Effective Assignment of Periodic Feedback Channels in Broadband Wireless Networks

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Abstract- **Advanced wireless technologies such as multiple- input–multiple-output (MIMO) require each mobile station (MS) to send a lot of feedback to the base station. This periodic feedback consumes much of the uplink bandwidth. This expensive bandwidth is very often viewed as a major obstacle to the deployment of MIMO and other advanced closed-loop wireless technologies. This paper is the first to propose a framework for efficient allocation of periodic feedback channels to the nodes of a wireless network. Several relevant optimization problems are defined and efficient algorithms for solving them are presented. A scheme for deciding when the base station (BS) should invoke each algorithm is also proposed and shown through simulations to perform very well.**

Keywords: - Channel state information, wireless networks, MIMO.

I.INTRODUCTION:

Now MIMO technology which is widely used in the 3GPP i.e., 3rd Generation Partnership Project and in WIMAX standards. The routing technique used by MIMO is cluster by cluster in each hop. And in the cluster the number of nodes will be equal or larger to one. When Multiple Input Multiple Output (MIMO) technology is integrated into 4G wireless networks, the amount of feedback to facilitate must be transmitted from the MSs to the BS increases significantly. And Cellular MIMO uses Uplink and Downlink efficiently. Transmit & receive phase differences don't change open loop MIMO. When MIMO is implemented using spatial multiplexing technique then it provides degree of freedom or multiplexing gain. MIMO using spatial multiplexing is aimed at improving the data rate of the system. When this MIMO used with the Diversity technique then it improves the reliability of the system, which is shown at the Fig.1.

In the MIMO closed-loop spatial multiplexing mode, for example, these feedbacks include the Rank Indicator (RI), the Precoding Matrix Indicator (PMI), and the Channel Quality Indicator (CQI). PMI report is used by the BS to determine how the precoding matrix should be configured for transmission. To identify the availability of number of transmission layer RI report is used. But all these indicators require a lot of expensive uplink bandwidth, mainly because they are sent periodically as long as there is transmission on the downlink channel. Major obstacle to the deployment of MIMO and other closed loop wireless technologies is this expensive bandwidth. Therefore, the uplink bandwidth to these indicators must be allocated very carefully, while achieving certain optimization objectives.

This framework comprises of all common indicators, including CQI, RI and PMI. CQI feedbacks can be either wideband CQI, where the CQI is measured for the entire downlink channel bandwidth, or sub-band CQI, where each CQI is measured over a sub-band. Here we do not distinguish between the various indicators but we collectively view them as CSI (Channel Status Information) channels. Both WIMAX and 3GPP supports periodic and aperiodic CSI feedback. Ax/802.16 [11] support periodic and
aperiodic CSI feedback. While a periodic CSI feedback requires the BS to send a signaling message each time it wants to receive a CSI report from an MS, periodic CSI feedback requires only one signaling message for the allocation of a CSI channel and one for its release. The location High throughput in networks is the increasing requirement day by day. Up to date information about the channel quality observed by the receiver has to be maintained by the transmitter. In this scenario Base Station (BS), Mobile Station (MS), Channel Quality Indicator (CQI) plays very important role in the data transmission. And now the advanced wireless technology require each mobile station (MS) to periodically transmit to the base station (BS) its Channel Quality Indicator (CQI). Channel Quality Indicator (CQI) is an indicator which carries information on how good/bad the communication channel is. It is also used as a measure of the downlink mobile channel and is used by the base station (BS) to adapt the modulation and coding parameters to the channel status of the corresponding node.CQI measurement also plays very important role in the Base Station's (BS) scheduling algorithm.

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N and periodicity of CSI slots is indicated by allocation message which comprises of the allocated CSI channel. Once a CSI channel is allocated, the MS transmits CSI messages on the slots of this channel until it receives a deallocation message. In this paper we have tried to present the formal framework for the allocation of periodic CSI channels. It also defines, again for the first time, several problems relevant to this framework and presents efficient algorithms for solving them.

