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EFFICIENT MULTICASTING IN WIRELESS NETWORKS USING NON-DOMINATED SORTING GENETIC ALGORITHM

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ABSTRACT

Multicasting is an efficient technique to transmit the same data to numerous users at one transmission from the source. The most important and challenging task is to reliably multicast data by efficient utilization through wireless network. In conventional method of network the utility maximization with respect to Throughput and Power consumption have high tradeoff. To reduce the tradeoff a multi-objective optimization technique called Non-dominated sorting genetic algorithm is applied for the optimization of throughput and power consumption independently. This paper improves the utility of the network by multicarrier wireless orthogonal frequency division multiplexing (OFDM). Using a unified utility maximization framework, equal path loss in conventional multicast scheme is more optimal. The optimal method for users experiencing different path losses is the group multicasts scheme. It divides the users almost equally into many multicast groups and multicasts over non-overlapping subcarriers to different groups of users.

KEYWORDS: Non-dominant sort genetic algorithm, Orthogonal frequency division multiplexing (OFDM), path loss, utility maximization, wireless cellular network

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INTRODUCTION

Multicast over the wireless networks is a challenging and important goal, but several issues must be considered before many group applications can be deployed on a large scale. Multicast communications has been supported using wired links in the Internet environment for fixed users. A host joins a multicast group by informing a local multicast router that in turn contacts other multicast routers; through a multicast routing protocol a multicast tree is thus created. To determine whether any of the hosts in its coverage is still a member of the multicast group, the multicast router periodically sends queries. Internet Group Management Protocol (IGMP) performs all multicast router communication. The most efficient method for supporting group communication than unicasting or broadcasting is multicasting. Because it allows transmission and routing of packets to multiple destinations using fewer network resources. By the widespread deployment of wireless networks, the fast-developing capabilities of mobile devices, content and service providers are increasingly interested in supporting the multicast communications over the wireless cellular networks.

In circuit switched networks, when a user is allowed to the network, a certain amount of network resource is allocated to the user and used by the user until its communication ends, regardless of whether the user has data to transmit during this period or not. But in packet switched networks, when a new user is allowed, no specific resource is allocated to it. A user only occupies the network resource when it has data to transmit. While considering a phone call, when the user starts to talk, voice packets are generated at a certain rate and when the user is silent, no voice packet is generated.

MULTICAST APPLICATIONS

Applications of wireless multicast support group-oriented mobile commerce, multimedia, distance education, military command and control, teleconferencing, database and intelligent transportation systems. In multimedia, number of users "tune in" to a video or audio transmission from a multimedia source station. In teleconferencing, a group of workstations form a multicast group such that a transmission from any member is received by all other group members. In database, all copies of a replicated file or database are updated at the same time. Distributed computation: Intermediate results are sent to all participants.

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In real-time workgroup Files, graphics, and messages are exchanged among active group members in real time. If group communication among mobile users is supported by wireless networks, many new m-commerce applications, including mobile auctions, will also gain significant benefit. These applications need continued connectivity, secure and reliable wireless multicast. In military environments, much important and confidential information may be multicast to users, tanks, and planes; such applications demand minimal delay and secure and reliable wireless multicast. Distance education and entertainment services are offered to mobile or remote users which require high bandwidth and near-real-time wireless multicast for quality viewing. Dynamic routing or rerouting of individual vehicles is involved in intelligent transportation systems.

RELATED WORK

In all existing works more important is given to the power consumption and also the utilization of the network resources. Power control is an important component for the resource management issue in wireless networks. A power control framework called utility-based power control (UBPC) is presented by reformulating the problem using a softened SIR requirement and adding a penalty on power consumption. User satisfaction will depend on both Qos and power consumption. Within this framework, a utility-based distributed power control algorithm is developed. Depending on whether the communication is unidirectional or bidirectional, there are two variations on routing and power consumption. Min-Power asymmetric routing and Min-Power symmetric routing. Constant-approximation algorithm is used for both min-power asymmetric and symmetric multicast routing.

