all the three architectures losses affect both ACK and TCP packet flows (ACK losses have a slight impact on the overall performance due to the cumulative nature of ACKs [4]).

#### Stand-alone GEO architecture

Data originating from the core network are forwarded via a gateway toward the GEO satellite, which transparently redirects the stream (bent-pipe satellite) to the end users. Users are considered to be fixed and equipped with VSATs appropriately mounted so as to guarantee line-of-sight (LoS) condition for the satellite-user link. Therefore, since the signal-to-noise ratio (SNR) is not only maximized but also relatively invariant due to the absence of mobility, low PER value can

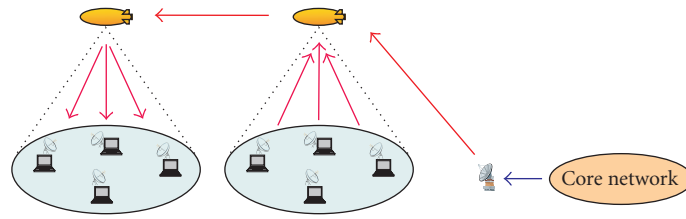


FIGURE 5: HAP constellation.

be assumed. Moreover, the gateway-satellite link is typically dimensioned to be error free.

#### Stand-alone HAPS

In comparison with the previous architecture, the GEO satellite has been replaced with a HAP, while the data flow maintains the same characteristics. The proximity of the HAP to the earth greatly decreases link latency and facilitates the connectivity of mobile users. In more detail, in the GEO satellite scenario, a mobile terminal should be equipped with high power transmission amplifier as well as sizeable antennas, so as to compensate the high free-space attenuation imposed by the long propagation path. These features lead to bulky and power consuming (limited autonomy) terminals, completely inappropriate for mobile use. On the contrary, providing access via a HAP located at an altitude of 20 km allows the use of small, cost-efficient, and user-friendly devices. Consequently, the stand-alone HAPS scenario considers mobile users, which are further divided into three categories based on their mobility characteristics: highway-users, suburban-users, urban-users. In particular, highway-users move in open areas with maximum LoS probability, while, as the city centre (suburban and urban users) is approached, the higher building in combination with the narrow streets hinder the LOS path and the received signal is the result of successive reflections (multipath). Moreover, according to the channel model, even in the case of a highway user, the average PER is much higher than in case of a fixed user that is served by a GEO system.

#### Integrated GEO satellite—HAP

The rationale behind the integration of the two systems is that one satellite can provide connectivity to multiple HAPs both among each other and toward the core network, without the deployment of extra infrastructures. In this case, as described in Section 3.4, the PER of the end-to-end link is determined by the PER of the user-HAP segment (equal to the of stand-alone HAP system), while the long RTT is imposed by the GEO-satellite segment (equal to the case of stand-alone GEO system).

As it becomes evident, the scenario involving a stand-alone GEO system with fixed users presents the highest RTT and the lowest PER, while the scenario involving a stand-alone HAP system presents the highest PER and the lowest

RTT. Finally, the integrated GEO-HAP scenario combines the characteristics of both of them, that is maximum RTT and maximum PER. Moreover, beyond the fact that these network scenarios present a wide range of RTT and PER values, they are also the most significant in terms of services and applications. Therefore, the analysis of these case studies can provide solid conclusions regarding the ability of the proposed TCP-CAC interaction to improve the network performance, in terms of both blocking probability and average throughput, in a great variety of channel conditions.

#### 4.2. Simulation scenario and parameters

All the users are classified into three QoS classes according to the nominal rate of their connections: 128, 256, and 512 kbps. The implementation of a weighted priority CAC scheme, as the one proposed in [15], guarantees the provision of equitable service of multiple parallel flows with different bandwidth requirements. According to this admission control algorithm, the aggregate capacity of the system is divided into a number of segments equal to the number of QoS classes. The width of each segment (i.e., the capacity percentage assigned to each QoS class) is determined by manipulating the desired blocking probability ratio between the QoS classes. Thus, a new flow belonging to the  $QoS_i$  class is admitted to the network on the basis of the bandwidth committed to the particular  $QoS_i$  class. Instead, in the case of a CAC scheme without any prioritization based on QoS class, the users of the higher QoS classes would be practically excluded from the network, as it would be difficult to satisfy their excessive bandwidth needs and they would be usually blocked in favor of users with lower data rate requirements. Therefore, a weighted priority CAC scheme as defined in [15] has been taken as reference in our analysis presented hereafter. Furthermore, the TCP driven CAC scheme has been derived from exactly the same notion, with the only difference that, as it has been described in Section 2, the TCP-CAC algorithm takes into account the TCP feedback of the flows instead of their nominal data rate in the process of computing the utilization of the channel and the availability of resources.