Finally, it presents a holistic scheme that indicates when the BS should invoke each of the proposed algorithms. In this paper, to each MS a framework is proposed which defines a profit/utility function for the allocation of a CSI channel. While the proposed framework and algorithms are general enough to address every profit function, we propose and discuss a specific function, for which the profit is equal to the expected number of packets transmitted to an MS using a correct CSI value due to the allocation of a CSI channel with a certain bandwidth.

Two commonly used BS scheduling algorithm are proportional fair and semi-persistent. The instantaneous transmission rate to each user is dynamically adjusted by the proportional fair scheduler, even on the sub-frame granularity. A semi persistent scheduler adjusts the instantaneous transmission rates less frequently; e.g., once every 10,000 sub-frames. The framework presented in this paper is generic and can work with both scheduling schemes, to make the discussion more concrete. This paper present more specific c profit function, which depends on the number of packets transmitted to each MS. This profit scheme is mostly suitable for semi-persistent schedulers.

The rest of the paper is organized into six divisions. In the section II Related work is discussed. In Section III, it is shown about how to allocate slots to CSI channels using a complete binary tree, in order to guarantee an efficient collision-free allocation, and describe the considered CSI channel allocation model. Section IV is the core of the paper. It defines the CSI allocation problems and presents efficient algorithms for them. In Section V study for the performance of the various algorithms and present a complete BS scheme for the allocation of CSI channels is made. Finally, Section VI concludes the paper.

II. RELATED WORK:

Previous works like improving utilization ratio of CQI channels and A mathematical model for analyzing the CQI channel mechanism have failed to adjust the periodicity of the CQI reports to the specific needs of each MS. Rather, they have tried to reduce the cost of the CQI reports by

i. Not sending CQI reports if the channel condition has not significantly changed.
ii. Sending a single CQI report for a subset of OFDM sub-channels.
iii. Sending a single CQI report to a group of MS. All these works are orthogonal to the scheme and algorithms presented in this paper.

In the previous work on improving utilization ratio of CQI channels and a mathematical model for analyzing the CQI channel mechanism, the authors propose a CQI allocation scheme for 802.16. Their scheme views the CQI bandwidth as a “toy brick.” In contrast to these work, this paper tries to present the CSI bandwidth as a binary tree, which allows us to minimize the number of changes for allocating a CSI channel when the available CSI bandwidth is fragmented. We also allow different channels to have different profit functions and seek to optimize the total profit of the BS.

In the previous work on Channel adaptive CQI reporting schemes for HSDPA systems, an adaptive CQI scheme is proposed, where a node reports the CQI value only if it has changed since the last report or if a timer expires. With the proposed scheme, battery capacity of the MS is conserved and uplink interference is reduced. While the Channel adaptive CQI reporting schemes for HSDPA systems,also considers periodic CQI channels, it does not, in contrast to our scheme.

i. Address the case where the CQI bandwidth is insufficient for all the CQI channels
ii. Attempt to change the periodicity of the CQI reports.

In the algorithmic view on OVSF code assignment, it addressed the OVSF code assignment problem. But their work does not focus on the target the allocation of CSI channels. This OVSF code assignment is relevant to this paper because in particular the allocation framework proposed in this paper is based on a complete binary tree that is similar to the OVSF tree used in the algorithmic view on OVSF code assignment. However, OVSF code assignment can only be assigned to a specific level in the tree whereas we allow each CSI channel to be associated with different levels and profit.

In the Low overhead CQI feedback in multi-carrier systems scenario, the problem of getting too many CQI reports at the BS is studied. The goal of the proposed scheme is to reduce the number of these reports by careful selection of the specific OFDM sub-channels for which such reports are required. In A hybrid CQI feedback scheme for 4G wireless systems, similar scheme of the Low overhead CQI feedback in multi-carrier systems which are also taken into the account of QOS requirements of each MS.

In the Efficient channel quality feedback schemes for adaptive modulation and coding of packet data, a new metric for the performance of CQI schemes is proposed and studied. It takes into account the total resources consumed by each CQI scheme. It is then used for comparing different, periodic and aperiodic, CQI schemes with different SNR values.

In the 802.16m CQI feedback framework, the authors proposed to reduce the CQI bandwidth cost by reporting a single CQI value for a subset of sufficiently proximate OFDM sub-channels. A hierarchical tree is used to create groups of sub-channels.

