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A Network Selection Scheme for 4G Communication Systems Using Multi-Level Optimization (MLO) Technique.

***Jeeva Susan Jacob[1] and Preetha K.G.[2].**

1. Department of Computer Science, Travancore Engineering College, Kollam, India.
2. Department of Information Technology, Rajagiri School of Engineering and Technology, Cochin, India.

Manuscript Info

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Abstract

Freedom of choice is the most respected right craved by all human beings. The most attractive feature of 4G communication systems is the provision for users to retain the right of choosing suitable network for each service they avail. Choosing the best one from a set of available networks can be a tedious problem due to the numerous factors to be considered and the complicated calculations involved. The intention of this paper is to find an effective method for selection of network from a heterogeneous set of available networks. Multi-Level Optimization has been proposed as a solution for the network selection in 4G systems.

Introduction:-

Arthur C. Clarke once said that: “Any sufficiently advanced technology is indistinguishable from magic”. In the modern world the progress in technology allows us to communicate with each other anytime from or to even the remotest corner of the world. The aim of technical progress, till date, in the field of wireless communication was to provide an “Always Connected” service to the user which promises uninterrupted services. But, as always, humans tend to be greedy the case of communication services too. Thus, in order to find the “Always Best Connected”(abc) service available, researches have progressed to the 4G communication systems.

The definition of 4G system suggests a global heterogeneous system which integrates all the service providers into one single standard. This is basically a broadband based communication system which utilizes advanced protocols like OFDMA (Optical Frequency Division Multiple Access), MIMO (Multiple Input Multiple Output), HSPC (High Speed Packet Access), SDR (Software Defined Radio) and the like. It promises a downlink rate of 100Mbps to 1Gbps, which is almost ten times that of the present day 3G systems. Commercialization of 4G will be a revolution in the field of communication, almost like the one caused by mobile phones in the recent past.

The major hindrance in the release of 4G standard based devices is the absence of suitable hardware. Researchers around the world are keen on developing one which can function appropriately with the new 4G standard, which clubs all the existing communication standards into one unique global standard. Using the broadband method of communication, 4G systems ensure seamless and scalable connectivity. Some of the concerns related to implementation of 4G based communication systems include vertical handoff, ie, handoff between various networks, network selection, accurate billing and the like.
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4G FEATURES	
TECHNOLOGY	DIGITAL
PERIOD	2010+
DATA RATE	100Mbps - 1Gbps
SWITCHING	BROAD-BAND
PROTOCOLS	OFDMA, MIMO, SDR .....

Figure 1. Major Features of 4G Communication Systems

This paper discusses the network selection issue in 4G communication systems and a solution based on Multi-Level Optimization (MLO) technique. The rest of this paper is organized as follows. Section 2 gives a brief introduction to network selection process in 4G systems. Related work is discussed in section 3. Section 4 describes the Multi-Level Optimization (MLO) method. Section 5 discusses the MLO based method for network selection. Future enhancements and conclusion are given in section 6 and section 7 respectively.

Network Selection Process in 4G:-

One of the major highlights in 4G systems is the freedom for network selection. Users or the device of use can select the best network available from the ones present for each service they are requesting for. This process called the network selection may depend on one or several parameters like bandwidth, cost, delay and the like or simply user's preference. This provides the users with huge benefits since they can avail the services of the best service provider available for each of the services they require at any time anywhere.

This also accelerates the proliferation of Ubiquitous Computing as well. However, the calculations and other necessities make this a complicated process. It needs continuous monitoring of the available networks in that particular region at that particular time and also their attributes like bandwidth, delay, cost and so on. Since the values of these attributes may vary in every few seconds, especially when the device or user is mobile, the process becomes tedious.

Figure 2 shows the handover taking place in 4G systems when the mobile device is moving. Each region has several networks providing various services to devices. These networks are given priorities (High – H, Medium – M, Low - L) according to the services provided by them. These can be also ranked based on the user's priorities. A mobile device is moving through these regions initiating the handover. The device switches from network 1 to network 2 and then to network 3 as it moves from region 1 to region 2 and then to region 3, and thus always ensures the best connected services.

