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Intelligent Multi-Operator Based Network Selection in Cellular Networks

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ABSTRACT

The network selection problem in cellular network is an optimization issue for its complexity. It needs well-designed approach in solving it as common handover techniques cannot optimally resolve the problem. This paper intends to present an effective network selection scheme using a genetic algorithm scheme getting better outcomes in terms of optimality concept. In this research, an intelligent technique is developed to select the most optimized network from mixed operators seamlessly. This is accomplished with the use of Genetic Algorithm that intelligently choose the best network for utilization while determining the appropriate network parameters for optimal selection between different GSM network providers.

INTRODUCTION

Rapid growth in the field of wireless network Telecommunication has brought numerous advancements to better the human life. However, challenges such as poor quality of services and limited channels availability upon high demands are peculiar to the current state of mobile communication networks. These may result to call drop, call block, illogical handoff among others. Efficient algorithm is needed which can seamlessly control the connection session at all time as long the users are connected to the network. Inability of non-selection of best network by the users leads to poor quality of service where vital network parameters are not being pre-checked and evaluated considering the optimality of the best network for utilization. There have been cases of low optimal selections (or poor network selection) reported by subscribers on various GSM providers and one perceived solution by User is the subscriptions to various mobile network providers. In this research, it is envisioned that the use of Genetic Algorithm (GA) intelligent optimal scheme for network selection in an overtly laid multi-network environment will ameliorate the improper selection of the limited channel and bandwidth available for network communication. The choice of determining the network with better Quality of Service (QoS) for handoff despite being on similar technological (GSM) type is highly demanding and a serious optimization work.

In Global System for Mobile Communication (GSM), the allocation of network resources which is channel in this case is a problem that requires pre-emptive measures and solutions in Optimizing the usage of the available limited resources.

Though, over the recent past, there have been remarkable Innovations in Telecommunication industry regarding the introduction of various mobile computing and communicating techniques (Yan and Mani, 2008). Present quests for network resources in a mixture of overlapped and overlaid GSM networks with guaranteed QoS anywhere and anytime have continued to generate interest around the world. In solving this problem of channel assignment, one of the proposed solutions is the introduction of seamless network connections and handoff in an overlapped GSM system (Dekleva *et al.,* 2007).

Despite initiation of handover between network of same type and networks of different types, there is still increasing demands for utilization of communication services and resources. The limited availability of these resources has led to present situation whereby mobile user subscribers to different mobile networks only to be able to access network whenever the arises. A typical mobile user with over four different phones with each phone subscribed to different network is shown in Figure 1

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Fig. 1. A user having many mobile phones at a time

This problem has been in existence since the inception of GSM system. The increase in mobile users has brought a corresponding increase in the explosive demand for: its limited resources; the necessity for effective channel assignment; and selection of network in overlapping networks environment. The optimal solution to this limited channel problem is the selection of the best network with highest optimal fitness value from the available networks at any time for communication session. Since, most GSM system is an overlapping hysteresis area and it is expected to provide good services with respect to the user's demands, hence the key goal is to provide simple uninterrupted connection to the demanded service at any time, irrespective of the network, location by the selection of network with highest optimal value (Lampropoulos *et al.,* 2008). The selection of network for handover with minimal delay and maximized throughput is a complex optimization problem. It has been shown that handover in GSM network with network selection parameters and reduced number of handoffs with the aid of artificial intelligent is more efficient than that of cellular network in public domain network (Zhu and Kwak, 2007). Hence, selection of optimal network is expected to solve the problem of users subscribing to more than one GSM provider. Figure 2 depicts the real environmental scenario where a mobile user is located in an area covered by different cell (BSs) networks represented with different colours. Each user is a representation of GSM cell that allocate channel to mobile station. Thus, it is obvious that selection of a network with higher throughput is an optimization problem being faced on daily basis.