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In the hierarchical selective CQI feedback scheme for 3GPP long-term evolution system, similar hierarchical mechanism is used, but only CQI values with sufficient quality are reported. It is claimed that the proposed scheme can significantly reduce the CQI feedback overhead at the expense of a little downlink performance degradation.

In the CQI feedback reduction based on spatial correlation in OFDMA system, proximate MSs are considered as a "CQI feedback group," and only one representative node is asked to send a CQI report.

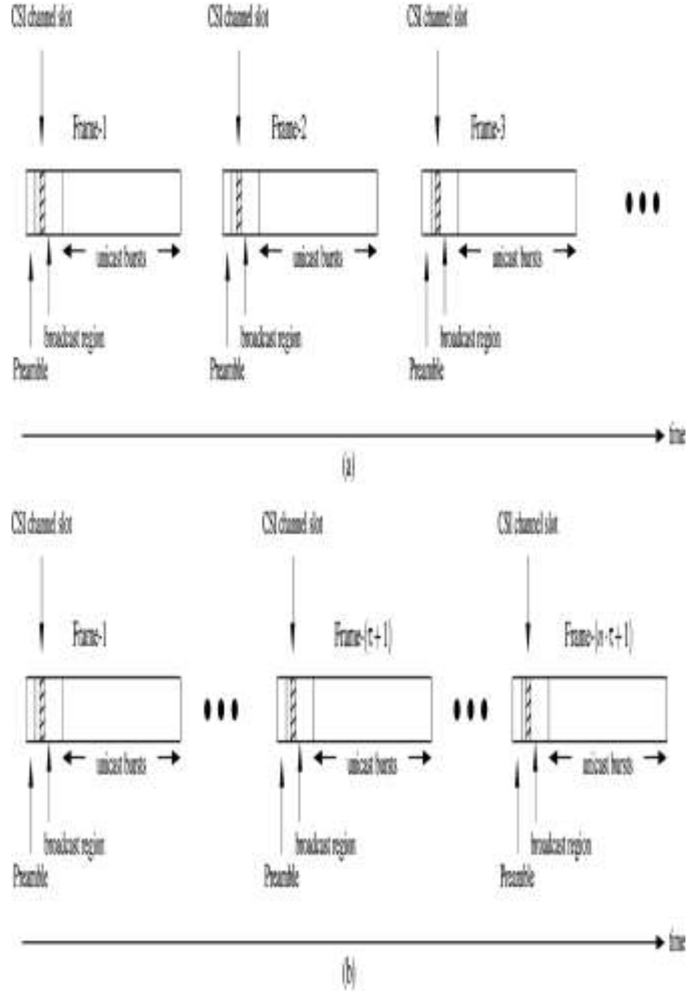
This paper deals with the allocation of feedback channels, and not with how and when the nodes send feedback information. This topic is addressed by many papers, some of them are mentioned below.

In the Mutual information based calculation of the precoding matrix indicator for 3GPP UMTS/LTE, the authors present an efficient method for calculating the PMI at the receiver. The method is based on maximizing the mutual information between the transmitted and received symbols with respect to the precoding matrix applied at the transmitter.

In the Calculation of the spatial preprocessing and link adaption feedback for 3GPP UMTS/LTE, the authors present an efficient method for calculating the PMI, RI and CQI at the MS. To reduce the MS computational burden, the proposed method decomposes the problem into two separate steps: jointly evaluating the PMI and RI using a mutual information metric, and choosing the CQI value to achieve a given target block error ratio constraint

III. PRELIMINARIES:

If the channel condition has not changed notably, cannot easily take advantage of the unused slots. This is because these slots are too short for regular packets and because the MS cannot rely on their availability. In this paper the approach taken is different and in this BS allocates different bandwidth to different CSI channels in accordance with each channel's individual profit function. Using this scheme we propose that the BS views the CSI bandwidth (i.e., the uplink bandwidth dedicated to the CSI channels) as a shared resource. The size of the resource is also adjusted by the BS. When BS realizes that there are not much Dynamic MS in its cell, then the BS can decrease the total CSI bandwidth and use it for other purpose. Super channels are derived from the CSI bandwidth. Every uplink of the super channels consists of a slot.
The number of CSI slots in each frame is equal to the number of super channels. Every super channel is divided into multiple CSI channels. Every slot in CSI channel uses only one slot every τ frames. This paper tries to provide an algorithm for the division of a super channel into multiple channels and it can



also be used to provide deallocation and allocation of CSI channels. In the case of allocation of CSI channel, BS sends the Control message to the MS with the parameters which are as follows.

