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Dynamic spectrum sharing among the operators using AODV

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ABSTRACT

Dynamic spectrum sharing aims to produce flexible spectrum usage and improve spectrum utilization with time. we have a tendency to propose two optimization models exploitation random optimization algorithms during which the secondary operator: 1) spends the stripped price to realize the target Grade of Service (GoS) assuming unrestricted budget or 2) gains the highest profit to realize the target GoS assuming restricted budget. We have a tendency to assume that there are spectrum resources accessible for secondary operators to borrow under merchant mode. Results obtained from every model are then compared with results derived from algorithms during which spectrum borrowings are random. Comparisons showed that the gain within the results obtained from our projected stochastic-optimization framework is considerably beyond heuristic counterparts. Second post-optimization performance analysis of the operators in the form of blocking probability in various scenarios is investigated to work out the probable performance gain and degradation of the secondary and primary operators, respectively.

Keywords— *Grade of service, Budget constraints, Blocking probability*

1. INTRODUCTION

The static partitioning of spectrum in cellular networks [6] has vital operational implications that are known by in-depth spectrum utilization measurements. These measurements show that an oversized a part of the spectrum, that is allotted to cellular use, ar well utilised, however the use varies dramatically over time and house. Such variation of spectrum utilization causes the supposed spectrum holes, which may be opportunistically utilised to enhance the network's grade of service (GoS). The grade of service is mostly outlined by the extent of interference chance, wherever higher interference chance suggests that lower grade of service. Depending on type of bandwidth (1 GHz, 2.5GHz) in an exceedingly cell, location of the cell, variety of users, demand of spectrum could vary considerably and GoS is usually degraded. Therefore, operators would need extra spectrum in high demand periods to enhance their GoS.

A solution to extend the potency of spectrum utilization by suggests that of sharing has been self-addressed within the analysis domain. Spectrum sharing between operators typically leads to a substantial improvement of GoS, though it'd incur extra prices to the operators. Since network operators typically operate with a restricted budget, the borrowing selections of a network operator can be affected. Consequently, the operators would want to create dynamic, on-demand and proper decisions of borrowing extra bandwidths from different operators.
PNOs- Primary Network Operators.
SNOs- Secondary Network Operators.

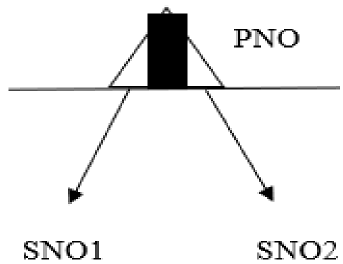

Fig. 1: Example of sharing spectrum between PNOs and SNOs

Figure 1 explains how we are sharing spectrum to SNOs from the PNOs. Unutilized frequencies of PNOs are shared to SNOs for a particular time and are shared based on their requirements. Here in figure 1 the dark part indicates utilised frequencies and remaining part indicates unutilized frequencies.

The main aim of the project is to improve the spectrum utilization, Grade of Service (GoS) and to minimize the SNOs borrowing cost and maximize the SNOs profit under the budget requirement.

The total spectrum is divided and given to primary operators for a licence period. In this period no other operators are not able to use their entire bandwidth. Frequencies utilisation varies with time so the grade of service varies with time.

Since network operators often operate with a limited budget, in the process of borrowing the borrowing decisions of a network operator could be affected.

2. LITERATURE SURVEY

A great range of studies has appeared in recent years on the look of dynamic spectrum sharing inside cellular networks.

Interests during this context embrace secondary leasing and evaluation ways among incumbent spectrum licence holders, SNOs and secondary users. The previous studies primarily centred on approaches victimization auction mode and scientific theory to implement the spectrum evaluation and allocation schemes by taking into consideration the variation of the networks demands and constraints like power, value and interference.

In the paper[1] authors report on spectrum use measurements disbursed synchronously over the quantity of 48+ hours in seven European cities. Special care has been placed on harmonizing the activity settings and instrumentation thus on acquire as comparable data as achievable. They have an inclination to explain totally the activity set up at the side of the coordinated preparation activities disbursed across the varied activity sites. They have an inclination to gift preliminary analysis of the obtained data set and notably highlight similarities and variations in spectrum use between selected activity locations. They tend to conceive to unleash later the whole data set for analysis community for the long standing time analysis. The total spectrum is split and given to primary operators for a licence amount. During this amount, no different operators don't seem to be ready to use their entire information measure.

Frequencies usage varies with time, therefore, the grade of service varies with time. Since network operators usually operate with a restricted budget, within the method of borrowing the borrowing choices of a network operator might be affected.