Both the TCP driven and the reference CAC scheme, have been simulated through an offline combination of two simulation tools that run sequentially. In particular, the network simulator ns-2 [16] is used to configure the communication scenario (nodes, link parameters, and communication protocols) and to obtain TCP statistics. Additionally, a C++



simulation tool gets as input the TCP statistics and provides the following functionalities:

- (i) it runs alternatively either the reference or the TCP driven CAC scheme;
- (ii) it calculates the instantaneous and the average throughput of the network;
- (iii) it computes the connection blocking probability for each QoS class as well as the connection blocking probability of the network.

To reproduce a trustworthy network traffic, we have considered packet error distribution (derived at TCP level) compliant to the HAP communication characteristics [13, 17], while satellite-HAP or satellite-user terminal link have been considered as almost error free. The latter assumption is rather realistic since satellite gateway EIRP can be set in order to counterbalance the atmosphere attenuation. Then, depending on the terminal mobility, the following PER distributions have been considered.

- (i) Fixed and portable terminals have been assumed always in line-of-sight (LoS) with the HAP/satellite. Thus, uniform packet loss distributions (TCP level) are considered with relatively low mean values ( $10^{-4}$  for fixed terminals and  $10^{-3}$  for portable terminals).
- (ii) In case of mobile terminals, a two-state channel model [13] is considered to feature the alternating LoS and shadowing conditions. Durations of “bad” and “good” states depend on the motion environment according to the values reported in [17].

Furthermore, both arrival and termination of TCP connections are managed by the C++ event driven simulator as Poisson processes [15]. Thus, the time between two successive arrivals of users ( $\tau$ ) and the duration of each admitted connection ( $d$ ) follow exponential distribution with mean value  $1/\lambda$  and  $1/\mu$ , respectively:

$$\begin{aligned} \text{pdf}(\tau) &= \lambda \cdot e^{-\lambda \cdot \tau}, & E[\tau] &= \frac{1}{\lambda}, \\ \text{pdf}(d) &= \mu \cdot e^{-\mu \cdot d}, & E[d] &= \frac{1}{\mu}. \end{aligned} \quad (2)$$

The parameters  $E[d]$  and  $E[\tau]$  along with the aggregate number of users in the network ( $S$ ) determine the traffic load of the network ( $L$ ).

### 4.3. Results

The impact of the TCP-CAC interaction on all the three selected network configurations (GEO, HAPS, and GEO-HAPS) has been evaluated in terms of blocking probability and average throughput. Moreover, the blocking probability and the average throughput are calculated for both the basic and the TCP-based call admission control scheme.

Figure 6 presents the system blocking probability for different traffic loads. Regardless the network architecture, the basic-CAC algorithm leads in every case to the same blocking probability for the whole variety of traffic loads, which is

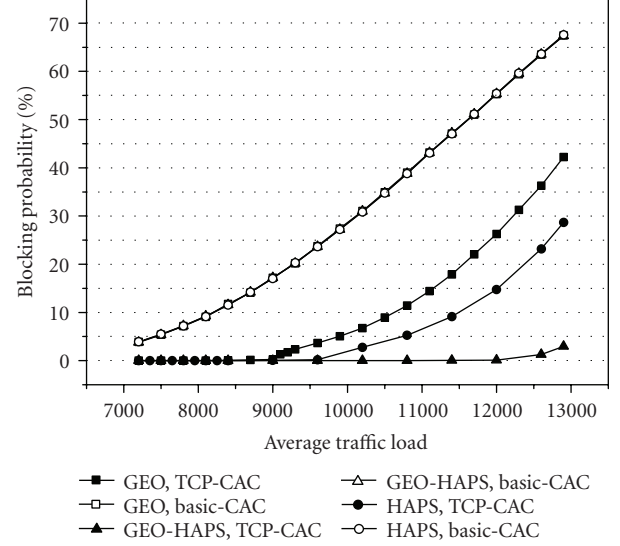


FIGURE 6: Blocking probability versus average traffic load.

expected, since only the nominal data rate of both the candidate and the already admitted users is taken into account during the acceptance/rejection procedure. The fluctuations in the TCP rate caused by the latency and the errors imposed by the different channels do not affect the admission procedure and therefore the curves regarding the basic-CAC algorithm for all the three scenarios completely coincide with each other. On the contrary, TCP-CAC algorithms present much lower blocking probability. Due to the TCP feedback, the system is able to calculate the actual occupancy of the available channels which is much lower than the one declared by the users initially during their admittance. Therefore, the unused bandwidth is reassigned to new users that would otherwise be blocked.

