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Investigation of Interoperability to improve End-End connectivity in Cellular Networks

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Abstract: The need for intersystem handoff occurs in highly populated areas. In order to achieve successful MU end-end connectivity under inadequate resource conditions in same network, intersystem handover becomes vital. The development of this interoperable system may be operated either in distinct or in conjunction with the existing telecommunication networks. When the user has to communicate with the other end at anytime, anywhere without any disturbance, the wish for the intersystem handoff happens. There is a hunger after network interoperability for Next Generation Wireless Communication (NGWC) to provide the uninterrupted services like web access, audio, video streaming and IP multimedia calls. Irrespective of the network technologies and geographic regions, Interoperability enables operators to offer their subscribers the ability to easily communicate with their family and social groups who are on a different operator's network.

Keywords: *Cellular Network, Handoff, Bandwidth management, Interoperability*

I. INTRODUCTION

The call admission control and efficient bandwidth management are important issues when the multiple networks are integrated. The more important issue is the bandwidth management, because, the different types of networks supports different services with different bandwidth requirements. It is important to ensure the successful end-to-end communication between MUs. As the number of networks increases, the connectivity problem also increases due to the limited bandwidth. In telecommunication, one of the most critical issues to be concentrated is intersystem handover. The interoperability enables the users seamless roaming across different types of networks. This enhances a transfer between different service providers which improves the ability of a MU to communicate with more than one network and hence provides a good level of QoS. The important expectation of a MU is to maintain the call connectivity without experiencing any disturbance during their connection lifetime. The intersystem handover offers an end to end quality of service between multi network or multi vendor even at stressed network condition. This type of intersystem handover may happen where two different service providers co exist and overlay networks. The interoperability may be at the levels like device to device, device to network, network to network and service to service. Interoperability can be achieved by having a common protocol between the service providers or by having a standard interface between the networks. By achieving a common standard between the service providers, the limited radio resource is shared by the MUs efficiently.

II. RELATED WORK

A change over is possible to change over the connection to another cell with better radio characteristics. In previous 2G systems like GSM, the change over process tears down due to the interrupts of connection in short period with different frequency is known as hard change over. And in the soft change over, before leaving the current cell there is no interrupts in connection of using same frequency in W-CDMA performing inter-frequency change over.Efficient prioritization scheme accommodates a number of new calls while guaranties the quality of service (QoS) of change over call. The overlapping area can be used to reduce the call blocking and dropping probabilities. It was greatly researched in call change over (JAHANGIR KHAN et al, 2010)

(SAYAN KUMAR RAY et al, 2007) developed the Efficient support of seamless change over management activity is an important requirement for communication technologies that are intended to be universally accepted in next-generation communication systems. This could be because the overall macro-mobility change over performance depends jointly on the performance. The key element to successful femtocells/macro cell integration lies in its self organizing capability. Provisioning of quality of service is the main technical challenge of the femtocell/macro cell integrated networks. Base Stations can improve the spectral utilization and QoS performances. Such communications and message sharing can reduce the number of scans, allowing a fast changeover was well described (MOSTAFA ZAMAN CHOWDHURY et al, 2010).

Next-generation wireless systems (NGWS) integrate different wireless networks, each of which is optimized for some specific services and coverage area to provide ubiquitous communications to the mobile users. A cross-layer (Layer 2 + 3) Change over Management Protocol (COMP) is developed to support seamless intra and intersystem change over management in NGWS. A COMP estimates mobile's speed and predicts the change over signaling delay of possible change over is developed (SHANTIDEV MOHANTY et al,2006)

Next generation wireless network is envisioned as a convergence of different wireless access technologies providing the user enhanced connection any where any time to improve the systems resource utilization. The WLAN/HIPERLAN will become an important complementary technology to cellular networks and typically used to provide hotspot coverage where there is a high density of users. the coverage extent of WLAN/HIPERLAN and CN is also computed by comparing the actual RSS with mobiles threshold settings alidated by simulations are described (K.AYYAPPAN et al,2008).