3. PROPOSED SYSTEM

Primary network operators are the incumbent holders of spectrum licences. In a particular period of time, they are not able to utilise their entire bandwidth because of unutilised frequencies spectrum holes are creating, which decrease the grade of service of the operators. In the unutilised period if they share spectrum to Secondary operators then the grade of service will reach a particular level. In the process of allocating spectrum to the secondary operators, we are using Radio Network Controller (RNC) methodology as shown in figure 2. Here based on the requirement of SNO RNC will share the PNO's spectrum licence for a period.

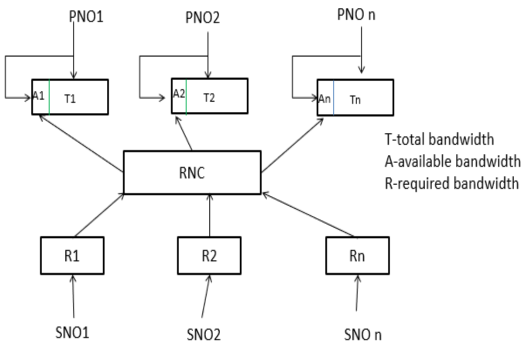

Fig. 2: Network model for a cellular network with N PNOs and S SNOs

3.1 Spectrum allocation by minimising the borrowing cost under the unrestricted budget

In this algorithm, we are going to allocate the spectrum to the secondary network operator which has less borrowing cost in the available spectrums. In the process of allocating spectrum to SNO, we select a PNO randomly which are at a 1-hop distance from the SNO location. After selecting the PNO algorithm is going to check whether the unutilised spectrum is available or not. If available then cost for borrowing that particular spectrum is calculated. Similarly, at all 1-hop distance, PNOs borrowing cost will be calculated. Now from the available spectrums which have less cost will assign to the SNO.

The optimal borrowing cost using this algorithm can only be found randomly from the set of capacity values (a_{pqr}) by satisfying the constraints(mention in equation 1) amount of spectrum bandwidths to be borrowed by SNO should not exceed amount bandwidth available at PNO which can be expressed mathematically as

$$x_{pqr} = \begin{cases} a_{pqr}(t), & r_{spq}(t) \geq a_{pqr} \\ r_{spq}(t), & \text{otherwise} \end{cases} \quad (1)$$

x_{pqr} (t)= unit of spectrum bandwidths to be borrowed from r^{th} PNO for q type resource at p^{th} cell during time interval t.

a_{pqr} (t) = unit bandwidth available from r^{th} PNO to be leased to s^{th} SNO for q^{th} type resource at the p^{th} cell during time interval t.

r_{spq} (t) = unit bandwidth required to satisfy the target blocking probability p_{ij}(t) for the s^{th} SNO's for q^{th} type resource at p^{th} cell during time interval t.

Algorithm
for every time slot (t) do
for all cells i ←1: L do
Set x_{pqr} ←{Φ} where {Φ} is an empty set.
Set counter ← $\sum c_{pqr} * a_{pqr}$
Choose a random integer n ϵ {1, 2…… N}
for all PNOs k = n : N 1 : (n -1) **do**
if 0 < a_{pqr} > (r_{pq} - counter) **then**
x_{pqr} ←(r_{pq} -counter).
break
else if a_{pqr} > 0 & (counter < rpq) **then**
x_{pqr}←a_{pqr} .
counter←counter + x_{pqr} .
else
x_{pqr} ←0.
return Total borrowing cost

3.1.1 Flow chart for minimum borrowing cost for SNO under unrestricted budget: At each randomly selected PNO in algorithm mentioned in subsection A go through the following process.