Figure 7 presents the improvement (decrease) introduced to the system blocking probability by the TCP driven CAC scheme in comparison to the basic-CAC scheme. It allows the reader to compare the impact of the proposed scheme on architectures with different propagation characteristics. As it becomes apparent,

$$BP\_decrease_{GEO} < BP\_decrease_{HAP} < BP\_decrease_{GEO-HAPS}. \quad (3)$$

This can be easily explained by the fact that in the case of the integrated GEO-HAPS system, the harsh reception environment (long latency and high reception error probability) leads to a severe degradation of the TCP performance and thus to an intense decrease in the actual data rate of the TCP connections. In fact, letting  $x$  be the aggregate amount of nominal traffic load applying for network resources and  $y$  the amount of traffic actually forwarded through the network channels, simulations have demonstrated that

$$\begin{aligned} x &> y_{GEO} > y_{GEO-HAPS}, \\ x &> y_{HAP} > y_{GEO-HAP}. \end{aligned} \quad (4)$$

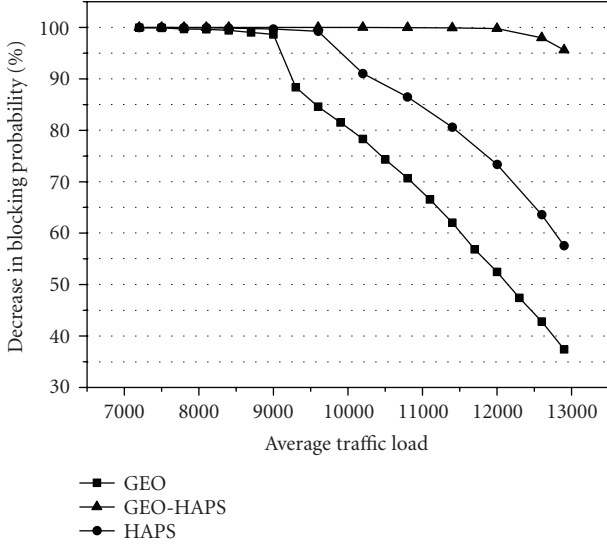


FIGURE 7: Blocking probability decrease versus average traffic load.

This means that users of the GEO-HAPS network leave a great percentage of the system resources unutilized and thus, in comparison with other architectures, the number of users that can be simultaneously served by a channel of given capacity is much higher (lower blocking probability).

Moreover, results shown in Figure 7 lead us to the conclusion that the exploitation of TCP-feedback is much more crucial in a stand-alone HAP system (high PER, low RTT) than in a stand-alone GEO (high RTT, low PER) configuration. Then, an error prone communication path, even with low RTT, can cause abrupt decrease in the connection transmission rate.

Blocking probability and average throughput are the two main metrics of the network performance, each dealing with the issue of the system efficiency from a different perspective. Blocking probability must be minimized to maximize the QoS (minimum delay) guaranteed to the users, while average throughput must be maximized to maximize revenues for the network administrator. Figure 8 shows that there is always a tradeoff between these two factors: increased average throughput leads to increased blocking probability, while limitation of the blocking probability results in a low bandwidth utilization. In addition, from Figure 8 it is evident that, regardless of the network scenario, the implementation of the integrated TCP-CAC scheme results in the same average throughput for any given value of blocking probability. This is due to the fact that the admission control algorithm bases the acceptance/rejection decision upon the knowledge of the real traffic load forwarded at that given time through the network.

Therefore, a new connection is blocked only if there is no further available bandwidth. Thus, since the availability of resources occurs on the basis of the new connection nominal rate, for a given throughput, the blocking probability is the same for all the possible scenarios (GEO, GEO-HAPS, HAPS). On the contrary, the basic-CAC algorithm assumes

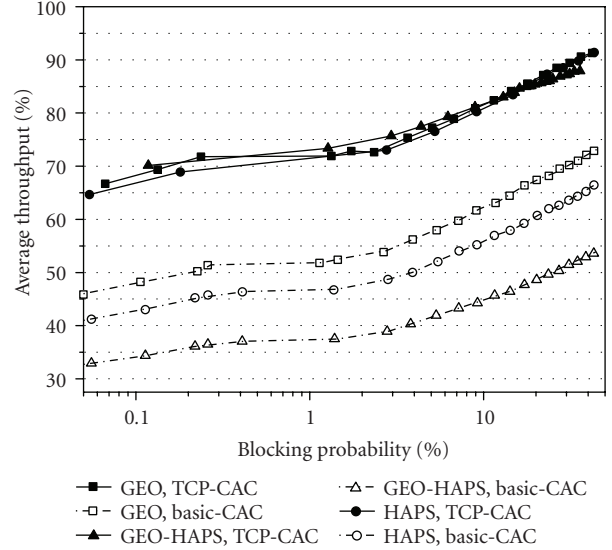


FIGURE 8: Average throughput versus blocking probability.

that the occupancy of the network capacity is equal to the aggregate of the nominal rates of all the active users. Consequently, the requests for new connections are rejected while there is still spare bandwidth. The average throughput for a given blocking probability relies now upon the amount of TCP data rate degradation. Therefore, the stand-alone GEO case presents the higher average throughput and the integrated GEO-HAPS architecture the minimum one, as they present, respectively, the minimum and the maximum decrease in the TCP data rate.