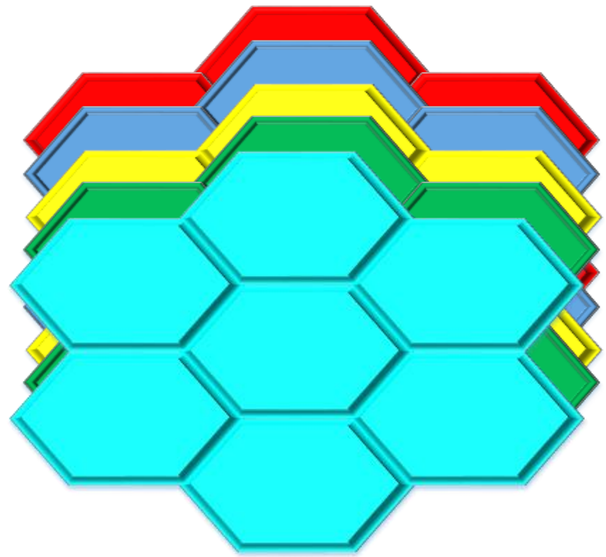


Fig. 2. Overlapped cellular structure

LITERATURE REVIEW

Review of Handoff Technique in wireless network

The main focus of this research work is seamless handoff of calls and data over various GSM networks. Thus, handoff represents the bedrock of the work. Thus, in this section, review of handoff techniques based on different categorization will be presented. Figure 3 shows the classification of handover techniques obtained from various literatures. Handoff and Handover are interchangeably used in this report as both are similar in meaning and technical-wise. Detailed explanation of each technique is presented herewith.

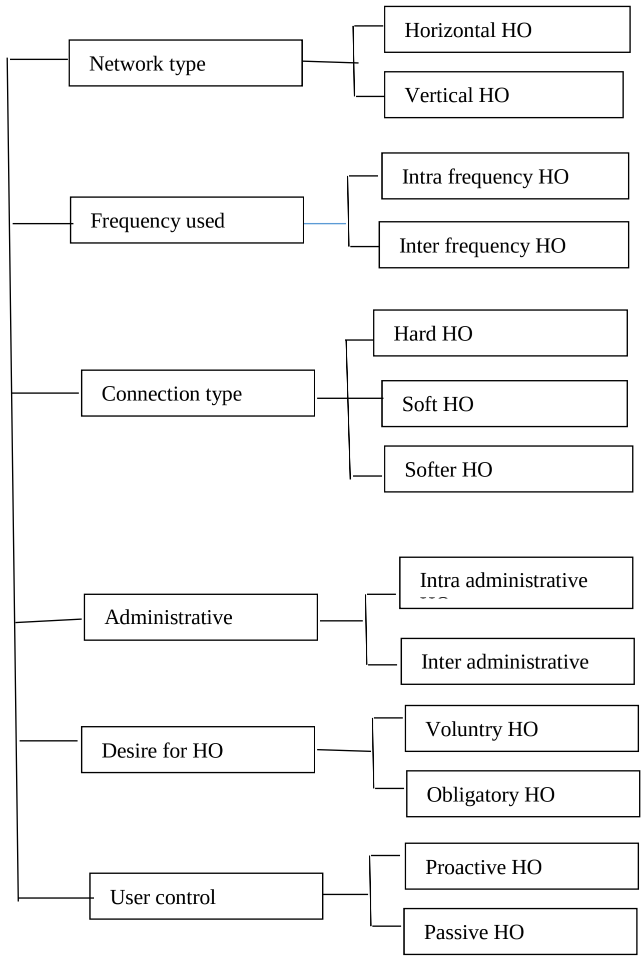


Fig. 3. Handover classification

Handoff based on Network type

Horizontal handoff (HHO) occurs when a call or user is handoff to a similar network type for seamless data and voice communication. Transmission of signal from one GSM base station to another GSM base station is an example of Horizontal handoff. Here, user routes in two closes by BSs in GSM cellular network.

Handoff based on frequency used type

This is based on the operating radio frequency of the BS in which a Mobile station (MS) transvers in the network coverage area. Intra-frequency and Inter-frequency. The Intra-frequency is execution of handover for mobile station across network access points operating on the same radio frequency. While the Inter-frequency is the handoff for mobile station on different frequencies for communication. This occurs in CDMA networks with time division duplex supported in GSM.

Number of Handoff based Connection

In considering which base station is serving the mobile station during the execution of handoff. Hard handoff occurs when a base station is served by one BS only at a time while the soft handoff is a situation where a mobile station connects to many access networks for handover (Zhu *et al.*, 2006). In Soft handoff, a MS is allowing to connect to many access networks during handover process (Zhu *et al.*, 2006) and is almost similar to soft handoff except that the connections in radio link is from the same network access point (Nasser, 2006).