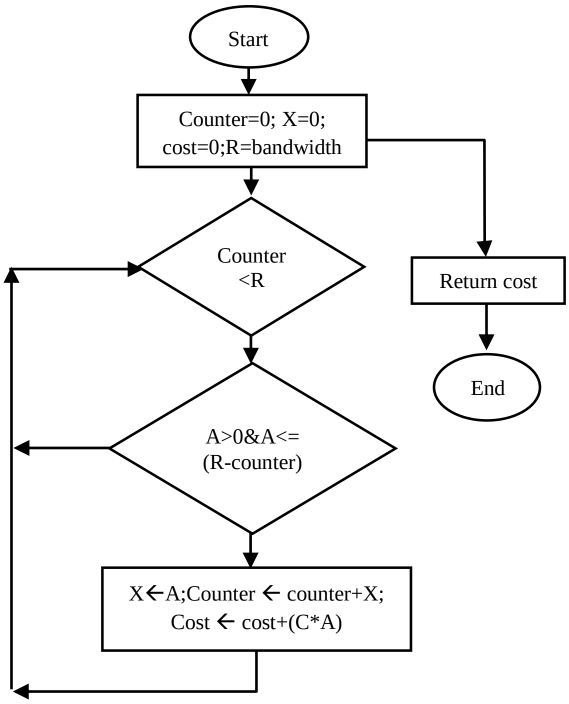

Fig. 3: flow chart for minimum borrowing cost

3.2 Spectrum allocation by maximizing the profit under restricted budget

In this section, we formulate the second spectrum allocation problem that illustrates how much spectrum bandwidths to be borrowed from each PNO to keep the blocking probability at a specific level. Given a set of possible available spectrum resources (a_{pqr} (t)), their associated prices (c_{pqr} (t)) and expected profit (γ_{pqr}(t)), the problem is to find the feasible set of spectrum bandwidths (x_{pqr} (t)) by maximizing the total profit of the s^{th} SNO, under-allocated budget and performing the selection process according to the highest possible profit combination which is similar to the selection process mention subsection A.

We solve the problem of spectrum allocation under budget constraint by a heuristic bandwidth selection algorithm. However, this Algorithm does not perform spectrum selection according to the highest possible profit combination from the set (a_{pqr}), rather runs on the randomly selected combination from the set (a_{pqr}) to satisfy the spectrum demand r_{spq}. The optimal profit using this Algorithm can only be found from the set of capacity values (a_{pqr}) satisfying the constraints we use

$$x_{pqr} = \begin{cases} a_{pqr}(t), & r_{spq}(t) \geq a_{pqr}, b_{spq} \geq c_{pqr} \\ r_{spq}(t), & r_{spq}(t) < a_{pqr}, b_{spq} \geq c_{pqr} \\ 0, & b_{spq} < c_{pqr} \text{ or } r_{spq}(t) = 0 \end{cases} \quad (2)$$

x_{pqr}(t)= unit of spectrum bandwidths (or sub-bands) to be borrowed from r^{th} PNO for q type resource at p^{th} cell during time interval t.

a_{pqr}(t) = unit bandwidth available from r^{th} PNO to be leased to s^{th} SNO for q^{th} type resource at the p^{th} cell during time interval t.

r_{spq}(t) = unit bandwidth required to satisfy the target blocking probability p_{pq}(t) for the s^{th} SNO's for q^{th} type resource at p^{th} cell during time interval t.

C_{pqr}(t) = cost of unit bandwidth to be borrowed from r^{th} PNO for q type resource at p^{th} cell during time interval t.

b_{spq} =budget for unit bandwidth from s th SNO's for q^{th} type resource at p^{th} cell during time interval t.

Algorithm

Set maximum allowed budget expenditure for every cell b_{pq}
for every time slot (t) **do**
for all cells p←1 : L **do**
Set x_{pqr}←{Φ}, where {Φ} is an empty set.
Set counter ←∑r x_{pqr} .
Choose a random integer n∈{1, 2,…. N}.
for all PNOs r = n : N and 1 : (n -1) **do**
if (0 < a_{pqr}) (r_{pq} – counter) & (c_{pqr}* a_{pqr})< b_{pq} then
x_{pqr} ← a_{pqr} .
counter←counter +x_{pqr} .
b_{pq}←b_{pq} -(x_{pqr} * c_{pqr}).
else if (a_{pqr} > 0) & c_{pqr} (b_{pq} -counter) & (a_{pqr} * c_{pqr}) > b_{pq} **then**
x_{pqr} ←[b_{pq}/c_{pqr}] where [x] means the floor of x.
counter←counter +x_{pqr} .
b_{pq} ←b_{pq} -(x_{pqr} *c_{pqr}).
else if (counter ≤r_{pq})& a_{pqr} > 0 & a_{pqr} ≤(r_{pq} -counter) & (a_{pqr} *c_{pqr}) ≤b_{pq} **then**
x_{pqr} ← (r_{pq} -Counter).
Counter←counter +x_{pqr} .
b_{pq} ←b_{pq} -(x_{pqr} *c_{pqr})
break
else if counter < r_{pq} & a_{pqr} > 0 & a_{pqr} (r_{pq}-counter) & (a_{pqr} * c_{pqr}) ≤b_{pq} **then**
x_{pqr} ←min {b_{pq} /c_{pqr}}
counter ←counter +x_{pqr}.
b_{pq}←b_{pq} – (x_{pqr} *c_{pqr}).
else
x_{pqr}←0.
return Total profit