Numerous methods have been put forward by researchers and scientists around the world for efficiently solving this problem. Nonetheless, a method which can choose the best network by taking into account the values of multiple attributes for each network available at a particular instant of time is yet to be developed.

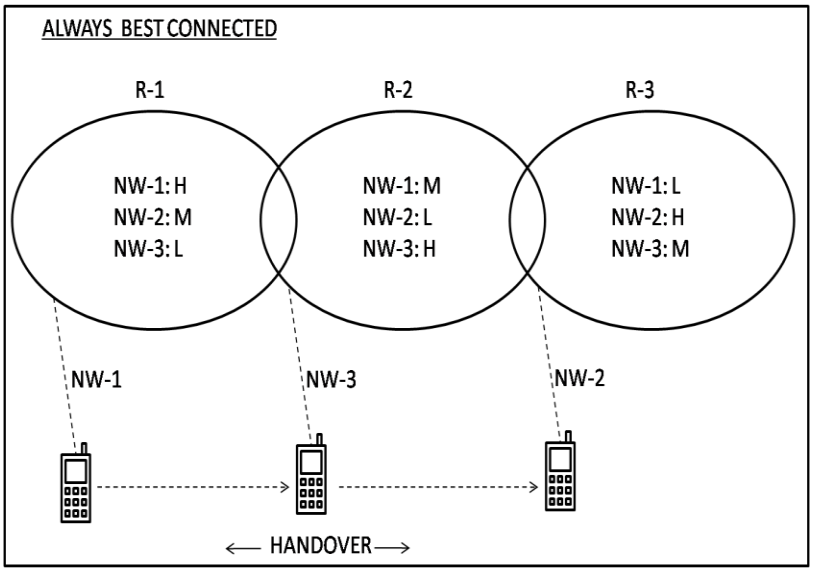

Figure 2. Network Selection process in 4G Systems.

Related Work:-

One of the prominent methods of network selection is the Quality of Service (QoS) based method. It is one of the best methods since it considers multiple parameter values to rank the available networks and then select the best one as per the rank. The Quality of Experience (QoE) based selection method gives more weight to the network which have experience in performing services heterogeneous environment of networks. The collaborative method of these two can ensure efficient selection although it produces a higher rate of overhead. The method based on Utility Theory includes calculations based on uses of networks and the weights assigned to them.

A much simpler method is the user preference based selection which simply chooses the network the user requests for. Another one is to simply rank the networks available as per some criteria and then select the network with the highest rank. The resources based method selects that network from the available networks which have the resources required to perform the service requested by the user. The methods based on cognitive theory and game theory also are inadequate to resolve the network selection in 4G systems. Therefore we need a new method for efficient selection of network in 4G communication systems.

Multi-Level Optimization (MLO):-

Genetic Algorithms aim at creating solutions for problems in various fields related to our day to day lives. Genetic algorithms generally function on the basis of the processes involved in natural selection and survival of the fittest theory. These are adapted from the research field of the origin of life and the evolution theory. Even though, this relates to field of biology, genetic algorithms provided solutions for numerous problems in the field of computing and communication.

This is done by searching through multiple possibilities and eliminating the less suited ones, eventually hitting upon the best possible solution for the problem considered. Genetic algorithms basically work with coding of the parameter set, population of points, payoff information and probabilistic transition rules. It is a form of evolutionary computing which has applications in areas like structural design, communication, artificial intelligence, software development, circuit design and so on.