1. The sequence number of the first frame that contains as lot of this channel.
2. The number of frames between two consecutive slots of this channel.
3. The time during which this CSI channel is allocated tothe MS. The BS can also allocate the channel with no expiration time, and then explicitly request it back.

A CSI channel Cj is denoted by τj/αj, τj is the periodicity of the slots and τj represents the first frame's sequence number which contains a slot of the channel. Based on the stability of the channel the optimal value of τj is determined. If the value of τj is too small then it is expected to get more identical CSI reports that will be affected by many factors like MS mobility speed, weather conditions, interference from other wireless networks.

I. Framework Allocation for CSI:
Fragmentation and collision are not allowed in the CSI. So we divide the CSI channel into multiple super channels by the help of complete binary tree. Root of the tree is considered as at least one sub-node of the tree. These allocated sub trees are mutually disjoint in nature.

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II. CSI allocation's algorithm:

Different kinds of algorithms were proposed at this point related to the following cases:

1. How can we allocate the bandwidth to the CSI channels when the tree is empty.
2. Reallocation method when the CSI channel is released.
3. How can we allocate a CSI channel to the new Mobile System(MS), when the available CSI channel is completely fragmented.

These suggestions are combined together into a new scheme at a situation when each algorithm has to be executed by the Base Station (BS).

When we go for new Mobile Station (MS) that enters the cell, the Base Station needs to determine the profit function of the Mobile station. The bandwidth dedicated for the initial CSI channels is assumed to be sufficient for all active MS.

For example,

The Base Station will have a binary tree whose height is dlogMe for this basic allocation, where M is the maximum number of Mobile Stations which can be activated in the cell. Then, the initial CSI channels are allocated from the leaves of this tree. The initial CSI channel is used by the BS in order to determine the initial Ej value for MSj, and to allocate a broader CSI channel when necessary. Since the BS can easily determine the expected number of packets transmitted by MSj between two CSI reports, it can also determine Ej and Pj(l). To simplify the discussion, if no CSI channel is allocated to MSj (except the initial channel), we say that MSj is allocated a tree node at level lj = □1, and that Pj(□1) = 0.

IV. ALGORITHMS FOR CSI ALLOCATION:

Based on the scheme of allocation for CSI, this paper address two different types of algorithm. One algorithm is based on the tree structure and another one algorithm is based on token strategy. Using these two algorithms we can dynamically allocate channels to CSI.

At first, we take the tree algorithm, it deals with the problem when the tree is empty and we have to find the best allocation for the given set of active Mobile Station. It is defined as Collision free CSI allocation in empty tree. This problem can be reduced into Multiple Knapsack problem.

An MCKP instance is an set of m mutually disjoint classes N1. . . Nm of items to be packed into a knapsack of capacity B. Each item i∈Nj a weight wij and has a profit pij. The aim is to choose at most one item from each class such that the aggregated profit is maximized and the aggregated weight is

Not larger than B. To minimize an instance of CF-CSI-E to an instance of MCKP,

Each CSI channel Cj is represented by a class Nj, and for each level i CSI sub tree that can be allocated to Cj (1 ≤ i ≤ lmaxj) there is an item i∈j. The knapsack holding capacity is set to B =2C. The weight of i∈Nj is set to wij = 2i.

Algorithm 1: (Collision Free CSI allocation in Empty Tree)

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1) Reduce the CF-CSI-E instance to an MCKP instance as described using above technical terms.

2) Run an algorithm, Approximate MCKP, which finds a solution to the MCKP instance.