The existing mobile networks technologies namely Global System for Mobile (GSM) and General Packet Radio Systems (GPRS) have the same Radio Access technology. Universal Mobile Telecommunications Systems (UMTS) based on Wide band Code Division Multiple Access (W-CDMA) introduced a new Radio Access Technology. Inter frequency change over is a major issue for services continuity is to provide the customer with seamless services. The behavior of the system and switching modes are described (BELAL ABUHAIJA et al, 2008).

Nowadays, Wireless Mesh Network is the best solution for extending the coverage of Wireless LAN. Users move to wireless communication networks and expect the same level of performance as their wire line counterparts.TRAN CONG HUNG et al**,** introduced Wireless Mesh Network and describe the change over schemes, leading to a new method for optimizing change over and a new power control approach optimization is crucial for guaranteeing the performance of soft change over.

Operators have to increase the WLAN coverage and charge the user for their great applications and services. Users benefit from the increasing number of new and useful applications and services. They can also maintain the online connection, when moving from one wireless system to another.(GOUTAM RAMAMURTHY et al,) presented Vertical HO is currently in the standardization state at 3GPP and propositions and designs are available in plenty to choose the best solution, keeping interoperability and backward compatibility.

Long Term Evolution (LTE) is considered as the basis of next generation mobile Internet. LTE Standards accommodate the use of Mobile Internet Protocol (MIP) to support inter-technology mobility between LTE and other generations.(DILSHAD MAHJABEEN et al,2011)proves that LTE (4G) provides better interoperability performance than other generations.

Uncontrolled development of wireless and mobile communication technology aims to provide the seamless continuous connection to access various wireless technologies and to have connection with the best network which provides the best quality of service (QoS). Select the best network for a mobile terminal when moving from one network to another, it is necessary to have a good decision making algorithm which decides the best network for a specific application that the user needs based on QoS parameter described (A. BHUVANESWARI et al, 2012).

(JAYDIP SEN et al, 2007) introduced an Efficient change over mechanisms are essential for ensuring seamless connectivity and uninterrupted service delivery Issues in location registration and change over management have been identified and several existing mechanisms have been presented in wireless networks. . Media Independent Change over Services of IEEE 802.21 standard as an enabler for change over has also been presented Security and authentication issues in next-generation. The UMTS technology was designed naturally as a mobile network. Hard change over allows only low speed mobility portability or simple mobility. Every Mobile Station (MS) communicate directly via Base Station (BS). The second topology is denoted MESH. In this mode, two MSs communicate without employment of BS. An advantage of this change over type is not using of explicit change over signaling messages when anchor BS is changed are described (Z. BECVAR et al, 2007).

(TONY SUN et al, 2006) presented a seamless change over solution, called Universal Seamless Change over Architecture (USCO). USCO is simple and requires minimal modification to the current Internet infrastructure. When change over from a low capacity link to a high capacity link, there is no service latency caused by the change over; whereas when the change over is from high capacity link to a lower capacity link, the non-negligible latency could not be alleviated unless early change over notification can be provided. Change over mechanism are mainly used when a mobile terminal (MT) is in overlapping area for service continuity in wireless networks main challenge is continual connection among the different networks like WiFi, WiMax, WLAN, WPAN etc.Visitor Networks (VN) for the continuous connection by the mobile terminal. The decision phase of the change over phases to take decision to which VN the mobile terminal to connect by different decision algorithms were described (K. SAVITHA et al, 2011). In wireless communication new technologies emerges regularly with faster data rates and larger coverage area. In order to reduce the latency two mechanisms such as neighbor bandwidth reservation and gateway relocation are employed. The parameters such as vertical change over delay, Mobile scanning interval activity, neighboring advertisement received are obtained that and seamless connectivity can be achieved are described (PARTHIBAN et al,2011).

