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Sum Power Maximization in Cross Layer Based Mobile Satellite Communication

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ABSTRACT: Mobile satellite communication is concerned with internetworking of heterogeneous network which provides global coverage and reliable broadband communication. The demand for higher rate and reliable broadband communication with less consumption of power is drastically increasing. The existing work was to control the power by allocating power to the transmitters with the support of Mixed Integer Linear Programming (MILP) and achieving maximum data. This method failed to allocate power for any new Tx-Rx pair getting into the network. Hence Sum-Rate Power Control (SRPC) method is introduced. This proposing work helps to control the power with Quality of Service (QoS) constraints to achieve optimum power level in cross layer based Mobile Satellite Communication network. It allocates the power for Tx-Rx pairs present in the network and also for new Tx-Rx pairs coming to the network by applying Analytical Power Control Algorithm (APCA) and Distributed Power Control Algorithm (DPCA) in case of two Tx-Rx pairs and more than two Tx-Rx pairs respectively. This will result in achieving the optimum power level with QoS constraints.

KEYWORDS: Mobile Satellite Communication, Mixed Integer Linear Programming (MILP), Sum-Rate Power Control (SRPC), Quality of Service (QoS), Cross layer, Analytical Power Control Algorithm (APCA), Distributed Power Control Algorithm (DPCA).

1 INTRODUCTION

Satellite communication makes bridges for a number of new, intelligent markets in commercial and private. They have got worldwide connections in the public and private Terrestrial Telecommunication Network (TTN) [1]. Soon after Mobile Satellite Communications (MSC) and Navigation Communication came to serve navy, ground and air forces worldwide and for economic reasons, they also provided commercial MSC. MSC was used, particularly because ocean-going vessels have become dependent for their commercial and safety communications on Mobile Satellite Services (MSS). Although, other transportations started before ships, due to many unsatisfactorily experiments and projects they have to follow the evident lead of Inmarsat maritime service. Thus, the updated ship's Mobile Earth Stations (MES) are today implemented on land vehicles and airplanes for all civil and military applications, including remote or rural locations and industrial onshore and offshore installations.

Telecommunications are the carriage of signal, sound or electronic means from one point to other point [8]. Earlier, that intelligent was communicated with the help of audible callings, fire and vapour and image signals. Mobile radio is a development of technology to extend communications coverage, accessibility, power consumption of equipment, reliability by reducing the size, cost and improving efficiency.

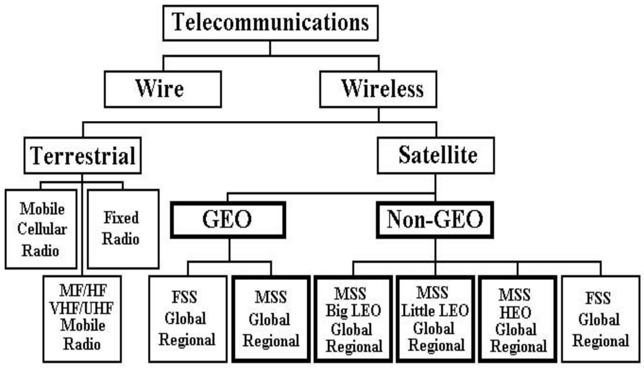

Fig.1. Overview of Telecommunication

The Global MSC network (GMSC) are GEO or Non-GEO satellite systems, which associates to all communications solutions that provides service directly to end users from a satellite and ground segment as well as TTN [4]. The term GMSC means not only global coverage but also involves local or regional. Some of the regional or local MSS can be integrated to establish a GMSC.

Fig.1 gives an overview of telecommunication systems [5]. The GMSC solution provides communication links to devices and later to aircraft and all kinds of road and railway vehicles. It must be noted that GMSC providing global and regional coverage represents a new technology era in which wire terrestrial and wireless cellular voice, image, video and data systems are combined with MSC applications. This provides communication services anywhere.