Handoff based on Administrative domain

A MS traversing from different networks control by the same administrative base while inter-administrative HO occurs in a situation where a MS handoff from one network of different administrative bases to the other. The terminal end of the users is paramount as it considers factors like QoS, power usage, service cost as well as non-real time actions for optimum utilization (Calvagna and Modica, 2004).

Handoff based on Necessity for Handover

The feature here bases on cost function. The scenario where is necessary for a mobile station in an access point to handoff another network access point to prevent disconnection along the link is called obligatory handover while that of voluntary handover is the situation where handoff is optional that might lead increasing QoS or not.

Review of Handoff based on User Control Allowance

Making signaling based sensitive the preference of the network users. The proactive handoff is a situation where the mobile terminal's user is permitted to decide when to handover from one network to the other. The decision is at the discretion of the user's preference while in that of passive handoff, the user cannot decide over the handoff process (Nasser, 2006).

Wireless Networks Handoff Parameters based on Signal strength

The RSS of the serving and target networks are compared as a deciding factor for handoff execution. The handover is needed when the identified RSS falls below a benchmark level. The RSS threshold values and a noise in wireless cellular network are -95dbm and -100 dBm respectively (Zhang and Holtzman, 1996).

Wireless Networks Handoff Parameters based on Bandwidth

Bandwidth rendered by the access network to the mobile station can also be used as a criterion for handoff in cellular network (Zahran *et al.,* 2006).

Wireless Networks Handoff Parameters based on Signal to Interference Ratio (SIR):

Signal to interference ratio is to measure the quality of the communication which triggers the algorithm when the SIR of the present BS drops less than that of the threshold value with the availability of other BSs of higher RSS.

Handoff based on Artificial Intelligence (AI) Techniques

Various handoff techniques according to Artificial Intelligence has also been carried out in the literature. Neural network, Fuzzy Logic and Genetic algorithm have been used for taking Handoff decision (Xia *et al.,*.; Nasser *et al.,* 2007;2007). The neural and fuzzy logic are used to model intelligent techniques coded as handoff schemes that train large input data to carryout optimal decision making. Adaptive handover fuzzy technique is proposed by (Israt *et al.,* 2008), Here, the velocity and distance were used in finding the measure of the adaptive threshold value of the RSS vital for triggering the handoff in wireless network. (Nasser *et al.,* 2007), presented a vertical handoff network arrangement that depends on neural networks to choose the best cellular network. This approach is dependent on the user's network preference and network parameters such as bandwidth, security and cost function were normalized between 0 and 1 based on the network parameters to be fed into ANN algorithm.

A multi-adaptive handoff technique implemented with fuzzy logic is presented and optimizes Elman neural system is proposed in (Guo *et al.,* 2005). In this methodology, RSS is fundamentally used to trigger handoff choice procedure while the neural system is used to forecast the number of network users in terminal network. The number of users and the mobile station speed, and the bandwidth of the terminal network served as input data to the fuzzy network.

A novel handoff decision for overlapped networks comprising of BS and WLANs is established in (Xia *et al.,* 2007). The terminal network was chosen using a fuzzy logic based standardized quantitative selection algorithm.

Alkhawlani and Ayesh, (2008) proposed a scenario where fuzzy logic and genetic algorithm make decision and adaptive, effective and realistic solution to the handover problems. At the decision-making stage, the fuzzified system reduces the inference rules and complexities and the outputs obtained from this stage as normalized form with their estimated weights are optimized by GA. The combined results are passed into the multi-functional system to improve the handoffs operation.

Channel Assignment in Wireless Network.

The transmission capacity or bandwidth accessible to the cell framework is scarce. In general, the bandwidth available is partitioned permanently into various channels and these channels are allotted to cells without violating the least reusable separation constraints. A resource congested channel occurs when there is unavailability of the network resources to the subscriber at the time of request. Cells utilize the distributed channels for calling or communication session (Isah *et al.,* 2014).

Kim *et al.,* (1997), proposed energy function that minimizes the total number of assigned channels from the available channels, but due to the larger scale of a cellular network system and many neurons needed, its computational time will be increased and thus, decreases performance. The allocation of channel decision is satisfying by each mobile station and base station, and the entire system information is not needed. The optimum performance is less achieved as the assignment principles based on mobiles on the edge of the cell where a single cluster size is fixed (Chong and Leung, 2001). Reducing the interference due to the demand constraints and limiting the random search smaller than the entire state space by other schemes and partially deterministic to search after the disappearance of chaos (Wang *et al*., 2004).