The importance of wireless communication is increasing day by day throughout the world due to cellular and broadband technologies. Everyone around the world would like to be connected seamlessly anytime anywhere through the best network. The requirements like capability of the network, change over agency, network cost, network conditions, power consumption and user's preferences must be taken into consideration during vertical change over VCO mechanism for 4G wireless networks that has the ability to satisfy maximum number of requirements improved (MANDEEPKAUR GONDARA et al, 2011)

III. ACHIEVING INTEROPERABILITY

The intersystem handover can be made successful if the different service providers have a common platform of standards. This may also be achieved by developing a standard interface that suits different network hardware elements. At the early stages of deployment, the network planning is a very important key. While planning the network, the vendor should analyze the geographical area, the type of customers and the services expected by the customers. While designing a network, a liberty should be given for the customer to migrate any network under unavailable resource condition while the call is in progress. The service provider should check the latest development and promotion of the universal intersystem handoff. It will be a confusing process for the MU to agree the new standards and system introduced by the vendor frequently. So it is the prerequisite of the service provider to establish a perfect QoS for the MUs. So whatever may be the standard developed, it should not disturb the MU in getting an unbroken service. This has given an opportunity to develop this thesis on supporting the handoff between two different network systems to make available uninterrupted call connectivity between the end-to-end users. The interoperability happens at different levels like Physical level, Network Level or at application level. Here in this research, the network level interoperability is analyzed and found to be an efficient mechanism to reduce the call failures in a cellular network. For a well established cellular network, developing a new standard or a hardware infrastructure is difficult. So a new algorithm is developed here to efficiently manage the available bandwidth. This ensures that the existing investments are reused as far as possible. Integrating the software would be easier when compared to a complex hardware development. Dynamic management of the bandwidth is developed allowing the operators to offer services to the users. Handover between two different networks has an appreciable effect on the capacity of the system through the sharing of load. This is proposed in Decisive Effort Best Service Algorithm (DBESA).

IV. BENEFITS OF INTERSYSTEM CHANGEOVER

The interoperability between different networks rewards the users, operators, manufacturers and the authorities in several ways. The users receive uninterrupted service under serious insufficient resources conditions, whereas the revenue of the operators will increase by offering the required service compromising the availability of the resource. The same hardware could be used when the planning and designing of the network is perfectly done at the earlier stage itself. This enhances the manufacturer to enjoy the sales and marketing. The authorities offer the required service for the user when a natural disaster or human disaster happens.

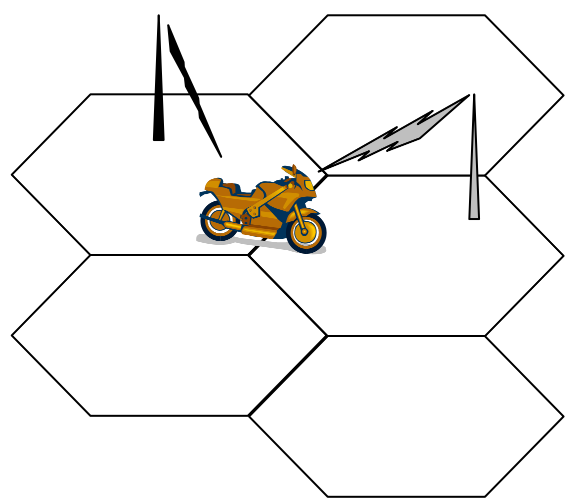

Fig.1 Inter System Handover between two service Providers

Inter system handovers are essential to support compatibility with other system architectures. For example, when the 3G networks emerged, the rural areas were not covered completely by WCDMA network. So the GSM networks are still used to provide better coverage in rural areas. But a WCDMA network supports additional capacity. So an algorithm designed to enhance intersystem handover, enables resource sharing of the overloaded network. Inter system handover over occurs in between cells belong to two dissimilar Radio Access Technologies (RAT) or different Radio Access Modes (RAM). The majority common case for the first type is usual between WCDMA and GSM/EDGE systems. Handover between two different CDMA systems or between two different GSM also belongs to inter system handover type. Fig 1 shows the intersystem handoff between two different service providers.