Additionally, new satellite technologies, such as Global Mobile Personal satellite Communication (GMPSC) and Very Small Aperture Terminals (VSAT), also allowed worldwide personal and commercial mobility. In fact, some of the new GEO or Non-GEO GMPSC systems have entered the field of MSC solutions, which for some years has been occupied predominately by inter-governmental Satellite Organizations. In recent years, a growing number of private entities have been prepared to develop and invest in satellite technology, such as Iridium, Globalstar, Teledesic, Ellipso, Orbcomm, LEO, etc.

2 RELATED WORKS

Earlier work was applied with Intelligent Network concept in Cross Layer Optimization (CLO) for MSN. Cross Layer Design (CLD) is a way of achieving information sharing between all the layers in order to obtain highest possible adaptability of any network. The wireless network consists of a number of interfering links. This leads to power control problem as well as rate maximization. The problem of allocating the transmitting power is intertwined with determining the links on which receivers can perform IC. Also power levels for new links cannot be allocated which becomes a major drawback of satellite network. In order to avoid such issues sum power maximization technique is used. A distributive solution is developed to decide optimal power allocation for new link problem. Distributed Power Control Algorithm (DPCA) is employed for power allocation.

3 EXITING WORK

The European Telecommunication Standard Institute Technical Committee (ETSITC) explained intelligent network based satellite network architecture that includes lower layers [4]. The satellite constellation involved was Teledesic. Teledesic plans to meet this demand using a constellation of (LEO) satellites operating in Ka-band (30/20 GHz).

The Teledesic network provided “fiber-like” service quality, including low transmission delay, high data rates, and low bit error rates to fixed and mobile users. The cross layer design required interfaces between non- adjacent layers. Each layer should know all the information about other layers so that the information can be exchanged between lower layer to higher layer and vice versa. Exchange of information through send and receive parameters has been done only at the adjacent layers in existing model [3].

The two basic cross layer approaches were: Implicit cross layer design and explicit cross layer design. During design process the exchange of information between layers were done in case of implicit design.

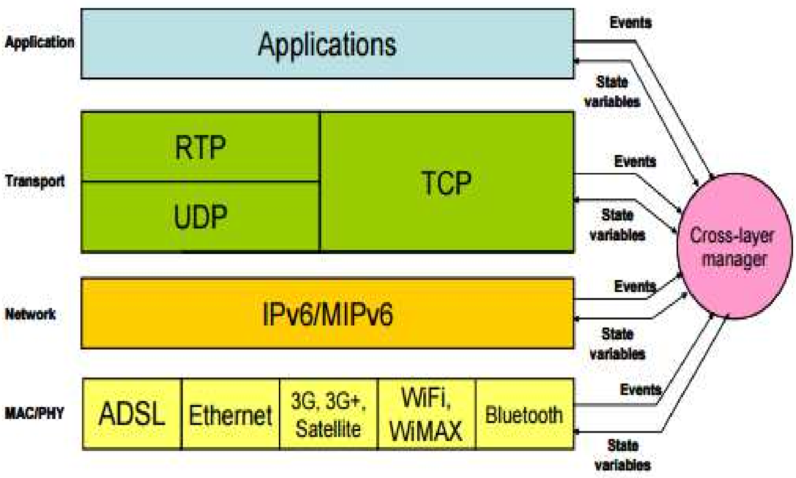

Fig.2. Cross Layer Design for MSC

Interactions among non-adjacent layers were done in order to perform dynamic adaptation for explicit design. In Fig.2 cross layer manager was used in order to perform the tasks between adjacent and non-adjacent layers.

This cross layer manager helps in performing the function without disturbing the information flow from lower to higher layer or higher to lower layer. The main layers involved are MAC/PHY, network, transport, application. The information about cross layer manager was known to all other layers so that it communicates with all layers and shares the required information to the particular layer.

In this work the parameter variations were considered and the environmental changes are also addressed to the required layer [3]. Adaptive techniques were deployed in tracking LEO satellites for communication. Hence the QoS was achieved in terms of minimum delay and higher throughput.

4 PROPOSED WORK

The wireless communication systems can make use of the spectrum for better use of licensed wireless bands. The system works at the equal frequencies, generating interference [1]. The number of interfering links present in wireless network leads to power control problem as well as rate maximization. Various algorithms were developed to minimize both interference and energy consumption in the networks.