Finally, according to Figure 9 the lower the network blocking probability is, the higher the gain from the utilization of the TCP feedback is. Moreover, the gain for the scenarios with the worst reception conditions is higher, since the basic-CAC algorithm severely limits the system throughput.

## 5. CONCLUSIONS AND FUTURE PERSPECTIVES

New and innovative wireless telecommunication architectures (including HAPs and satellite segments) are identified to provide broadband services in a cost-efficient and ubiquitous manner, ensuring seamless interoperation with the existing infrastructure. To ensure network efficiency for such architectures it is worth optimizing the performance of protocols originally designed for terrestrial networks and for classical architectures. Cross-layer techniques are becoming fundamental to cope with the dynamic variations characterizing wireless environments. The present paper focuses on optimal utilization of the precious wireless resources when flows running TCP share the channel. Referring to 5 different architectures based on HAP/satellite links, we have analyzed the potential drawbacks leading to suboptimal end-to-end performance. A TCP driven CAC scheme has been proposed in order to guarantee QoS for multimedia services with different bandwidth requirements, guarantee an

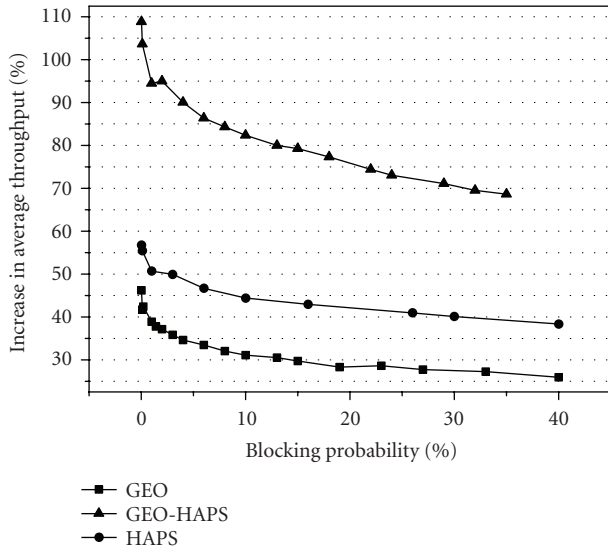


FIGURE 9: Average throughput increase versus blocking probability.

optimal resource utilization, and reduce the system blocking probability, without altering the TCP standard mechanisms.

Through simulation, we demonstrated a considerable improvement on the performance with respect to a reference CAC algorithm that takes into account only QoS requirements and physical parameters.

## ACKNOWLEDGMENT

This paper has been supported by the European IST-FP6 project: “SatNex II—Satellite Communications Network of Excellence II.”

