On Performance Optimization in Self-Organizing Networks using Enhanced Adaptive Simulated Annealing with Similarity Measure

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***Abstract*-Network performance optimization is among the most important tasks within the area of wireless communication networks. In a Self-Organizing Network (SON) with the capability of adaptively changing parameters of a network, the optimization tasks are more feasible than static networks. Yet, with an increase of OPEX and CAPEX in new generation telecommunication networks, the optimization tasks are inevitable. In this paper, it is proven that the similarity among target and network parameters can produce lower Uncertainty Entropy (UEN) in a self-organizing system as a higher degree of organizing is gained. The optimization task is carried out with the Adaptive Simulated Annealing method, which is enhanced with a Similarity Measure (SM) in the proposed approach (EASA). The Markov model of EASA is provided to assess the proposed approach. We also show a higher performance through a simulation, based on a scenario in LTE network.**

Keywords-components; Self-Organizing, Similarity Measure, Simulated Annealing, Uncertainty Entropy, Markov Model, Degree of Organization

I. INTRODUCTION

Performance evaluation and optimization of wireless communication networks are among the most important tasks as they are directly related to energy efficiency and value-added strategies. With an increase of OPerational Expenses (OPEX) and CAPital Expenses (CAPEX) in the new generation of networks, optimizations are inevitable. The overall capacity for different cells can be increased, while at the same time, human interaction will be decreased. Thus, the optimization in SON is usually known as self-optimization.

Although in literature, there is no evidence of a unified framework for SON, it has main features, such as globally coherent pattern, local interaction of the nodes, parallel and/or distributed. In this study, a new approach to satisfy the first feature is presented while other features have been supposed. Consequently, a Degree of Organizing (DoO) has been chosen, based on input/output UEN as a measure of disorder:

$$\text{DoO: } [1-\text{UEN(out)}/\text{UEN(in)}] \quad ; 0 \le \text{DoO} \le 1 \tag{1}$$

As the entropy of a system is monotonically related to the DoO, a proof shows that the output entropy of a system will be of lower value for a closed self-organizing system. Here, exploring the similarity in the optimization process produces a higher DoO, which indicates lower disorder in the SON. The similarity between the set of target parameters and the set of network parameters is measured statistically. As a statistical measure, the Similarity Measure (SM) is among the most realistic measures for such approaches. The SM of order P between two L-dimensional vectors is defined as:

$$SM(x,y) = \Big\{\sum_{i=1}^{l} S^{p}(x_i, y_i)\Big\}^{1/p}$$

$$S(x_i, y_i): similarity \;\; between \;\; x_i, y_i \tag{2}$$

To gain a coherent pattern among nodes, we propose the Key Performance Indicators (KPI) as target parameters of a network in which every node interacts locally to optimize (maximize) its performance towards the KPIs. Consequentially, every node in SON needs to search the states space to find its attractor.

For the optimization, using SA, there are several approaches regarding the annealing process in the literature, but scheduling with respect to the target values has not been conducted. We integrated the similarity measurement in the Adaptive Simulated Annealing (ASA) method, which differentiates the annealing process from that of the classical method. Thus, the final Enhanced Adaptive Simulated Annealing (EASA) method is proposed for the optimization process.

II. SYSTEM MODEL

To evaluate the performance optimization in EASA we exploited the in-homogeneous Markov Model (figure 1), where we considered m as number of the underlying and n as the number of total states. Every transition probability is calculated as conventional method. The annealing process in EASA is influenced by similarity, as we have:

$$T(t) = \alpha(SM)T(t-1) \;\; and \;\; T_0 : at \;\; t = 0 \tag{3}$$

where SM is the similarity measure and α is a linear function of SM. Therefore, T as the temperature is changed over time at a non-constant rate, which depends on the similarity measure here. Figure 2 shows the upper and lower bounds for the annealing process in EASA, as any value within these bounds can be applied during an optimization process.

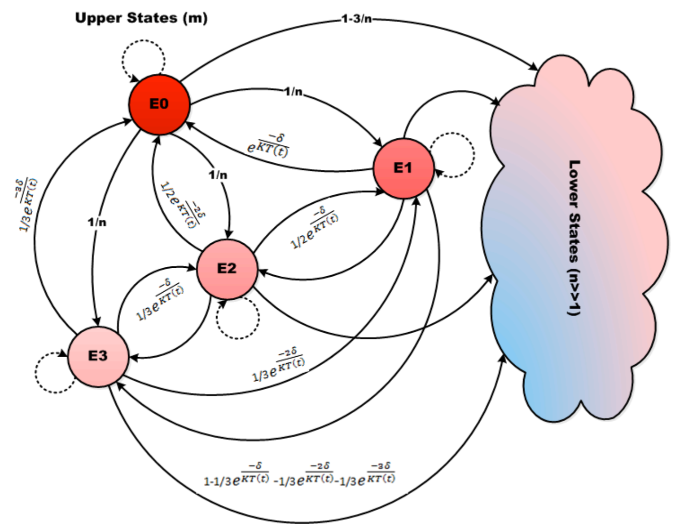

Figure 1: Markov Model for Proposed Algorithm (m=4, n>>1)