Using a high SINR approximation, low complex sub-optimal power control algorithm is developed.

$$SINR_k = \frac{G_{kk} p_k}{\sum_{l \neq k} G_{lk} p_l + \sigma_k^2} \quad (1)$$

Equation (1) shows the SINR experienced by the Rx. The algorithm provides QoS guarantees for individual links and can be implemented in a distributed manner for any number of TX-RX pairs in the network. Let R^i_{min} denote the target data rate constraint for TX-RX pair I in equation (2). We can formulate the optimization problem with the help of equation (3) & (4) for N TX-RX pairs:

$$\max_{p_1, p_2, \ldots, p_N} c(P_1, P_2, \ldots, P_N) = \sum_{i=1}^{N} R(P_1, P_2, \ldots, P_N) \quad (2)$$

subject to

$$R_i(P_1, P_2, \ldots, P_N) \geq R_i^{\min}, \forall_i = 1, \ldots, N \quad (3)$$

$$\sum_{i=1}^{N} P_i \leq P_T \quad (4)$$

The optimization problem for N TX-RX pairs with QoS constraints can then be written as,

$$\max_{p'_1, p'_2, \ldots, p'_N} \frac{1}{\ln(2)} \sum_{i=1}^{N} \ln\left(\frac{g_{ii} e^{p'_i}}{\sum_{j \neq i} e^{p'_j} g_{ji} + \sigma^2}\right) \tag{5}$$

subject to

$$\frac{1}{\ln(2)} \ln\left(\frac{g_{ii} e^{p_i'}}{\sum_{j \neq i} e^{p_i'} g_{ji} + \sigma^2}\right) \geq R_i^{\min}, \forall_i \tag{6}$$

With the help of equation (5) optimization problem can be solved using the Lagrange dual decomposition theory [2]. We can define the following Lagrangian function and power for user index i specified in equation (7) & (8),

$$l_2(P'_1, \ldots, P_N', \mu_1, \ldots, \mu_N, \lambda) = \frac{1}{\ln(2)} \sum_{i=1}^{N} \ln\left(\frac{g_{ii} e^{p_i'}}{\sum_{j \neq i} e^{p_j'} g_{ji} + \sigma^2}\right) \geq R_i^{\min}, \forall_i \tag{7}$$

$$P_i = \frac{(1+\mu_i)}{\lambda \ln(2) + \sum_{k \neq i} \frac{(1+\mu_k) g_{ik}}{\theta_k + \sigma^2}} \tag{8}$$

5 DISTRIBUTED POWER CONTROL ALGORITHM

An iterative algorithm is developed for more than three TX-RX pair problem with additional QoS constraints [1]. The algorithm is Distributed Power Control Algorithm. The steps are as follows:

1) Initialize power value to zero.
2) Transmit interference channel gain values to other TXs in the network
3) Receive the same from remaining TXs.
4) Calculate power P_i and broadcast it to other TXs.
5) Receive the values of power Pk from remaining TXs.
6) Compute the data rate Ri achieved by Tx-Rx pairs.
7) Compute the difference between targeted data rate and achieved data rate, and difference between targeted power and used power.
8) If the difference is greater than zero then set S_i^m = 1 else set S_i^m= 0.
9) Broadcast the value of S_i^m to other TXs.
10) Receive the values of S_i^m from remaining TXs.
11) The power difference is compared with a constant value and if it is greater than that and S_i^m =0 the Lagrange multiplier is updated and go to step 1.
12) The power difference is compared with a constant value and if it is greater than that and S_i^m =1 the Lagrange multiplier is updated and go to step 1
13) The power difference is compared with a constant value and if it is less than that and S_i^m =0, stop the algorithm and declare non-convergence.
14) The power difference is compared with a constant value and if it is less than that and S_i^m =1, stop the algorithm and declare convergence.