The multicast data are separated into layers and any combination of layers can be decoded at the receiver, the network throughput can be increased by performing subcarrier/bit allocation. It also consider the concept of Proportional Fairness (PF), the fairness factor can be increased while minimizing total throughput degradation. To reduce the complexity, a simple heuristic algorithm by separating subcarrier allocation and bit loading is used. Multicast data are separated into layers and any combination of layers can be decoded at the receiver. Within a cell, every user is associated with a base station. To maintain a

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reliable connection between the user and its home Base station, the SIR at the receiver should be no less than some threshold that corresponds to a Qos requirement such as the bit rate. For the purpose of energy conservation, each node can adjust its transmitting power based on the distance to the receiving node and the background noise. Due to non linear power attenuation the total power consumption required session can be potentially reduced by relaying signal through intermediate nodes.

To maximize the user's aggregate throughput in fading broadcast channels, the capacity region and optimal power allocation can be achieved by superposition coding and successive decoding. In fading broadcast channel where users have different rate demands, the channels between transmitter and receiver are block fading i.e, the channels remain fixed over the coherence interval. The average throughput increases with the number of users in a multicast group. The bandwidth resource allocated to a group is proportional to the number of users in a group. Number of users and subcarriers needed for throughput to be arbitrarily close to its asymptotic value.

System Model

Consider a wireless OFDM system that consists of base stations with N subcarriers and K users. Client nodes are located in a cell region and they communicate through the base station with which they are associated. According to a multicast strategy, K users are divided into M multicast groups. The principle behind the OFDM system is to decompose the high data stream of bandwidth W into N lower rate data streams and then to transmit them simultaneously over a large number of subcarriers. Value of N should be kept sufficiently high to make the individual bandwidth (W/N) of subcarriers lower than the coherence bandwidth (Bc) of the channel. The individual subcarriers experiencing flat fading is compensated by using single tap equalizers. These subcarriers are orthogonal to each other which allow the overlapping of the subcarriers. At the receiver side orthogonality ensures the separation of subcarriers. OFDM systems are more spectrally efficient compared to FDMA systems, which do not allow spectral overlapping of carriers. Consider the system capacity of an OFDM system, transmitting over a time and Frequency selective Rayleigh fading channel. The transmissions of multicast packets are scheduled over a prescribed frequency

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band, using a fixed transmission rate. Each subcarrier should have equal bandwidth. Orthogonal subcarriers are used in OFDM based communication systems to transmit multiple data simultaneously. If there is large-scale fading, the received power at a distance *d* will decrease.

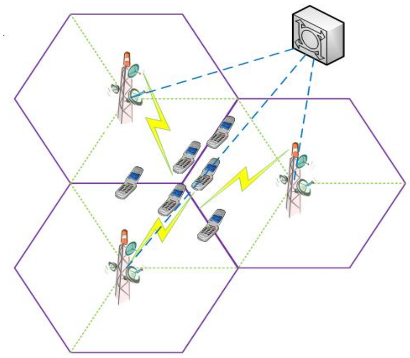

Fig 1: OFDM system model

There are many advantages associated with using the OFDM approach. The major advantage of OFDM is that it allows the transmission over highly frequency-selective channels at a low receiver implementation cost. This includes the ability to efficiently capture multipath energy, simplified transceiver architecture, enhanced frequency diversity, and spectral flexibility to avoid low quality sub-bands and to cope with local regulations.

Maximizing Network Utility

A fair resource allocation of resources in networks can be done by maximizing the average user utility. Suppose the resource available in network is C that is to be divided among N different users, one way of performing the allocation is to simply divide the resource into N parts and allocate C/N to each user. Each user might value the resource differently so we refer to the value or "utility" obtained from an allocation x as U(x).