Also, according to the previous statement regarding the annealing temperature, it can be changed non-monotonically during the processing time. In practice, the ideal annealing rate cannot be determined beforehand and should be empirically adjusted for each problem. If the rate of annealing is high, so-called quenching, it is most likely to be trapped in the local minima. Then the annealing is a key process during optimization using SA. Annealing Adaptive Search (AAS) suffers from lack of measure for new schedule of annealing. This is essential as we can avoid dependency on the initial values for different nodes in SON.

To see how it does affect UEN, the model in figure 1 has been considered and calculations carried out for n>>1, if $p := \exp\{-\delta/(KT_0\alpha^t)\}$,K is Boltzmann constant, generally for m states, the UEN can be proved as:

$$UEN(m,p):\ -\Big\{\sum_{q=1}^{m}\sum_{r=q}^{m}[p^q \log(p^q/r)/r] \quad \ldots + \sum_{r=1}^{m} \begin{matrix}[(1-p/r-\ldots-p^r/r)\ldots \\ \log(1-p/r-\ldots-p^r/r)]\end{matrix}\Big\} \qquad (4)$$

Firstly, we evaluate UEN for an in-homogeneous model as it is depicted in figure 3 for m=4, with and without similarity. As it can be seen from figure 3, the SM as similarity measure improves the DoO of the underlying system by decreasing the output UEN. After achieving state of the equilibrium, the overall decrease using the similarity is much higher than the classical optimization and therefore, the DoO in the same system will be higher. The distributed algorithm for EASA, as an extension of the current study, should be a more reliable approach for performance optimization in cellular/sensor/ad hoc networks. This study on the Distributed EASA (DEASA) is on-going.

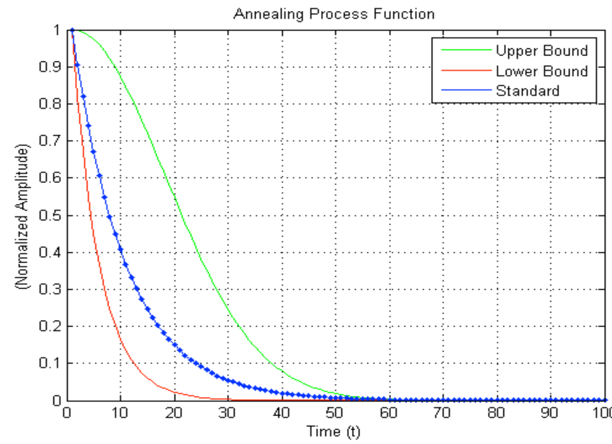

Figure 2: Annealing Function and Boundaries for Proposed Method

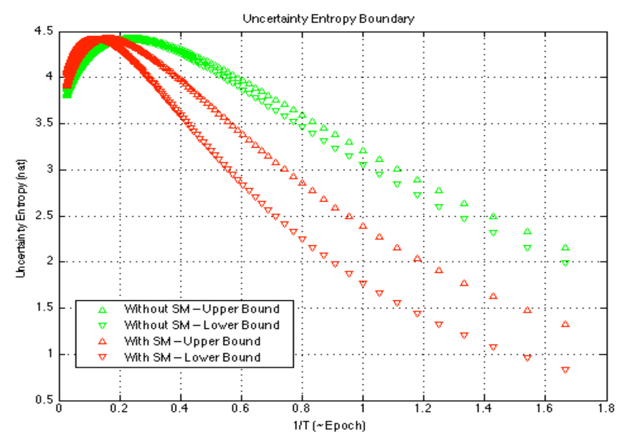

Figure 3: Uncertainty Entropy using Similarity Measure in EASA

III. Results and Conclusion

We considered LTE for simulation the Coverage & Capacity Optimization use-case (CCO) that is one of eight self-optimization use-cases recommended by 3GPP. The results show the performance using similarity outperforms other methods under the same conditions.

[*the simulation is presented separately*]

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References

[1] H. Peyvandi, “Self-Similar Self-Organizing Network (S3ON): Part I: System Model”, Tech. Rep., CCSR, University of Surrey, 2011.

[2] L.A. Zadeh, “Similarity relations and fuzzy orderings”, Information Sciences, Vol.3, pp 177-200, 1971.

[3] L. Ingber, “Adaptive Simulated Annealing (ASA)”, Control and Cybernetics, 1996.

[4] F. Heylighen, “The Science of Self-Organization and Adaptivity”, The Encyclopedia of Life Support Systems, 2001.