6 CHALLENGES IN DEPLOYING THE TECHNIQUE

The sum power maximization helps in allocation of power levels to new Tx-Rx pairs entering into the network and also helps in achieving maximum data rate. The major challenge in implementing this method is the computation of N-1 values of interference channel gains. In the network some links have high channel gains while some have low channel gains. Solving the quadratic equation is also one of the challenges.

7 SIMULATION RESULTS

This section describes the parameters such as power, throughput, and delay in cross layer based mobile satellite communication. As the QoS parameters such as throughput and delay has already been discussed in earlier work of Cross layer Optimization the power control issues should mainly be addressed. The results of the throughput and delay graphs has been specified below.

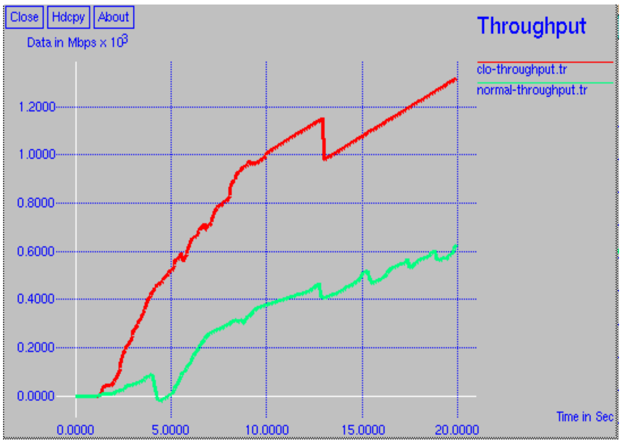

Fig.3. Throughput Comparison with and without Cross Layer Optimization.

Fig.3 shows Throughput comparison graph. Here throughput is given between time and data. The throughput increases with speed of transmission of information with the help of cross layer design in comparison with the existing OSI model

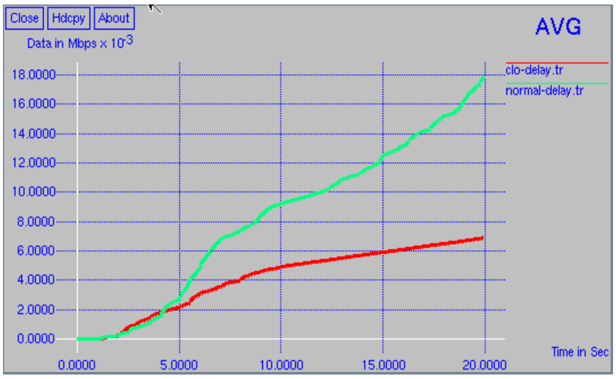

Fig.4. Delay Comparison with and without Cross Layer Optimization

Fig.4 shows the simulation output for delay. In this overall delay with the help of CLO is reduced as the number of packets increases with respect to time is in optimized level when compared to the existing OSI model.

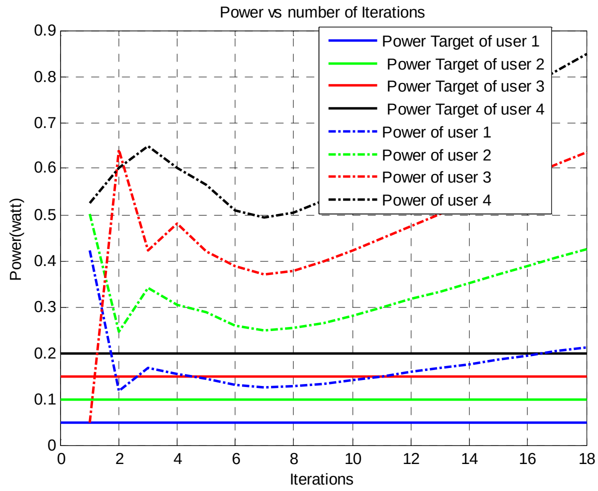

Fig.5. Power Allocation with MILP Approach

Fig.5 shows the power allocation using MILP approach for wireless networks. In this case, a targeted power is fixed and the power used by the user should reach the targeted power value. But the power used by the users does not reach the targeted power.