## REFERENCES

- [1] T. C. Tozer and D. Grace, “High-altitude platforms for wireless communications,” *Electronics and Communication Engineering Journal*, vol. 13, no. 3, pp. 127–137, 2001.
- [2] S. Uskela, “Key concepts for evolution toward beyond 3G networks,” *IEEE Wireless Communications*, vol. 10, no. 1, pp. 43–48, 2003.
- [3] J. Postel, “Transmission Control Protocol,” IETF RFC 793, September 1981.
- [4] W. Stevens, *TCP/IP Illustrated. Volume 1: The Protocols*, Addison-Wesley, Reading, Mass, USA, 1994.
- [5] C. Partridge and T. J. Shepard, “TCP/IP performance over satellite links,” *IEEE Network*, vol. 11, no. 5, pp. 44–49, 1997.
- [6] P. Loreti, M. Luglio, R. Kapoor, et al., “Satellite systems performance with TCP-IP applications,” in *Proceedings of IEEE Military Communications Conference on Communications for Network-Centric Operations: Creating the Information Force (MILCOM '01)*, vol. 2, pp. 811–815, McLean, Va, USA, October 2001.
- [7] W. Stevens, “TCP Slow Start, Congestion Avoidance, Fast retransmit, and Fast recovery Algorithms,” Internet RFC 2001, 1997.
- [8] H. G. Perros and K. M. Elsayed, “Call admission control schemes: a review,” *IEEE Communications Magazine*, vol. 34, no. 11, pp. 82–91, 1996.
- [9] K. Shiimoto, N. Yamanaka, and T. Takahashi, “Overview of measurement-based connection admission control methods in ATM networks,” *IEEE Communications Surveys and Tutorials*, vol. 2, no. 1, pp. 2–13, 1999.
- [10] C. Roseti, G. Theodoridis, M. Luglio, and N. Pavlidou, “TCP driven CAC scheme for HAPS and satellite integrated scenario,” in *International Workshop on High Altitude Platform Systems (WHAPS '05)*, Athens, Greece, September 2005.
- [11] M. Allman, “TCP Congestion Control with Appropriate Byte Counting (ABC),” RFC 3465, February 2003.
- [12] S. Karapantazis and N. Pavlidou, “Broadband communications via high-altitude platforms: a survey,” *IEEE Communications Surveys & Tutorials*, vol. 7, no. 1, pp. 2–31, 2005.
- [13] J. L. Cuevas-Ruiz and J. A. Delgado-Penín, “Channel model based on semi-Markovian processes: an approach for HAPS systems,” in *Proceedings of the 14th International Conference on Electronics, Communications and Computers (CONIELECOMP '04)*, pp. 52–56, Veracruz, Mexico, February 2004.
- [14] R. Miura and M. Oodo, “Wireless communications system using stratospheric platforms: R & D program on telecom and broadcasting system using high altitude platform stations,” *Journal of the Communications Research Laboratory*, vol. 48, no. 4, pp. 33–48, 2001.
- [15] B. M. Epstein and M. Schwartz, “Predictive QoS-based admission control for multiclass traffic in cellular wireless networks,” *IEEE Journal on Selected Areas in Communications*, vol. 18, no. 3, pp. 523–534, 2000.
- [16] K. Fall and K. Varadhan, *The ns manual, VINT Project*, University of California, Berkeley, Calif, USA, 2001, <http://www.isi.edu/nsnam/ns/ns-documentation.html>.
- [17] Recommendation ITU-R P.681-6, “ITU-R P.681-6 Propagation data required for the design of Earth-space land mobile telecommunication systems,” January 2003.



## Special Issue on FPGA Supercomputing Platforms, Architectures, and Techniques for Accelerating Computationally Complex Algorithms

### Call for Papers

Field-programmable gate arrays (FPGAs) provide an alternative route to high-performance computing where fine-grained synchronisation and parallelism are achieved with lower power consumption and higher performance than just microprocessor clusters. With microprocessors facing the “processor power wall problem” and application specific integrated circuits (ASICs) requiring expensive VLSI masks for each algorithm realisation, FPGAs bridge the gap by offering flexibility as well as performance. FPGAs at 65 nm and below have enough resources to accelerate many computationally complex algorithms used in simulations. Moreover, recent times have witnessed an increased interest in design of FPGA-based supercomputers.

This special issue is intended to present current state-of-the-art and most recent developments in FPGA-based supercomputing platforms and in using FPGAs to accelerate computationally complex simulations. Topics of interest include, but are not limited to, FPGA-based supercomputing platforms, design of high-throughput area time-efficient FPGA implementations of algorithms, programming languages, and tool support for FPGA supercomputing. Together these topics will highlight cutting-edge research in these areas and provide an excellent insight into emerging challenges in this research perspective. Papers are solicited in any of (but not limited to) the following areas:

- Architectures of FPGA-based supercomputers
  - History and surveys of FPGA-based supercomputers architectures
  - Novel architectures of supercomputers, including coprocessors, attached processors, and hybrid architectures
  - Roadmap of FPGA-based supercomputing
  - Example of acceleration of large applications/simulations using FPGA-based supercomputers
- FPGA implementations of computationally complex algorithms
  - Developing high throughput FPGA implementations of algorithms
  - Developing area time-efficient FPGA implementations of algorithms

- Precision analysis for algorithms to be implemented on FPGAs
- Compilers, languages, and systems
  - High-level languages for FPGA application development
  - Design of cluster middleware for FPGA-based supercomputing platforms
  - Operating systems for FPGA-based supercomputing platforms

Prospective authors should follow the EURASIP Journal on Embedded Systems manuscript format described at the journal site <http://www.hindawi.com/journals/es/>. Prospective authors should submit an electronic copy of their complete manuscript through the journal Manuscript Tracking System at <http://mts.hindawi.com/>, according to the following timetable:

Manuscript Due	July 1, 2008
First Round of Reviews	October 1, 2008
Publication Date	January 1, 2009

### Guest Editors

**Vinay Sriram**, Defence and Systems Institute, University of South Australia, Adelaide, South Australia 5001, Australia; [vinay.sriram@unisa.edu.au](mailto:vinay.sriram@unisa.edu.au)

**David Kearney**, School of Computer and Information Science, University of South Australia, Adelaide, South Australia 5001, Australia; [david.kearney@unisa.edu.au](mailto:david.kearney@unisa.edu.au)

**Lakhmi Jain**, School of Electrical and Information Engineering, University of South Australia, Adelaide, South Australia 5001, Australia; [lakhmi.jain@unisa.edu.au](mailto:lakhmi.jain@unisa.edu.au)