During intersystem handover, a mobile at the same time communicates with two or more cells belonging to different BSs of the identical MTSO (intra-MTSO) or different MTSOs (inter-MTSO).

V. DBESA

In Soft handover the UE can be connected to more than one channels at the same time, it is also known as make before break because it keep the previous channel from source until it gets the channel from source cell. Although soft handover increase the complexities but it has many advantages also like the high hand over success rate and reduction of call drop probability and elimination of inference

Two different channel types are identified here to carry the traffic to maximize the throughput. The channels are either in a common pool or faithful channels. The faithful channels are used for voice communication. The resources are efficiently utilized and this supports soft handoff. The common channels are used for transferring limited information. The admission control designed here avoids the system overload. It is a compromise between coverage and capacity of the system. This admission control algorithm estimates the network load. When a new or handoff call arrives, based on the estimated load the call is either admitted or rejected. This algorithm also maximizes network usage depending on the arrival of calls.

When the user moves from one place to another, the network may still get overloaded. If that kind of overload occurs, the algorithm triggers the inter frequency handoff and transfers the M Us to less loaded operator's network. A best effort service is offered here in which the no resources are reserved and the bandwidth is allocated depending on the arrival of the calls and the priority assigned to the arrival. Best Effort Service algorithm is executed if

1. When the signal strength of the MU in a cellular system falls below a given threshold, the MU measures the signal strength of the next operator's signal strength. If the signal strength of the available operator's is good, the MU is ready to get transferred to the second operator's network.
2. If the available resources are not sufficient to continue the call, the MU is transferred to the second operator.

The main challenge to achieve this inter system handover is the technical feasibility solutions for the User Equipment (UE) and the network implementations. The UE needs to measure two different operators' network while the call is in progress. For example, if the MUs call is in progress in GSM network, it needs to measure the CDMA network, if no resources are available in the primary network. The function of the operator is to maintain the QoS to the MU and the MU should not experience any interrupts of the ongoing calls when they move out of coverage of the primary network or if the primary network suffers from shortage of resources.

The two modes of mobility operation are:
User Equipment-Controlled Mode (UECM)
Network Controlled Mode (NCM)

In UECM, the user equipment selects the cell to which it has to connect and in NCM the network decides the cell to which the user has to connect. The load of the network is one of the important parameters to select the target cell. The UE measures the cell continuously while performing the cell selection. When the quality of the signal measured is falling below the threshold, the UE scans the received signal strength of the in close proximity operators.

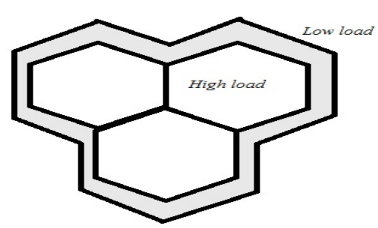

Fig 2. Cell Load

If the close by operators signal strength is exceeding the minimum threshold, when no resources are available in the primary network, the UE selects the other operator's network whose signal strength exceed the minimum threshold. The admission control varies depending upon the traffic load.