The scheme is characterized by parallelism for detecting problem difficulty from different areas without heuristics. There is possibility of linking the algorithm to "soft" interference criteria. The least probability of excess interference is ignored initially to take care of inadequate number of functioning channels (Kunz, 1991).

Fixed Channel Assignment (FCA)

Fixed channel allocation (FCA), is the scheme where cellular channels are stich permanently assigned to each user. In FCA frameworks, the duty of MSC is limit and communicate the new BS about handoff demands, and to get an affirmation or dismissal message from the new BS, about the handoff (Katzela and Naghshineh, 1996).

Dynamic Channel assignment

In dynamic channel assignment, any channel is permitted to use any cell if the interference constraints are met. Having more than one channel in the pool to be allocated to cell which needs a channel, some techniques must be used to choose the allocated channel (Cox and Reudink, 1971). The key purpose of DCA technique is to choose a candidate channel with selected minimum cost. This might base on the unknown call blocking probability in certain cell, interference, useable frequency spectrum, traffic condition, frequency reuse distance, mean call blocking probability of the cellular networks system (Tekinay and Jabbari, 1991).

Hybrid Channel Assignment (HCA)

Hybrid Channel Assignment (HCA) scheme assign some channels statically and other channels dynamically. It is a combination of FCA and DCA schemes. In HCA plans, aggregate channels of mobile network are divided into fixed and dynamic. The channels involved in the fixed set are allotted to every cell through utilizing the FCA plans. While, the dynamic arrangement of channels is shared by the base stations. When a mobile user requires a channel for its call, and every channel in the fixed set are occupied, then a solicitation from the dynamic set is made. In the process of assigning channel to a base station, information with respect to the cellular network and system condition is needed. This information can be user priori pattern of demand, current information of the network operation state and status of accessible channels (Farid *et al.*, 2007).

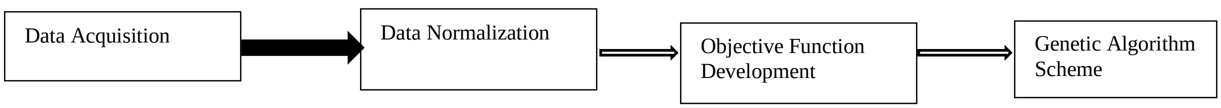
Table 1 Justification for GA-based techniques and others schemes

S/N	Scheme	Cost function	Optimization	Network size	Computational time	Complexity	Flexibility	Efficiency	Performance rate
1	(Kin *et al.*, 1997)	Low	High	small	High	High	high	Low	low
2	(Funabiki *et al.*,2000)	High	High	Large	High	High	Low	High	Low
3	(Kunz *et al.*, 1991)	Low	Low	Large	High	High	Low	High	High
4	(Wang *et al.*, 2004)	Low	Low	small	High	Low	Low	High	Low
5	(Chong and Leung, 2001)	High	Low	small	High	High	Low	Low	High
6	(Pattavina *et al.*, 1995)	Low	Low	Large	High	High	Low	High	High
7	(Chen and Chong, 2003)	Low	Low	small	High	High	High	High	High
8	(Yu and Leung, 1997)	High	High	Large	High	High	High	Low	High
9	(Levine *et al.*, 1997)	High	High	Large	High	Low	High	Low	High
10	(Cuppini, 1994)	Low	High	Large	Low	High	High	High	High

MATERIALS AND METHODS

Genetic Algorithm Based GSM Network Selection Technique

This part has elaborate explanation of the research implementation as shown in block diagram below and the justification for adopting the scheme. The GA-based handoff algorithm was developed as shown in figure 4.



Fig, 4, Mythology Structure

Determination of Optimal parameters for Horizontal Operator Handoff

GSM network handover between various mobile network operators involve accurate determination of the required parameters. These parameters measure network status over various operators' systems, thus giving insight to the QoS status of each network. This research work considered the received signal level (RXLev), received signal quality (RXQUAL), Bandwidth (BAND), time advance (TA) and bit error rate (BER). Table 2 shows the selected network parameters, considered very important in measuring the numerical status of a network for effective and efficient good QoS of network prior to handoff.