**Miriam Leeser**, School of Electrical and Computer Engineering, Northeastern University, Boston, MA 02115, USA; [mel@coe.neu.edu](mailto:mel@coe.neu.edu)

## Special Issue on Active Antennas for Space Applications

### Call for Papers

Over the last years, many journal articles appeared on the principles, analysis, and design of active and active integrated antennas (AAs and AIAs). An AA is a single system comprising both a radiating element and one or more active components which are tightly integrated. This gives clear advantages in terms of costs, dimensions, and efficiency. In the case of an AIA, both the active device and the radiator are integrated on the same substrate. Both options lead to very compact, low-loss, flexible antennas, and this is very important especially at high frequencies, such as those typical of a satellite link. As microwave integrated-circuit and the microwave monolithic integrated-circuit technologies have ripened, AA and AIA applications have become more and more interesting, not only at a scientific level but also from a commercial point of view, up to the point that they have recently been applied to phased array antennas on board moving vehicles for satellite broadband communication systems.

The goal of this special issue is to present the most recent developments and researches in this field, with particular attention to space-borne applications, as well as to enhance the state of the art and show how AAs and AIAs can meet the challenge of the XXI century telecommunications applications.

Topics of interest include, but are not limited to:

- Active (integrated) antenna design, analysis, and simulation techniques
- Active (integrated) antenna applications in arrays, retrodirective arrays and discrete lenses
- Millimeter-wave active (integrated) antennas

Authors should follow International Journal of Antennas and Propagation manuscript format described at the journal site <http://www.hindawi.com/journals/ijap/>. Prospective authors should submit an electronic copy of their complete manuscript through the journal Manuscript Tracking System at <http://mts.hindawi.com/>, according to the following timetable:

Manuscript Due	September 1, 2008
First Round of Reviews	December 1, 2008
Publication Date	March 1, 2009

### Guest Editors

**Stefano Selleri**, Department of Electronics and Telecommunications, University of Florence, Via C. Lombroso 6/17, 50137 Florence, Italy; [stefano.selleri@unifi.it](mailto:stefano.selleri@unifi.it)

**Giovanni Toso**, European Space Research and Technology Center (ESTEC), European Space Agency (ESA), Keplerlaan 1, PB 299, 2200 AG Noordwijk, The Netherlands; [giovanni.toso@esa.int](mailto:giovanni.toso@esa.int)

## Special Issue on Challenges on Complexity and Connectivity in Embedded Systems

### Call for Papers

Technology advances and a growing field of applications have been a constant driving factor for embedded systems over the past years. However, the increasing complexity of embedded systems and the emerging trend to interconnections between them lead to new challenges. Intelligent solutions are necessary to solve these challenges and to provide reliable and secure systems to the customer under a strict time and financial budget.

Typically, intelligent solutions often come up with an orthogonal and interdisciplinary approach in contrast to traditional ways of engineering solutions. Many possible intelligent methods for embedded systems are biologically inspired, such as neural networks and genetic algorithms. Multi-agent systems are also prospective for an application for nontime critical services of embedded systems. Another field is soft computing which allows a sophisticated modeling and processing of imprecise (sensory) data.

The goal of this special issue is to provide a forum for innovative smart solutions which have been applied in the embedded systems domain and which are likely useful to solve problems in other applications as well.

Original papers previously unpublished and not currently under review by another journal are solicited. They should cover one or more of the following topics:

- Smart embedded (real-time) systems
- Autonomous embedded systems
- Sensor networks and sensor node hardware/software platforms
- Software tools for embedded systems
- Topology control and time synchronization
- Error tolerance, security, and robustness
- Network protocols and middleware for embedded systems
- Standardization of embedded software components
- Data gathering, aggregation, and dissemination
- Prototypes, applications, case studies, and test beds

Before submission authors should carefully read over the journal's Author Guidelines, which are located at <http://www.hindawi.com/journals/es/guidelines.html>. Authors should follow the EURASIP Journal on Embedded Systems manuscript format described at the journal's site <http://www.hindawi.com/journals/es/>. Prospective authors should submit an electronic copy of their complete manuscript through the journal's Manuscript Tracking System at <http://mts.hindawi.com/>, according to the following timetable:

Manuscript Due	August 1, 2008
First Round of Reviews	November 1, 2008
Publication Date	February 1, 2009

### Guest Editors

**Bernhard Rinner**, University of Klagenfurt, 9020 Klagenfurt, Austria; [bernhard.rinner@uni-klu.ac.at](mailto:bernhard.rinner@uni-klu.ac.at)

**Wilfried Elmenreich**, University of Klagenfurt, 9020 Klagenfurt, Austria; [wilfried.elmenreich@uni-klu.ac.at](mailto:wilfried.elmenreich@uni-klu.ac.at)