Consider that the utility function is continuously differentiable, non-decreasing and strictly concave. If person is downloading a file, the effect of the rate increase from 1 kbps to 100 kbps much more than an increase from 1 Mbps to 1.1 Mbps although the increase is same in both the cases. The capacity constraints of the links cannot be violated at any instance. Each source is allocated with a non-negative rate of transmission. It is commonly known that a strictly concave function has a different maximum over a closed and bounded set. As the utility function is perfectly concave, the maximization problem satisfies the requirements, and the constraint set is closed and bounded.

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The network utilization maximization, is always associated with utility function of all user allowed in it. The utility function is the measure of satisfaction of each user when they obtain a certain data rate from the network. A utility function is assigned to each user in the network by a service provider with the goal of achieving a certain type of resource allocation.

Path Losses Equally

The situation when all users experience the path losses almost equally. This condition may occur when the users are almost equally far away from the base station. The maximum distance between the user terminals is much smaller than the average distance between the base station and user terminals.

Path Losses Differently

The situation when all users experience the path losses differently. This condition may occur when the users are uniformly distributed in a unit-radius circular cell. In multicasting users within different groups experience different path losses.

Algorithm for maximizing utility

The utility maximization framework is applied to network resource allocation. Many notions of fairness in communication. networks have been proposed over the years. In particular, max-min farness has been studied extensively Max-Min Fairness**.** The widely used fairness criterion in communication networks is max-min fairness. Fairness generalizes arbitrarily close approximation of max-min fairness.

The notion of fairness characterizes how computing user share the bottleneck resources. One of the most common fairness definition is max-min in which a feasible flow rate x is defined to be max-min fair if any rate xi cannot be increased without decreasing some xj, which is smaller than or equal to xi. Each group of users is assigned a proportion of bandwidth that increases with the distance.

The received power of each group of users decreases with the distance due to large scale fading. The impact of large-scale fading can be made up by the proposed bandwidth. Hence all users will receive same message over different subcarriers at a same data rate. Each group has an approximately equal number of system bandwidth that changes with the distance from the base station.

Non-Dominated Sorting Genetic Algorithm

A genetic algorithm (GA) is a search heuristic that mimics the process of natural evolution. This heuristic is routinely used to generate useful solutions to optimization and search problems. Genetic algorithms belong to the larger class of evolutionary algorithms (EA), which generate solutions to optimization problems using techniques inspired by natural evolution, such as inheritance, mutation, selection, and crossover.

Genetic algorithms find application in bioinformatics, phylogenetics, computational science, engineering, economics, chemistry, manufacturing, mathematics, physics and other fields. NSGA-II is a non-dominated sorting based multi-objective evolutionary algorithm with a computational complexity of $O(MN^2)$ (where M is the number of objectives and N is the population size). NSGA-II incorporates an elitist approach, a parameter-less niching approach and a simple constraint handling strategy.

Due to NSGA-II's low computational requirements, elitist features and constraint handling capacity, it has been successfully used in many applications. It proved to be better than many other multi-objective optimization algorithms. It is worth mentioning that the number of Pareto-optimal solutions obtained by NSGA-II is limited by its population size. Our methods keep track of all the feasible solutions found during the optimization and therefore do not have any restrictions on the number of Pareto-optimal solutions found.

With respect to each objective the crowding distance proposed in NSGA-II is used to estimate the density quantity of a particular solution in the population by calculating the average distance between other surrounding solutions. After two parents have been selected from population, let the parent with larger crowding distance be named as the better parent and the other one is the worse parent.

The proposed evaluative crossover imitates the gene-therapy process at the forefront of medicine, which inserts genes into an individual's cells to treat a disease by replacing a defective mutant allele by a functional one. Therefore, the evaluative crossover integrates a gene-evaluation method with a gene-therapy approach in the traditional uniform crossover scheme.