Table 2. Selected Network Parameters

S/N	Parameter	Parameter Symbol	Definition
1	Received signal level(strength)	X_1	The received signal strength of the serving cell measured on all time slot and subset of time slots. That is power corresponding to the received signal of the downlink as measured by mobile station
2	Received signal quality	X_2	The level signal corresponding to the mobile station perceived quality of the downlink by mobile station
3	BAND	X_3	The parameter that shows in which frequency band a mobile station is currently operating.
4	Bit error rate	X_4	The ratio of number of bit error to the total number of bits transmitted in a Studied time interval
5	Time advance	X_5	The time that base station calculates from the access burst and send to the mobile station to enable it advance its transmission time to the base station to compensate for the propagation delay.

Data Normalization

Data normalization is defined as process of allocating attributes to entities. The normalization of data is vital as the selected networks parameters are of different units, ranges and values to ensure data integrity, reduces data redundancy, compliment data modeling and reduces data anomalies level. In this work, data normalization has been undertaken in order to provide similar range for all the data during optimization process. Thus, parameters with higher or lower values are not at disadvantageous position during minimization or maximization operation respectively. The equation 1 is used to obtain the normalized experimented data from different operators.

$$\beta = \frac{\alpha - \min(\alpha)}{\max(\alpha) - \min(\alpha)} \qquad 1$$

The use of min-max data adopted for this work is given in (1),

Where β is the normalized data, α is the data to be normalized, min(α) is the lower bound for x and max(α) is the upper bound for data α .

. **Mathematical Formulation of Handoff Objective Function**

In the development of the Handoff Objective function, the 5 selected parameters for network a, be arranged in vector form as in (2).

Thus, in Matric form, this gives as in (3.2),

$$\left.\begin{matrix} X_1 & = & \chi_{1,1} & \chi_{1,2} & \chi_{1,3} & \cdot & \cdot & \cdot & , & \chi_{1,N} \\ X_2 & = & \chi_{2,1} & \chi_{2,2} & \chi_{2,3} & \cdot & \cdot & \cdot & , & \chi_{2,N} \\ X_3 & = & \chi_{3,1} & \chi_{3,2} & \chi_{3,3} & \cdot & \cdot & \cdot & , & \chi_{3,N} \\ \cdot & = & \cdot & \cdot & \cdot & \cdot & \cdot & \cdot & , & \cdot \\ X_N & = & \chi_{N,1} & \chi_{N,2} & \chi_{N,3} & \cdot & \cdot & \cdot & , & \chi_{N,N} \end{matrix}\right\} = N_{bs} \qquad 2$$

Where $\chi_{i,j} \varepsilon P^n, i, j = 1,2,..., \mathrm{N}, \mathrm{X}$ (N=no of networks, χ =number of parameters, n = 1,…, pop size) and N_{bs}= best selected network.

Thus, the formulation of objective function involves thus:

$f(\chi)$ = p^n

Thus, $y = f(\chi_n)$ can be formulated as

$$f(\chi) = f(\chi_1, \chi_2, \chi_3, \chi_4, \chi_5) \qquad 3$$

where $\chi_1, \chi_2, \chi_3, \chi_4, \chi_5$ are the input parameters and y is the output data in (2).

Since the work is about the selection of an optimal network, hence this is an optimization problem, the equation 3.3 is the function to compute the fitness values of respective parameters data and they must all be optimized. In a compressed form, the formulation for the objective function is given as:

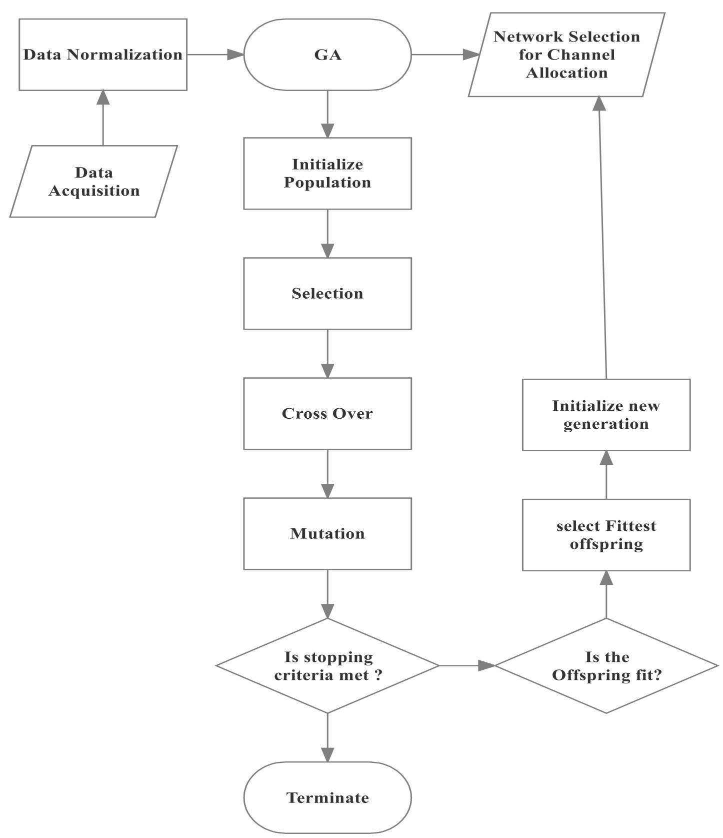
$$f(\chi_i) = \sum_{i=1}^{n} \chi_i \qquad 4$$

$$f(\chi_5) = \chi_1 + \chi_2 + \chi_3 + 1/\chi_4 + 1/\chi_5$$

Where χ_i is the input GSM parameters data, n (=5) is the network and i = 1, 2…,5. (number of network parameters used).

Development of GA-based Handoff Algorithm

GA is among the known evolutionary algorithms (EA) that uses principles of biological evolution process in the search for the optimal solution of a given problem (Golub, 1996). GA flow diagram as used in this work is as shown in Figure 5 . GA reduces the risk of convergence to local minima a major shortcoming of those optimization techniques being be effective and robust search algorithm that allows the quick location of high quality solution areas in a large and complex search space (Branke, 1995; Weiss, 1994). Though, it uses probabilistic rules to guide its search, by favoring the mating of the fitter individuals.



Fig, 5, GA based Handoff Algorithm flowchart

GA was used to determine the optimal network parameters in this work. In determining the optimal GSM network to connect to, potential network parameters was represented as a set of parameters called genes. Genes are joined together to form a string of values called chromosome (Srinivas and Patnaik; Beasley *et al.*,; Holland, 1994;1993;1975). In this work, since five parameters have been selected, i.e. x_1, x_2… x_5, these were joined togther to form a chromosome. Chromosome representation in this work is an array of bits called binary, thus each chromosome consists of a binary representation of the network parameters. The required number of bits, n, in equation (4), required to convert the network parameters after normalization to binary bits is is given as

$$2^{n-1} < \{\chi_{max}(j) - \chi_{min}(j)\} \times 10^k \le 2^n - 1 \quad 5$$

where $[\chi_{min}(j)$ and $\chi_{max}(j)]$ are the lower and upper limits of the model order respectively and k is the number of decimal point. Furthermore, given n, the precision (6) value $(\Delta\chi)$ is given as

$$\Delta\chi = \frac{\chi_{max}(j) - \chi_{min}(j)}{2^n - 1} \quad 6$$

The precision value of the binary chromosomes can be increased by increasing the number of bits per chromosomes (Srinivas and Patniak, 1994; Jamaudin, 2009; Michalewicz, 1994). Similarly, the decoding operation is given as in (7)

$$\chi(j) = \chi_{min}(j) + bin2dec(binary\ string) \times \frac{\chi_{max}(j) - \chi_{min}(j)}{2^n - 1} \quad 7$$

where bin2dec converts the binary string to decimal (Jamaluddin, 2009).

Individuals were selected for recombination and reproduction for next generation population space from the available population space of likely optimal network parameters solution. Thus, the parents were selected randomly from the population using roulette wheel selection scheme and the selected chromosomes were recombined using the mechanisms of single point crossover technique to alters each gene with a small probability. The population evolves over successive generations so that the fitness of the best and the average individual in each generation increases towards the optimum model order. Thus, convergence is the progression towards increasing uniformity of the solution space towards convergence and optimization of networks parameters.

Implementation of the proposed algorithm

The normalization of the data within the Lower and Upper bounds was implemented consisting the acquired GSM network parameters in Table 4.