**Ralf Seepold**, Universidad Carlos III de Madrid, 28911 Leganes, Spain; [ralf@it.uc3m.es](mailto:ralf@it.uc3m.es)

**Volker Turau**, Technische Universita"t Hamburg-Harburg, 21073 Hamburg, Germany; [turau@tuhh.de](mailto:turau@tuhh.de)

**Markus Kucera**, University of Applied Sciences, Regensburg, Germany; [markus.kucera@informatik.fh-regensburg.de](mailto:markus.kucera@informatik.fh-regensburg.de)

## Special Issue on Network Structure and Biological Function: Reconstruction, Modelling, and Statistical Approaches

### Call for Papers

We are particularly interested in contributions, which elucidate the relationship between structure or dynamics of biological networks and biological function. This relationship may be observed on different scales, for example, on a global scale, or on the level of subnetworks or motifs.

Several levels exist on which to relate biological function to network structure. Given molecular biological interactions, networks may be analysed with respect to their structural and dynamical patterns, which are associated with phenotypes of interest. On the other hand, experimental profiles (e.g., time series, disturbances) can be used to reverse engineer network structures based on a model of the underlying functional network.

Is it possible to detect the interesting features with the current methods? And how is our picture of the relationship between network structure and biological function affected by the choice of methods?

Perspectives both from simulation approaches as well as the evaluation of experimental data and combinations thereof are welcome and will be integrated within this special issue.

Authors should follow the EURASIP Journal on Bioinformatics and Systems Biology manuscript format described at the journal site <http://www.hindawi.com/journals/bsb/>. Prospective authors should submit an electronic copy of their complete manuscript through the journal Manuscript Tracking System at <http://mts.hindawi.com/>, according to the following timetable:

Manuscript Due	June 1, 2008
First Round of Reviews	September 1, 2008
Publication Date	December 1, 2008

### Guest Editors

**J. Selbig**, Bioinformatics Chair, Institute for Biochemistry and Biology, University of Potsdam, Germany;  
[selbig@mpimp-golm.mpg.de](mailto:selbig@mpimp-golm.mpg.de)

**M. Steinfath**, Institute for Biochemistry and Biology, University of Potsdam, Germany;  
[steinfath@mpimp-golm.mpg.de](mailto:steinfath@mpimp-golm.mpg.de)

**D. Repsilber**, AG Biomathematics & Bioinformatics, Genetics and Biometry and Genetics Section, Research Institute for the Biology of Farm Animals, Dummerstorf, Germany; [repsilber@fhn-dummerstorf.de](mailto:repsilber@fhn-dummerstorf.de)

## Special Issue on CNN Technology for Spatiotemporal Signal Processing

### Call for Papers

A cellular neural/nonlinear network (CNN) is any spatial arrangement of mainly locally coupled cells, where each cell has an input, an output, and a state that evolves according to some prescribed dynamical laws. CNN represents a paradigm for nonlinear spatial-temporal dynamics and the core of the cellular wave computing (also called CNN technology). Partial differential equations (PDEs) or wave-like phenomena are the computing primitives of CNN. Besides, their suitability for physical implementation due to their local connectivity makes CNNs very appropriate for high-speed parallel signal processing.

Early CNN applications were mainly in image processing. The possible availability of cellular processor arrays with a high number of processing elements opened a new window for the development of new applications and the recovery of techniques traditionally conditioned by the slow speed of conventional computers. Let us name as example image processing techniques based on active contours or active wave propagation, or applications within the medical image processing framework (echocardiography, retinal image processing, etc.) where fast processing provides new capabilities for medical disease diagnosis.

On the other hand, emerging applications exploit the complex spatiotemporal phenomena exhibited by multilayer CNN and extend to the modelling of neural circuits for biological vision, motion, and higher brain function.

The aim of this special issue is to bring forth the synergy between CNN and spatiotemporal signal processing through new and significant contributions from active researchers in these fields. Topics of interest include, but are not limited to:

- Theory of cellular nonlinear spatiotemporal phenomena
- Analog-logic spatiotemporal algorithms
- Learning & design
- Bioinspired/neuromorphic arrays
- Physical VLSI implementations: integrated sensor/processor/actuator arrays
- Applications including computing, communications, and multimedia

- Circuits, architectures and systems in the nanoscale regime
- Other areas in cellular neural networks and array computing

Authors should follow the EURASIP Journal on Advances in Signal Processing manuscript format described at <http://www.hindawi.com/journals/asp/>. Prospective authors should submit an electronic copy of their complete manuscript through the journal Manuscript Tracking System at <http://mts.hindawi.com/>, according to the following timetable:

Manuscript Due	September 15, 2008
First Round of Reviews	December 15, 2008
Publication Date	March 15, 2009