3.2.1 Flow chart for maximizing the profit under restricted budget

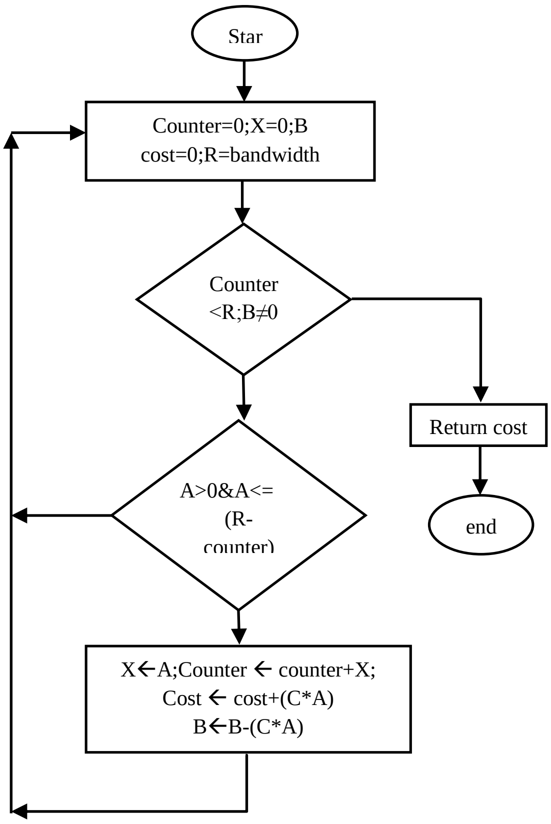

Fig. 4: Maximizing the profit under restricted budget

3.3 Calculation of cost of unit bandwidth to be borrowed from KTH PNO

We now formulate the spectrum allocation problem, that is, how much spectrum bandwidths to be borrowed from each PNO to keep the blocking probability in a specific level, for instance, at 1%. Given a set of possible available spectrum resources {a_{pqr}(t)} and their associated prices {c_{pqr}(t)}, the problem is to find the feasible set of spectrum bandwidths {x_{pqr}(t)} by minimizing the total borrowing cost. The PNOs set their prices according to the maximum allowed transmit power $\$_{pqr}$ and the pricing coefficient ϕ_{pqr}, which can be expressed as below

$$c_{pqr} = \left(\sum_{r \in a_{pqr}} \left(\log\left(1 + \frac{h\omega_{pqr}}{\varphi}\right) \right) - (\omega_{pqr}\varphi_{pqr}) \right) (a_{pqr})^{-1} \quad (3)$$

Where h is the average aggregated channel gain, %i is the additive noise received by SNO users at cell p and ϕ_{pqr} represents pricing coefficient of PNO k for the SNO in the p^{th} cell for causing each unit of interference. Equation (3) shows that PNOs select prices in a way such that the collective preference orders of transmit power, channel gain and noise are retained. This cancels the intuition that prices are selected so that all channels available for borrowing are equally preferable to a secondary. In addition, each PNO incurs a minimum cost X (min) when it leases its channel to the SNOs and therefore it is not possible to select a price lower than X (min) such that

$$c_{pqr} = \begin{cases} RHS\ of\ Eq(3), & RHS\ of Eq(3) \geq X_{min} \\ X_{min}, & otherwise \end{cases} \quad (4)$$

4. RESULTS

Step by step of simulations results:

- Initialisation each and every node with a time gap of 10ms between nodes as shown in figure 5.

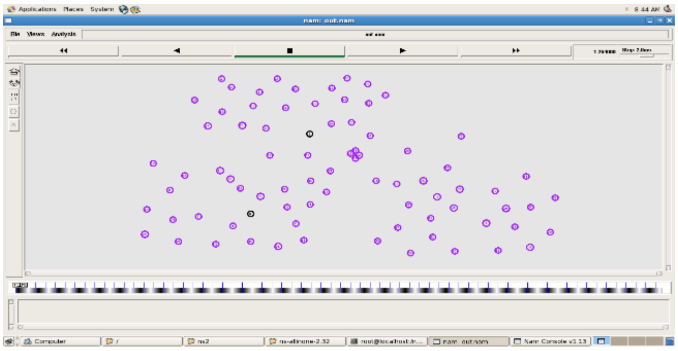

Fig. 5: Initialization of nodes

- After some time as the node get initialised the colour of the node gets change, here it is from indigo to black
- After all, nodes are initialised, some nodes change their colour to brown, here it indicates the operators need spectrum but still not allocated
- After routing (Routing is the process of moving packets across a network from one host to another.) is happened, there exists a path between the primary (host) operator and secondary (target) for spectrum sharing as shown in figure 6.