Table 3. Lower and Upper Bound for Identified Network parameters.

S/N	parameter	Parameter name	Lower bound	Upper bound
1	X_1	received signal level	25	50
2	X_2	received signal quality	0	30
3	X_3	frequency band	0.8257	1
4	X_4	bit error rate	0	19.7
5	X_5	time advance	1	23

Table 3 contains vital network parameters acquired from the GMS networks with SIM900 GSM shield in real time. These parameters form the basis of the acquired data to carry out the performance analysis where X_1 ranges between: 25 and 50 dBm, X_2: 0 and 30 dBm, X_3: 0.8257 and 1 MHz, X_4: 0 and 19.7 dBm and X_5: 1 and 23 second bounds. These parameters were randomly generated in the neighborhood of ten different networks to determine fitness value of the parameters of the available networks.

Network parameter Optimization

$$f\chi_i) = f(\chi_1, \chi_2, \chi_3, 1/\chi_4, 1/\chi_5) \quad 8$$

This consists of Genetic Algorithm which has basic operations: selection, crossover, mutation and termination. Initially, selected parameters (data) are termed initial population. The selection is a very vital part of the GA operation where an objective function is used to perform operation (computation) on the selected data and scoring the networks based on their associated fitness values from the data (x_1, x_2, x_3, x_4 and x_5). In this work, the selected parameters were normalized equation using equation 1. The optimization of the normalized data is performed with the developed objective function in MATLAB to reduce redundancy of data. as follows in (7).

Developed Objective Function

$$f(\chi_i)=f(\chi_1+\chi_2+\chi_3+1/\chi_4+1/\chi_5)$$

Where $\chi_1,\chi_2,\chi_3,\chi_4,\chi_5$ are the input network parameters as in table 5 and $f(\chi_i)$ is the output data representing the fitness value of each parameter and sum total optimization computational weight of every network as in (7) above. This objective function is used to select the fittest individual network at each generation.

Genetic Algorithm Implementation

The Genetic algorithm as an optimization technique was adopted in this research. It is to maximize the selected parameters to develop optimal network selection scheme. The GA operation in this thesis used the parameters shown in table 4.

Table 4. GA parameters used

S/N	GA parameter	Value
1	Population	5 by10(5*10)
2	Number of generations	1000
3	Fitness scaling	Rank
4	Crossover technique	Heuristic
5	Probability of crossover	0.8
6	Mutation technique	Uniform
7	Generation gap	0.9
8	Lower boundaries	25, 0, 0.8257, 0, 1
9	Upper boundaries	50, 30, 1, 19.1, 23

Initiation population

1. The matric elements represented the initial population generated as N*X. This represents a network selection at the end of each iteration or generation.

Selection Operation

2. At the end of row in (X…Xn), a fitness values of each parameter were computed with respect to each network.

3. Step 2 was repeated for all the parameters and networks available.

4. A pair of parents (X_a, X_b) of high fitness values at the end of each row operation are selected as parents to mate.

5. Step 4 was performed equal to the number of networks (N_1, N_2, N_3, …, Nn) under consideration to select best optimized network at the end.

Crossover operation

6. The Pc, (cross over rate) in Table 3.3 was applied to the selected parents (parameters) to mate and reproduce offsprings of optimized values (solutions).

7. Assigned fitness to offsprings as in step 2 with respect to their inherent parents $(X_1, X_2, X_3, ..., X_N)$ components.

8. check if the cross over condition is met/Ok/Finished.

Mutation operation

9. Applied Pm (mutation rate) in Table 3 if step 8 is achieved to select the selected “crossovered” offsprings to make alteration to retain the composition of their original parents, else.

10. Steps 4-9 were repeated.

11.Optimal value for a network (Ns) was computed and incorporated the new individual (Xs) into the population to keep the initial number.