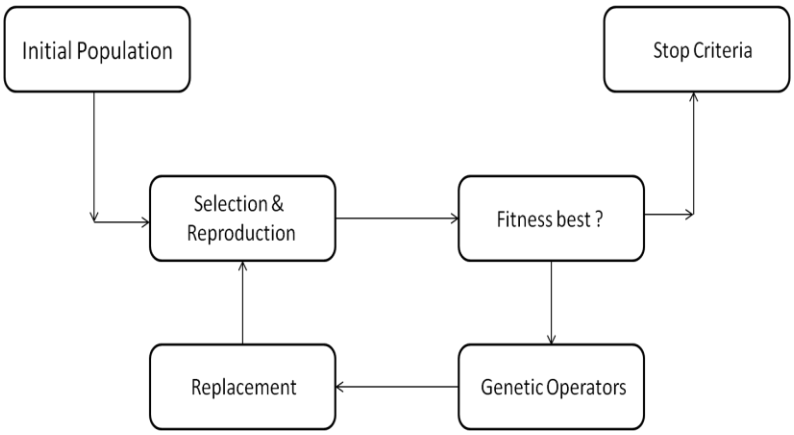

Figure 3. Functioning of Genetic Algorithms.

The major general steps done in finding a solution using genetic algorithms includes the following.

a) Create an initial population of solutions.
b) Generate a fitness function for each member of this population.
c) Perform various genetic operators like selection, mutation and crossover to create a new solution.
d) Check if the new solution is better than the one considered
e) Continue these steps till the best solution is found from the available population of solutions.

Genetic Algorithms are also used as optimization techniques for various problems which can guarantee the best results by maximizing desirable features or by minimizing undesirable features of a solution for a problem. The search space, which comprises of numerous solutions for a single problem, can be optimized to choose the best solution by eliminating the less suitable ones. The various optimization algorithms belonging to genetic algorithm category includes Multi-Objective Optimization (MOO), Multi-Level Optimization (MLO), Constraint Optimization (CO) and so forth.

Multi-Level Optimization (MLO) is a genetic algorithm based application where an optimum solution can be found by dividing the process or search space into multiple steps or levels. Introduced in 2000s, its applications are numerous in resolving problems in diverse fields of research. It removes the hurdles of time consumption and vast amount of calculations involved in genetic algorithms by eliminating unsuitable solutions through various levels of optimization. The number of levels included in the whole process depends on the criteria for selection of solution.

The various steps included in Multi-Level Optimization are as follows :

a) Analyze the optimization problem and determine the set of solutions.
b) Determine the requirements for the process including the number of levels, list of attributes, constraints and so on.
c) For each solution, decide on the attributes, operators, terminal criteria and so forth.
d) Implementation starts from top module to the lower levels. Upper levels send control messages to the lower levels and the lower levels send feedback messages to the upper levels while processing.
e) The implementation is repeated till the best solution is found or the termination criteria is met.

MLO Based Network Selection:-

Multi-Level Optimization can be used for effective selection of network to perform requested services in 4G Communication Systems. This method is apt as it performs well in a heterogeneous environment. The method proposed here finds the available networks at that particular instant at that particular area and figure out the best network to provide service to the user using genetic algorithm based processing technique satisfying the constraints

of performing that service. The process of Multi-Level Optimization based network selection for 4G communication systems to perform the service requested by the user is described in figure 4.

The initial step involves analyzing the service request made by the user. This helps in determining the attributes of the networks which are required to satisfy the request by performing the service. Thus a decision can be made on how many levels are required based on the number of attributes and constraints assigning one level for each. Mostly the attributes required consists of high bandwidth, low cost, low delay, high security, high speed, good performance in a heterogeneous environment and so forth. An additional level is also required for the user's preference for a particular network.

To begin with, the networks which have the necessary attributes or resources to provide the service requested is figured out at the top level using a basic genetic algorithm. In the next level which is level 1, each of these networks is dealt in separate sublevels, the total number of which equals the number of the networks selected, which perform genetic algorithms on each of them to find out the value of a particular attribute during performance. The score of each of these networks is upgraded.