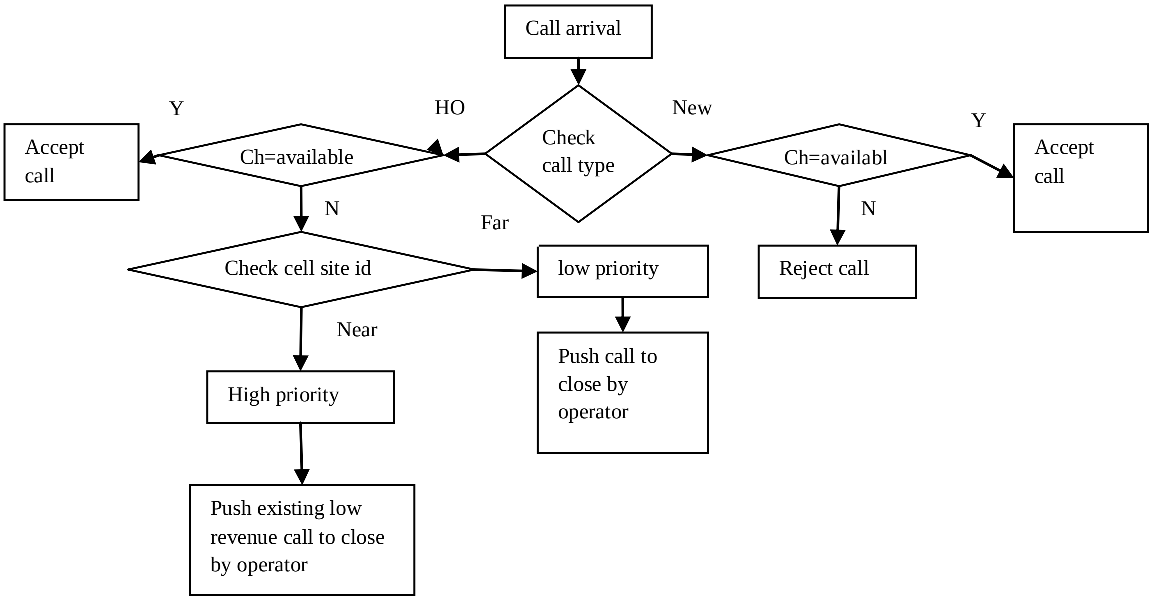

Fig 3 Simplified flow chart of DBSEA

When load of the cell is less, i.e. Number of users is less in the cell; the MU gains good QoS even from a long distance long distance base station. But when the number of users in the cell is high, to get a good QoS even when the MU is close to the BS is difficult because of the interference level of the nearby subscribers. The other reason is that there is a heavy competition between the users to get the required resource. So an innovative idea suggested here is to move the low priority users to the less loaded cells and keeping the high priority users in the primary network. This will improve the network revenue as well as provides a satisfied service to the customers.

Admission Control: When a MU arrives to a cell, the admission control algorithm designed estimates the network load, then the new arrival load is either allowed to enter the network or blocked. Here depending on the user's demand, the operator expands the network usage within a set of network QoS levels. If the algorithm is inefficient, even network overload may occur because of the frequent movement of users' from one place to another.

To avoid this kind of overload, the following actions are performed by the DBESA.

- The bandwidth allotted to the existing non real time users' shall be degraded
- Some of the MUs are moved to less loaded frequencies by inter frequency handover
- In worst case, some of the less priority MUs are forced to terminate to keep the QoS of the existing high priority calls

In the proposed admission control, shown in Fig 3, the arrival of the calls is examined to fix priority to the arriving calls. Table 1 shows the arrival and corresponding priority fixing. Here two different classes of calls are considered, audio and video. The arrival of new calls is designated as λ_1 and handoff is λ_2. The handoff audio call (λ_{2a}) is assigned highest priority and new audio call (λ_{1a}) is assigned lowest priority. Here the priority assignment is done based on the distance between the cell sites. To interrupt long distance call is more annoying compared to the short distance call.

Table 1 Priority Assignment

Call Arrival	Distance between Cell site	Revenue paid by user	Priority Assignment
λ_{2a}	Very long	Low	1
λ_{1v}	Short	High	3
λ_{2v}	Long	High	2
λ_{1a}	Very nearby	Low	4

So when a long distance call arrives, the mechanism designed here pushes a existing low revenue new call, for example λ_{2a} to the less loaded cell, The total bandwidth available in a cell is B_{max} and the bandwidth allotted to the existing users is B_x.

The bandwidth remaining for new arrivals is

$$B_r = B_{max} - B_x \quad (1)$$

The handoff video call is dropped if and only if

$$B_{2v} \square B_x + B_{2a} \quad (2)$$

Where B_{2v} is the bandwidth required for handoff video call, B_{2a} is the bandwidth required for handoff audio call, B_{1v} is the bandwidth required for new video call.
The lowest priority new audio call is blocked only if

$$B_{1a} \square B_x + B_{2a} + B_{1v} + B_{2v} \quad (3)$$

Where B_{1a} is the bandwidth required for new audio call of same cell and operator.