Termination

12. Terminate, if optimal value is obtained, else.

13. Repeat steps 7-11.

RESULT AND DISCUSSIONS

The Normalized and Optimized values for first Generation

Table 5. Normalized and Optimized values for first Generation

Network	Network parameter					NGV	GAV
	X1	X2	X3	X4	X5		
1	41.108	6.232	0.8799	11.363	2.881	48.6553	62.464
2	34.465	9.037	0.987	5.008	6.775	44.8365	56.2721
3	45.289	14.128	0.901	11.514	18.622	60.4584	90.4545
4	38.321	6.915	0.858	13.584	1.643	46.7754	61.3203
5	38.768	25.329	0.983	4.235	21.435	60.3637	85.751
6	48.475	5.843	0.997	2.243	17.067	55.8189	74.6244
7	46.898	6.778	0.902	5.667	11.749	54.8401	71.9943
8	38.754	5.121	0.845	6.089	13.728	44.9573	64.5364
9	40.562	6.829	0.871	8.102	6.22	48.5467	62.5843
10	39.676	13.071	0.897	9.7	11.095	53.8372	53.8372

The result obtained from applying GA technique on the selected parameters for the first generation is shown in Table5 where column GAOPV represented the range of fitness values for the ten networks considered for the first generation. To confirm the optimality of the Genetic Algorithm-based, the generated data was run through the developed objective function with GA in MATLAB platform and obtained results better off in Table 5 From this, as in Selection Operation network three will be selected for communication or channel allocation as it has the highest optimal value of 90.4545. This shows a higher numerical value as a translation of better optimal network to provide quality services to the network users.

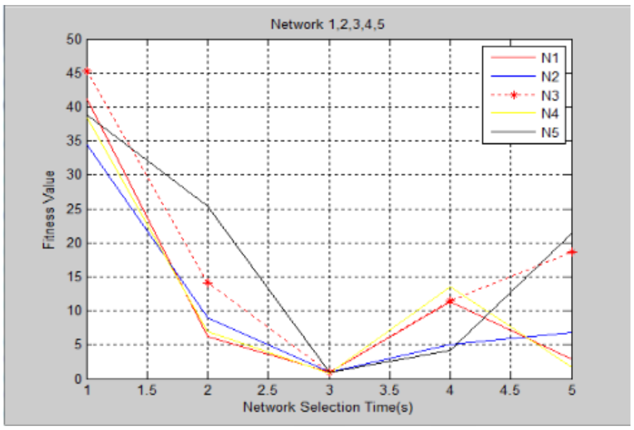


Fig. 6. Combined first five networks analysis for 1st gen.

The Figure 6 shows that network 3 has the highest optimal value, despite in mixed cellular networks. This algorithm seamlessly selects the best (N_3) in this scenario irrespective of the network providers.

The developed algorithm performs better than other "non-GA" as shown in Figure 7. The gain of 30 with GA-based shows an improved contribution by selecting a network with high optimality and sharp decrease in percentage ratio in the error rate and the connection period between the network 3 and the closest network in value and as well the consistent rise in signal level, quality, and bandwidth of network 3 indicated that it can give better network services to users

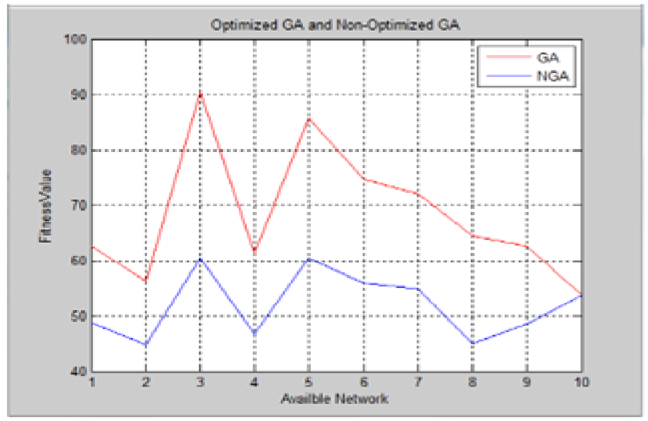


Fig. 7.GA and NGA networks selection analysis for 1st generation

CONCLUSION

In this work, the selection of optimal network for GSM handoff over different networks have been undertaken and network selection parameters have been determined. The developed technique was applied in a real-life scenarios and subsequent analysis of its performance was carried out. It was observed that GA-based technique for seamless handoff was developed. Thus, establishing the applicability of GA in selection of best network of higher optimal value to allocate channel to mobile station in a multi-network providers' environment. The developed algorithm can also be applied in network resource management and prioritization in the telecommunication where necessary. Experimental results have proven that the developed system outperforms the traditional computation in optimality rate of network selection.

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