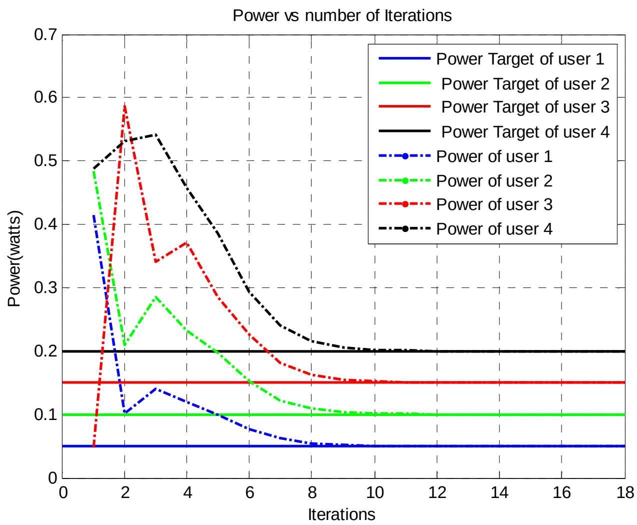

Fig.5. Power allocation with DPCA approach

Fig.5 The power allocation graph is plotted using proposed work DPCA approach for satellite network. Here the condition of reaching the targeted power is achieved. The power graph is plotted between iterations and power. Hence the power target is reached with the help of DPCA approach.

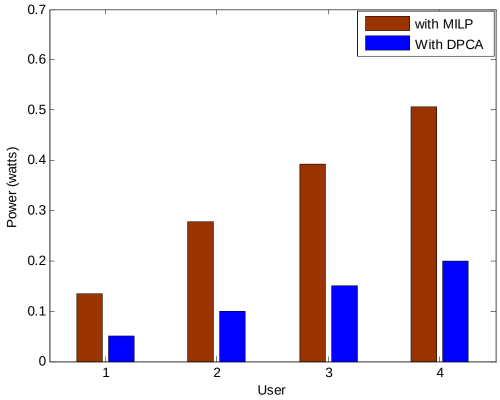

Fig.6. Power Allocation Comparison with MILP and DCPA

Fig.6. shows the power allocation graph plotted between MILP and DPCA approach for satellite network. The bar graph explains the power used the users both using MILP and DPCA method. The power used by the DPCA approach is less when compared with MILP approach.

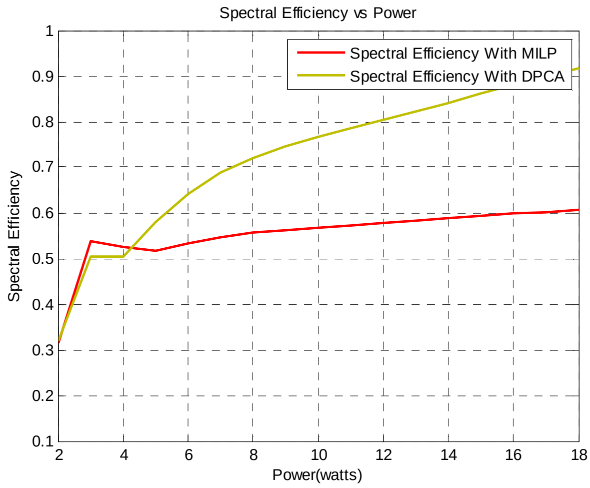

Fig.7. Spectral Efficiency Comparison with MILP and DCPA

Fig.7 shows the spectral efficiency graph plotted between no. of users and spectral efficiency. The DPCA approach is compared with MILP approach. As the no. of users increases the spectrum used by them also increases. The DPCA approach increases the spectrum efficiency with respect to the power.

8 CONCLUSION

This section discusses about the purpose of power control in cross layer based MSC. Power control plays a vital role during transmission of data from satellite to ground station or vice versa. An efficient power control task leads to reduced consumption of power and improved signal quality. Initially MSN and LEO satellite communication has been addressed. The power control method with DPCA algorithm has been analyzed. The algorithm is employed in case of N>3 Tx-Rx pairs. The challenges in using this method have been discussed. Finally the comparison between the DPCA and MILP in terms of power control spectral efficiency and throughput has been clearly mentioned.

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