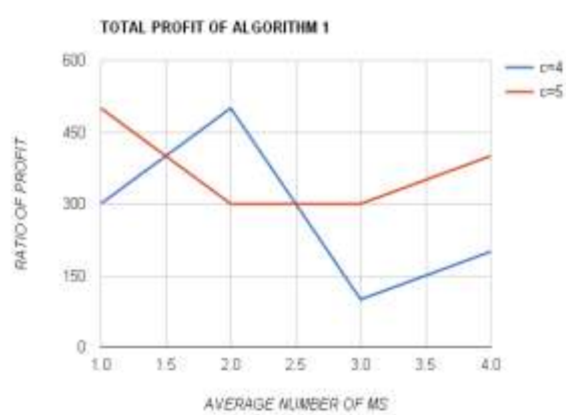
3) Translate the solution returned by Approximate MCKP to a solution for CF-CSI-E, such that a CSI channel Cj is allocated a tree node in level i if item i in class Nj is chosen for the MCKP solution.

Lemma 1: If Approximate MCKP is a α-approximation to MCKP, Algorithm 1 is an α-approximation to CF-CSI-E. MCKP has a simple 2-approximation greedy algorithm whose running time is O(I log I), where I is the total number of items.

Using linear selection, the running time can be improved to O(I) . It also has a pseudo polynomial time optimal dynamic programming algorithm whose running time is O(B · I).

For practical occurrences, B ≤ 2 10 = 1024 holds for CF-CSI-E, because this allows a periodicity of up to 1 second. Thus, the running time for the optimal dynamic programming algorithm is O(I).

This algorithm is converted into an optimal polynomial time algorithm for CF-CSI-E. The solution found by Algorithm 1 indicates only the tree level of each CSI channel and not about the specific tree node. However, given such a solution, we use the following result, declared in the context of OVSF code assignment, to convert this information into a structured allocation: There exists a collision-free allocation of the tree nodes if and only if P u∈V 2 l(u) ≤ 2 C, where V is the set of all allocated nodes in the tree, l(u) is the level of an allocated node u in the tree, and C is the height of the tree.



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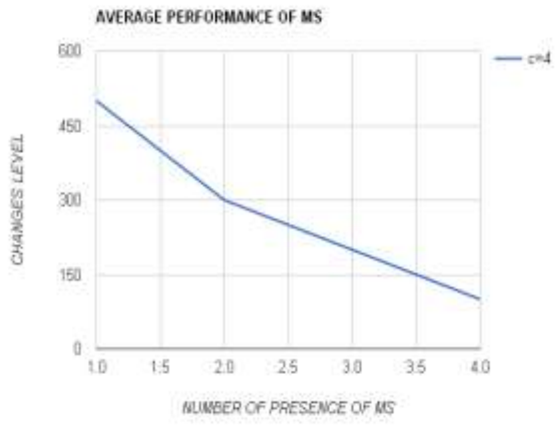


Algorithm 2: (An algorithm for CF-CSI-NC)

1) Reduce the CF-CSI-NC instance to an MC-MKP instance as described above.

2) Run an algorithm, that finds a solution for the MC-MKP instance.

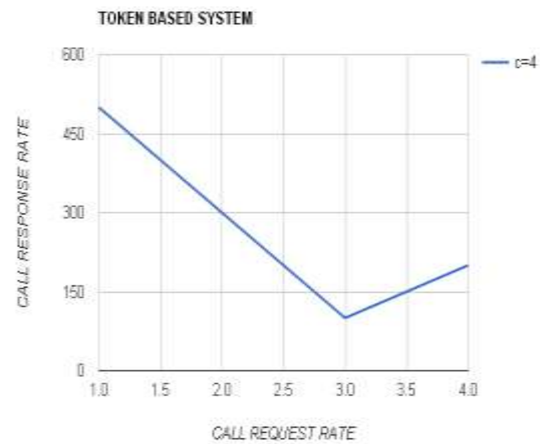
3) Translate the solution returned by to a solution for CF-CSI-NC, such that a CSI channel is allocated a tree node in level of sub tree if item in class is packed in knapsack of the MCKP solution.