### Guest Editors

**David López Vilarino**, Departamento de Electrónica y Computación, Facultad de Física, Universidad de Santiago de Compostela, 15782 Santiago de Compostela, Spain; [dlv@dec.usc.es](mailto:dlv@dec.usc.es)

**Diego Cabello Ferrer**, Departamento de Electrónica y Computación, Facultad de Física, Universidad de Santiago de Compostela, 15782 Santiago de Compostela, Spain; [diego@dec.usc.es](mailto:diego@dec.usc.es)

**Victor M. Brea**, Departamento de Electrónica y Computación, Facultad de Física, Universidad de Santiago de Compostela, 15782 Santiago de Compostela, Spain; [victor@dec.usc.es](mailto:victor@dec.usc.es)

**Ronald Tetzlaff**, Lehrstuhl für Grundlagen der Elektrotechnik, Fakultät für Elektrotechnik und Informationstechnik, Technische Universität Dresden, Mommsenstraße 12, 01069 Dresden, Germany; [r.tetzlaff@iap.uni-frankfurt.de](mailto:r.tetzlaff@iap.uni-frankfurt.de)

**Chin-Teng Lin**, National Chiao-Tung University, Hsinchu 300, Taiwan; [ctpeter.lin@msa.hinet.net](mailto:ctpeter.lin@msa.hinet.net)



# RESEARCH LETTERS IN COMMUNICATIONS

## Why publish in this journal?

**Research Letters in Communications** is devoted to very fast publication of short, high-quality manuscripts in the broad field of communications. The journal aims for a publication speed of 60 days from submission until final publication. Articles will be limited to a maximum of four published pages, and they should convey important results that have not been previously published.

### Why publish in this journal?

#### Wide Dissemination

All articles published in the journal are freely available online with no subscription or registration barriers. Every interested reader can download, print, read, and cite your article

#### Quick Publication

The journal employs an online «Manuscript Tracking System» which helps streamline and speed the peer review so all manuscripts receive fast and rigorous peer review. Accepted articles appear online as soon as they are accepted, and shortly after, the final published version is released online following a thorough in-house production process.

#### Professional Publishing Services

The journal provides professional copyediting, typesetting, graphics, editing, and reference validation to all accepted manuscripts.

#### Keeping Your Copyright

Authors retain the copyright of their manuscript, which are published using the “Creative Commons Attribution License,” which permits unrestricted use of all published material provided that it is properly cited.

#### Extensive Indexing

Articles published in this journal will be indexed in several major indexing databases to ensure the maximum possible visibility of each published article.

### Submit your Manuscript Now...

Please visit the journal’s website found at <http://www.hindawi.com/journals/rlc/> in order to submit your manuscript and click on the “Manuscript Submission” link in the navigational bar.

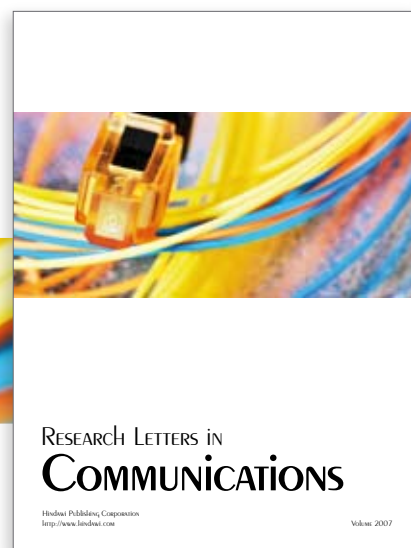
Should you need help or have any questions, please drop an email to the journal’s editorial office at [rlc@hindawi.com](mailto:rlc@hindawi.com)

ISSN: 1687-6741; e-ISSN: 1687-675X; doi:10.1155/RLC

Hindawi Publishing Corporation

410 Park Avenue, 15th Floor, #287 pmb, New York, NY 10022, USA

HINDAWI



#### Editor-in-Chief

Maria-Gabriella Di Benedetto  
*Italy*

#### Associate Editors

Huseyin Arslan  
*USA*

E. K. S. Au

*Hong Kong*

Zhi Ning Chen  
*Singapore*

René Cumplido  
*Mexico*

Michele Elia  
*Italy*

Lijia Ge

*China*

Amoakoh Gyasi-Agyei  
*Australia*

Peter Jung

*Germany*

Thomas Kaiser

*Germany*

Rajesh Khanna  
*India*

David I. Laurenson  
*UK*

Petri Mahonen

*Germany*

Montse Najar

*Spain*

Markus Rupp

*Austria*

Nikos C. Sagiias

*Greece*

Theodoros Tsiftsis

*Greece*

Laura Vanzago

*Italy*

Yang Xiao

*USA*

Guosen Yue

*USA*