VI. RESULT

The system is assumed to have four different service providers and the channel sharing is done between them inorder to reduce the call failures due to network overload. The number of call arrivals assumed is 100, 4 different network operators are considered and the traffic arrival is studied for 10 cycles.

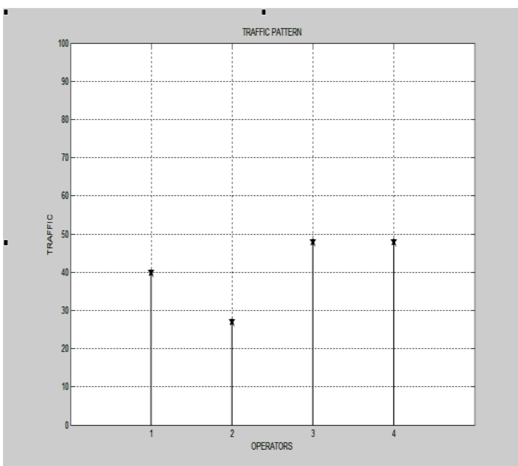

Figure 4 Traffic arrival of four different operators

Figure 4 Shows the traffic arrival of four different operators. The operator 4 is experiencing more traffic and it is anticipated that call failures in operatator 4 will be more than other operators. To overcome this drawback the algorithm proposed in this chapter suggests to have a common sink node which acts as a bandwidth allocator. In this sensible situation, the bandwidth allocator searches for the free channels in the close by less loaded operators.

The actual scenario of bandwidth allocaiton is demonstrated here. Figure. 5 Shows the channel allocaiton pattern of different operators. Operator 3 and 4 experiences maximum traffic and operator 1 experiences lesser traffic comparatively.

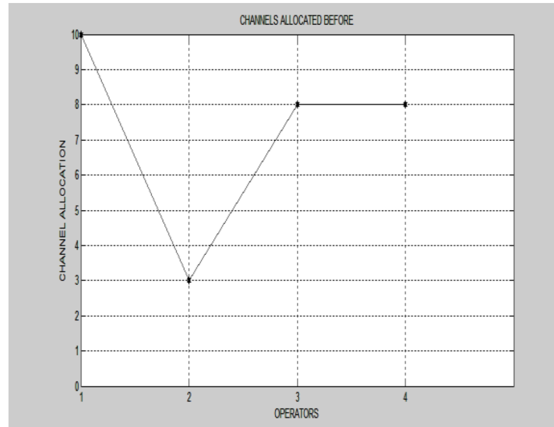

Figure 5 Channel allocaiton pattern of different operators

Though the traffic experienced by operator 1 is less than operator 3 and 4, the channel utilization is maximum in operator 1's MTSO. Further new arrivals experiences lack of resources and hence will be blocked from continuing the call.

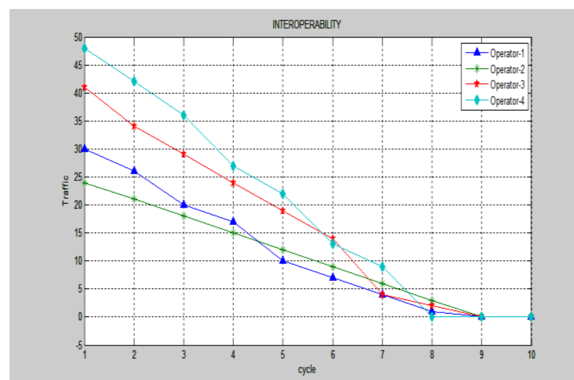

Figure 6 Traffic arrival to the operators at different time interal

By implementing the proposed algorithm, the channel allocation is done uniformly to all operators by the bandwidth allocator. Figure 6 shows the traffi arrival to the operators at different time interal. The traffic arrival is studied at different cycles. From Figure 5, it is seen that, initially peak traffic arrival is experienced by the operators.