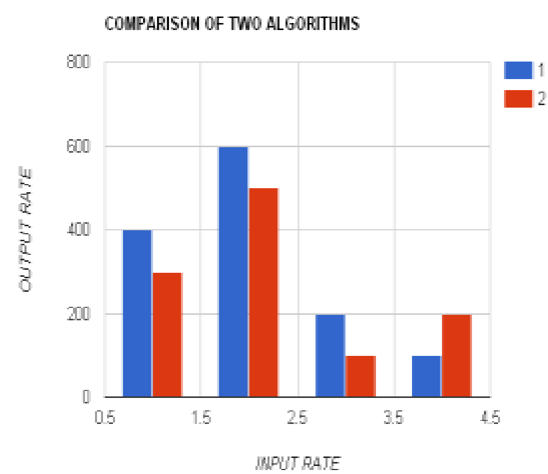
Lemma 2: If is an -approximation to MC-MKP, Algorithm 2 is an -approximation to CF-CSI-NC.
It is shown that even without multiple choice, MC-MKP is hard to approximate in a fully polynomial time. We now present a 2-approximation greedy algorithm for MC-MKP.
This algorithm combines the 2-approximation greedy algorithm for MCKP and the 2-approximation algorithm for MKP

Algorithm 3:

This algorithm is totally different from the binary tree concept because it is focused on the token based channel allocation of the CSI. This algorithm basically works on the call request from the Mobile Station and if
the process is free then the request is accepted by the Base Station. And the space is allocated for the CSI channel and BS provides the feedback

```
For m = 0:48
For k = 0:399
C[m]. Tc[k] = –1 // C[m] denotes Cm i.e. mth numbered Cell
End For
End For
For k = 0:399
For i = 0:48
T[k].Req[i]← 0
End For
T[k].S←false
End For
TempCi ← null
Count←0
```





V. Complete BS Scheme

We now combine Algorithms 1 and 2 into a complete allocation scheme for the BS. An action is required from the BS in the following cases:

1) a new MS becomes active;
2) an active MS leaves the cell or becomes inactive;
3) the profit function of an active MS changes (e.g., due to a change in the user mobility speed).
Algorithm 2 allows an increase in the profit without the overhead associated with the removal of existing CSI channels. However, Algorithm 2 is often unable to allocate a CSI channel, not because the bandwidth is insufficient, but because it is fragmented. In such cases it might be more beneficial for the BS to clear the CSI allocation tree and invoke Algorithm 1.Thus, Algorithm 1 brings two important benefits to the scheduler. First, it serves as a benchmark for Algorithm 2

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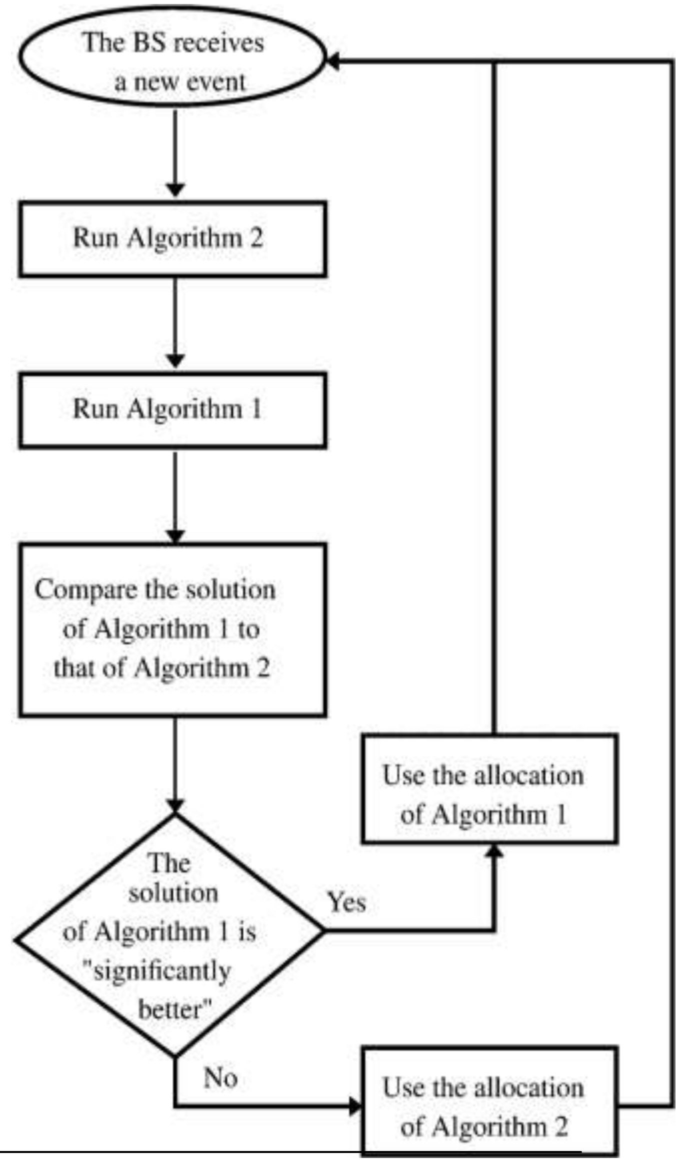
because it Indicates the maximum total profit that can be obtained at every moment. Second, it can be occasionally invoked by the BS in order to replace the existing tree with a new one for the purpose of maximizing the profit.