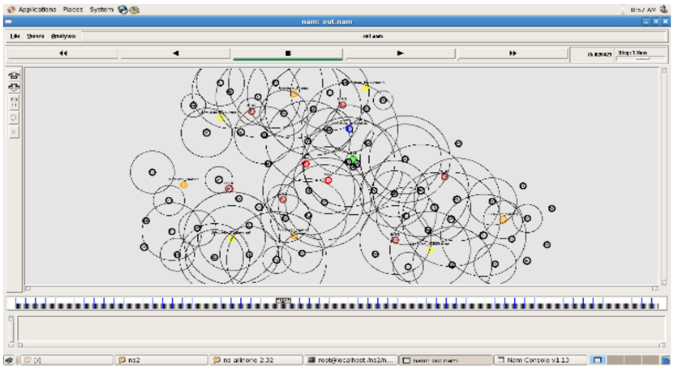

Fig. 6: Routing

- Hereafter routing, path exists between nodes. Primary operator their licence to the secondary operator for some time as shown in figure 7.

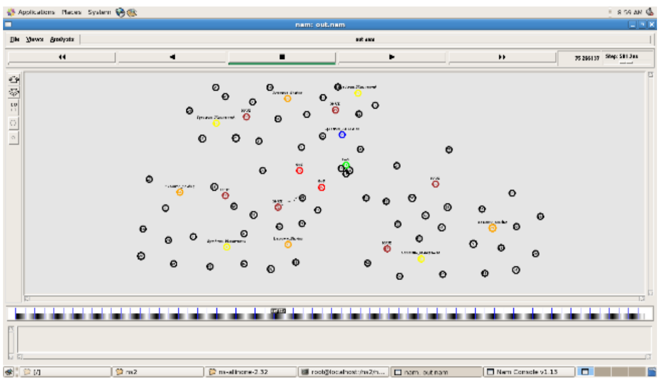

Fig. 7: Shows the path between the nodes

- Here the figure shows already existing path between the SNO and PNO
- Once the time slot for sharing is ended if the operator still needs spectrum then the new path exit between the operators
- While sharing some bandwidth will loss

5. COMPRESSION BETWEEN THE HEURISTIC AND OPTIMAL

As the cell index increases cost for heuristic is more when compared with optimal algorithms per cell as shown in figure 8.

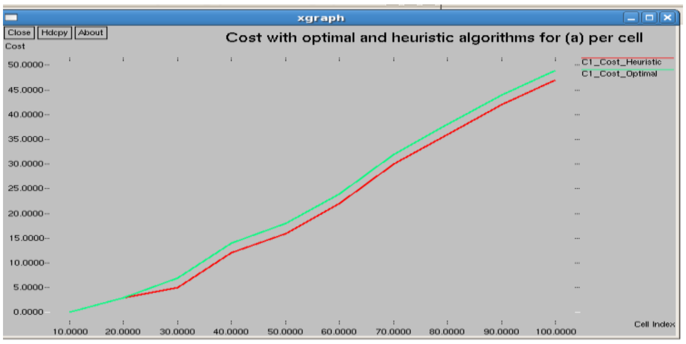

Fig. 8: Cost with optimal and heuristic algorithms per cell

Profit is constant in case of optimal borrowing methods whereas in heuristic profit decreases with the cell index per cell as shown in figure 9.

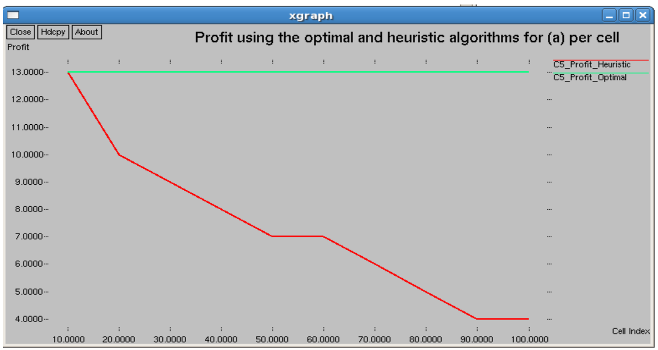

Fig. 9: Profit using optimal and heuristic algorithms for cell

In this project, we presented two optimization algorithms to solve two optimization problems for dynamic spectrum sharing. The efficiency of the proposed algorithms is compared with their corresponding heuristic algorithms. We also presented the post-optimization performance analysis of the SNO and PNOs through blocking probability, which provides useful details about spectrum sharing strategy.

The post-optimization analysis of spectrum sharing among the operators is an emerging topic that requires further research that would cover other issues like different sharing strategies (multipath rather than the single path) and configurations.

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