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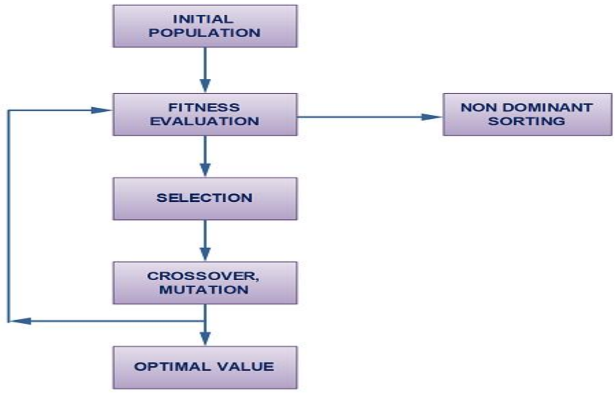

Fig 2: Flow chart of NSGA

Fig 2 is a flow chart specifying the functions of NSGA.

The functions of each blocks is specified below:

A. Initial Population

Initially many individual solutions are randomly generated to form an initial population. The population size depends on the nature of the problem, but typically contains several hundreds or thousands of possible solutions. Mainly, the population is generated randomly, covering the entire range of possible solutions. Sometimes, the solutions may be "seeded" in areas where optimal solutions are likely to be found.

B. Selection

During each continuous generation, a proportion of the existing population is selected to breed a new generation. Individual solutions are selected through a fitness-based process, where fitter solutions (as measured by a fitness function) are typically more likely to be selected. Certain selection methods rate the fitness of each solution and preferentially select the best solutions. Other methods rate only a random sample of the population, as this process may be very time-consuming.

C. Reproduction

The next step is to generate a second generation population of solutions from those selected through genetic operators: crossover (also called recombination), and/or mutation. For each new solution to be produced, a pair of "parent" solutions is selected for breeding from the pool selected previously. By producing a "child" solution using the above methods of crossover and mutation, a new solution is created which typically shares many of the characteristics of its "parents". New parents are selected for each new child, and the process continues until a new population of solutions of appropriate size is generated. Although reproduction methods that are based on the use of two parents are more "biology inspired", some research suggests more than two "parents" are better to be used to reproduce a

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good quality chromosome. These processes ultimately result in the next generation population of chromosomes that is different from the initial generation. Generally the average fitness will have increased by this procedure for the population, since only the best organisms from the first generation are selected for breeding, along with a small proportion of less fit solutions, for reasons already mentioned above.

Although Crossover and Mutation are known as the main genetic operators, it is possible to use other operators such as regrouping, colonization-extinction, or migration in genetic algorithms.

D. Termination

This generational process is repeated until a termination condition has been reached. Common terminating conditions are:

E. Termination

This generational process is repeated until a termination condition has been reached. Common terminating conditions are:

- A solution is found that satisfies minimum criteria
- Fixed number of generations reached
- Allocated budget (computation time/money) reached
- The highest ranking solution's fitness is reaching or has reached a plateau such that successive iterations no longer produce better results
- Manual inspection
- Combinations of the above candidate solutions to a Pareto front constrained by a set of objective functions. The algorithm uses an evolutionary process with surrogates for evolutionary operators including selection, genetic crossover, and genetic mutation. The population is sorted into a hierarchy of sub-populations based on the ordering of Pareto dominance. Similarity between members of each sub-group is evaluated on the Pareto front, and the resulting groups and similarity measures are used to promote a diverse front of non-dominated solutions.

CONCLUSION AND FUTURE ENHANCEMENT

The uniformly distributed Pareto-optimal front of multi-objective optimization problems evaluates crossover by a gene evaluation method with a gene-therapy approach in the traditional NSGA. For the simpler problems this methods performed equally well and for the difficult problems, NSGA outperformed in most respects. In our future work we plan to increase the utilization of each user and to increase the power consumption by means of fountain codes. The bandwidth of each user in a group will not depend each other.

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