The traffic consitutes both the handoff arrivals and new arrivals. It is evident that, as the algorithm is implemented, there is drastic decrease in traffic congestion. The total traffic arrival rate of operator 4 is 48 calls initially. The bandwidth allocator checks the traffic of other operators and transfers some low priority calls to the less loaded operators. So, in cycle 4, the traffic present in operator 4 has reduced to 23 calls. In this scenario, the existing calls throughly enjoys the requested QoS and uninterrupted service. This is because of controlling the congestion in operator 4's network.

In cycle 3, the operator 3 experiences 45 new arrivals and in cycle 4 the call arrival is 37. It is found that the channel allocation to the operator is reduced by 10% in cycle 4.

In cylce 3, the load experienced by operator 4 is 84 calls and the channel allocation is 70%. In cycle 5, the same network experiences a load of 67 calls but the channel allocation is 90%. This is because the network accepts calls of high priority and high revenue. So the bandwidth allocator carefully allocates the channels required for the users

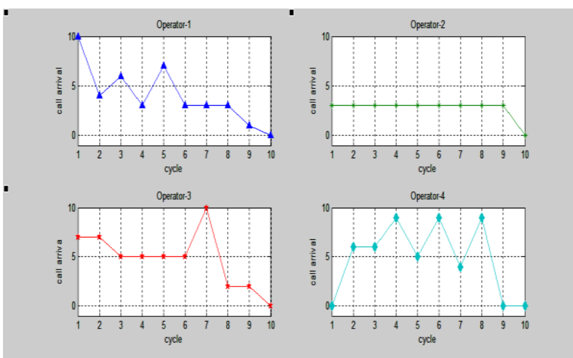

Figure 7 Channel allocation to different operators

Depending on the total call arrivals, the bandwidth allocator allocates channels to the service providers. This is demonstrated in Figure 7. In cycle 4, the call arrival rate for operator 2 is 15 calls and 30% channels are allocated to carry this traffic. Depending on the prioritization, the bandwidth allocator share the available channels between the operators. It is evident that at different cycles of arrivals, proportionate channel sharing is processed. The channel sharing between different operators is one intellegnet approach to reduce network overloading.

It is observed from Figure 7 during the tenth cycle, the traffic arrival is considrably reduced in all the operators, since the call arrivals are distributed among the operators depending on the existing network load.

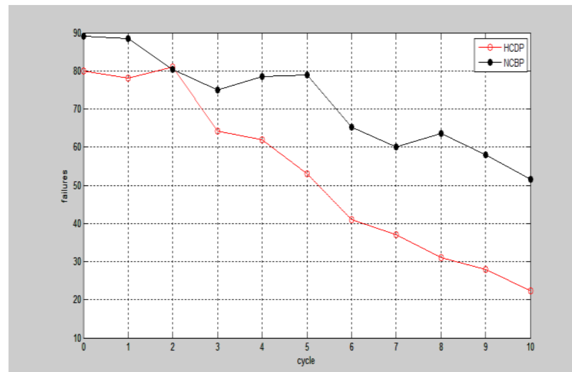

Figure 8 Collective call failures in a cell

In this experiment, the total load of the cell is considered. Irrespective of the type of the network, channel sharing proposes a drastic reduction in collective call failures. This distinguished feature is demonstrated in Figure 8. The collective HCDP and NCBP in a cell, irresepcetive of network operator is found to be minimized. The new algorithm proposed in this chapter is suitable for a congested cell and overloaded networks.

VII. CONCLUSION

The possibility and performance of interoperability of service providers is examined in this paper. An extensive simulation is done to demonstrate the ability of the algorithm and to show that the call failures is reduced to a remarkable level. The algorithm proposed here is found to be suitable for networks with unexpected arrival of traffic. This algorithm also facilitates the network to reduce congestion and improve the revenue of the service provider. The available bandwidth is efficiently shared dynamically for the users so that the users enjoy a successful journey for their calls.

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