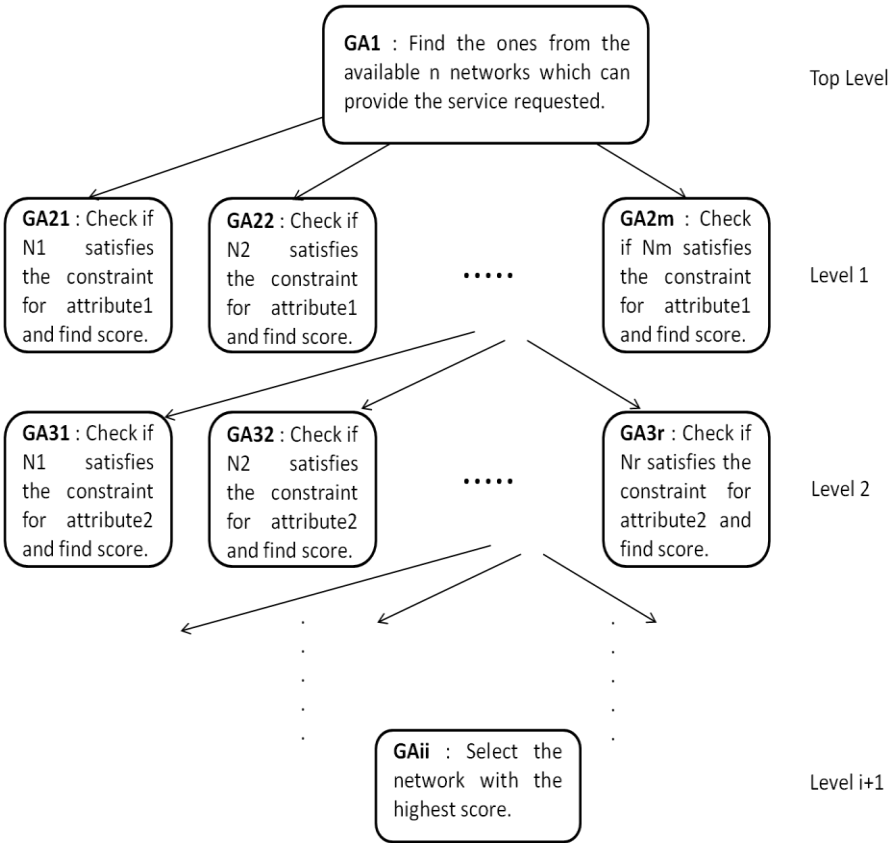

Figure 3. MLO based Network Selection in 4G Systems.

Only those networks for which the score exceeds a certain threshold are passed on to the next level. This process is repeated at each of the next levels with different attributes. Additional weights can be added to the score of the network which the user prefers. Thus after the execution of all the levels corresponding to all attributes the network with the best score is selected to perform the requested service.

This proposed method is much better than the existing methods of network selection as it considers all attributes related to the performance of a network before selecting a suitable one. This ensures better performance while implementing the service requested by the user. The calculations are also simplified as it is done in multiple levels

and their sublevels. Although this may take bit longer to execute, this gives the best possible result, hence satisfying the aim of 4G; ie, to provide "always best connected" service.

Future Enhancements:-

Future research opportunities include speeding up the calculations involved in the proposed method. Integration of a memory module may help in avoiding repetitive execution of the selection procedure for repeated service requests placed in a matter of few seconds. Using optimized genetic operators in the basic genetic algorithm block in each of the levels in the procedure and their sublevels may also improve the performance quality of the proposed method. Researches should also be done on the various other issues faced by 4G communication systems like vertical handoff, billing frauds, seamless integration and the like.

Conclusion:-

Enabling seamless connection and providing a global communication channel for the whole world, 4G is set to be a revolution in the domain of communication. 4G is keenly awaited by scientists and common people everywhere alike. 4G sets up an anytime anywhere communication system which provides "always best connected" service for users. The method proposed in this paper is an effective scheme for execution of proper network selection for services requested by the users which is the key feature of 4G communication systems. Researches to resolve the network selection issue can pave the way for implementation of 4G in the nearest possible future.

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