All these considerations are combined into the complete BS scheme presented in Fig. 9. The scheme is invoked when a new event is triggered at the BS. When a new MS becomes active or an active MS becomes inactive, the BS checks the ratio between the profits obtained by updating the current tree using Algorithm 2 and that obtained by building a new tree using Algorithm 1. If this ratio is smaller than a certain threshold, then the new tree built by Algorithm 1 is used.

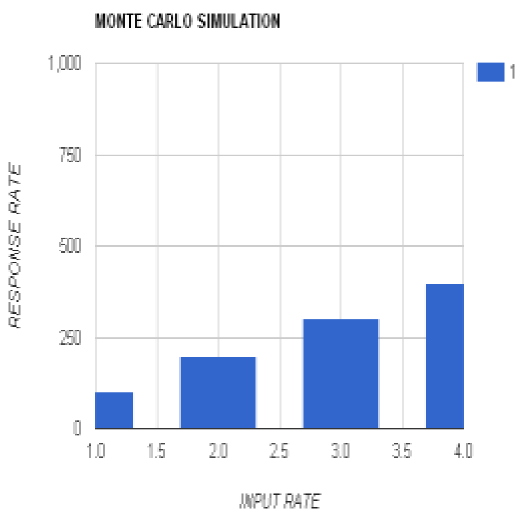
Otherwise, the current tree is updated using Algorithm 2. This ensures that the obtained profit is never worse by a factor of than the maximum possible.

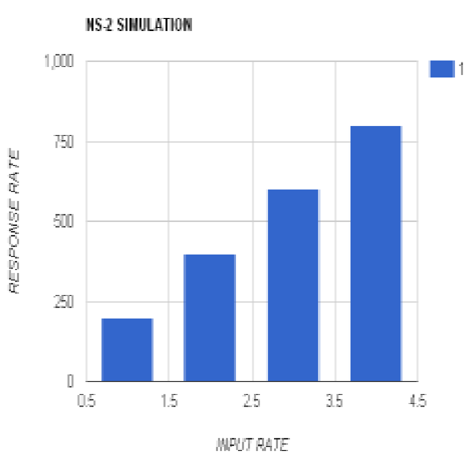
Profit achieved by the proposed scheme divided by the maximum profit that can be achieved using Algorithm 1, as a function of the thresholdnumber of CSI control (allocation and deallocation) messages sent to the MSs Increases.



Simulation study for both systems:

These both algorithms are different from each other. So two different algorithms are used to allocate channels to CSI. Both of them are working on different concepts called binary tree and token. So two different simulators are used to simulate the different system. NS-2 for algorithm 2 and Monte Carlo simulation for algorithm 1.Based on their performance the simulation chart is listed below.





VI. CONCLUSION:

In this paper we have just published the framework for the allocation of periodic CSI channels. In this proposed frame work, bandwidth is allocated as tree. Profit function plays important role in the Mobile station existence. This paper has defined two optimization problems to this framework. The simulation of these frame work shows that these optimization can be combined together to make an unique scheme. This paper uses a function that aims to maximize the number of packets sent using the correct CSI value.

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