THE GENETIC NEURO-FUZZY CDMA CONTROLLER

In the work it has been proposed to use fuzzy logic, neural networks and genetic algorithms in CDMA networks for channel allocation. Architecture of the genetic neuro-fuzzy controller was developed. Linguistic variables, terms and membership functions for input and output values have been defined. Rules base has been developed. Mathematical models for the genetic neuro-fuzzy controller have been presented. The genetic algorithm structure has been developed.

Keywords – CDMA, channel, cell, fuzzy-controller, neural network, genetic algorithm.

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ГЕНЕТИЧНИЙ НЕЙРО-ФАЗІ КОНТРОЛЕР ДЛЯ CDMA

Anotomy - у роботі запропоновано у мережах CDMA для призначення каналів застосовувати такі сучасні інтелектуальні технології як нечітка логіка, нейронні мережі та генетичні алгоритми.

Для мереж CDMA запропоновано фазі-контролер, що має дві вхідні та одну вихідну лінгвістичні змінні. Вхідними лінгвістичними змінними розробленого фазі-контролера є числа вільних каналів \( N \) та навантаження у комірці \( L \), а вихідною – можливість передачі \( C \). Для кожній змінній визначені терми та функції належності.

Також у роботі розроблено структурні схему нейро-фазі контролера. Розроблено базу правил, що складається із 6 шести правил типу “якщо-то”, Подано математичні моделі роботи кожного із трьох шарів нейро-фазі контролера.

Розроблений пристрій пропонується використовувати у мережах CDMA для удосконалення механізму керування перерозподілом каналів у випадку їх перевантаження.

Introduction

In the third generation of the CDMA systems, it must be able to support integrated services applications and keep different quality-of-service requirements guaranteed. Fuzzy systems, neural networks, and genetic algorithms have replaced conventional techniques in many engineering applications, especially in control systems. When combining fuzzy logic, neural networks, and genetic algorithms it is possible to get a hybrid system that can process uncertain values and can be trained and optimized. In modern telecommunication networks the control techniques [1-5] are widely used. Fuzzy and neural network control has been used to improve the system performance for CDMA. The implementation of these schemes is based on the concept of fuzzy set theory and the experience of operators constructing a control scheme without adequate mathematic model. The great advantage of GAs is that they can find a right solution through evolution. It is suggested to use a genetic neuro-fuzzy controller for channel allocation in the CDMA system that allows avoiding calls dropping.

Architecture of the fuzzy controller

We propose to use in CDMA networks a fuzzy controller having two input and one output linguistic variables (fig.1). Input linguistic variables of the fuzzy-controller are a number of free channels \( N \) and load in the cell \( L \), its output variable is channel transference \( C \).

Fig.1. The architecture of the genetic neuro-fuzzy controller

For defining the number of free channels \( N \) terms “few” and “many” are used. Thus, the term set of the number of free channels \( N \) is:

\[ T(N) = \{ Few(F), Many(M) \} \]

Membership functions for \( T(N) \) are presented on fig. 2,a.

For defining the load in the cell \( L \) terms “low”, “moderate”, and “high” are used. Thus, the term set of the load in the cell \( L \) is:

\[ T(L) = \{ Low(L), Moderate(M), High(H) \} \]

Membership functions for \( T(L) \) are presented on fig. 2,b.

For defining the channel transference the terms “big transferring”, “small transferring”, “small
Membership functions for $T(C)$ are presented in Fig. 2.c.

The proposed fuzzy controller works according to a rules base consisting of six rules:

1. if $N = F$ and $L = L$ then $C = BT$;
2. if $N = F$ and $L = M$ then $C = ST$;
3. if $N = F$ and $L = H$ then $C = ST$;
4. if $N = M$ and $L = L$ then $C = SA$;
5. if $N = M$ and $L = M$ then $C = BA$;
6. if $N = M$ and $L = H$ then $C = BA$.

Neural network operation

The proposed neuro-fuzzy controller block diagram is presented in Fig. 3.

In layer 1 each input gets a corresponding fuzzy value:

$N \Rightarrow N_F, N_M$;
$L \Rightarrow L_L, L_M, L_H$.

In layer 2 each node represents firing strength of a rule:

$w_1 = \min[N_F, L_L]$, $w_2 = \min[N_F, L_M]$, $w_3 = \min[N_F, L_H]$, $w_4 = \min[N_M, L_L]$, $w_5 = \min[N_M, L_M]$, $w_6 = \min[N_M, L_H]$.

Layer 3 normalizes the firing strength:

$w_i^p = \frac{w_i}{w_1 + w_2 + \ldots + w_6}$.

In layer 4 crisp values are obtained:

$D_1 = w_1^p \cdot C_{BT}$, $D_2 = w_2^p \cdot C_{ST}$, $D_3 = w_3^p \cdot C_{ST}$, $D_4 = w_4^p \cdot C_{SA}$, $D_5 = w_5^p \cdot C_{BA}$, $D_6 = w_6^p \cdot C_{BA}$.

The output of layer 5 is an overall output:

$D_0 = \sum_{i=1}^{6} D_i$.
Genetic algorithm

In this neuro-fuzzy controller it is suggested to use a genetic algorithm (fig.4).

The fitness function is as follows:

$$F = \frac{1}{a \cdot R_{ncb} + b \cdot N_{lp} + c \cdot D}$$

$a$, $b$, $c$ – coefficients,

$R_{ncb}$ – new calls blocking rate

$N_{lp}$ – lost packets number

$D$ – delay

Conclusion

Radio Resource Management is one of the most important engineering branches in third-generation mobile communications where the radio spectrum is a much needed resource. Such systems are to provide mobile multimedia services like voice, video, high-speed Internet, data, etc. CDMA systems are in some way very attractive because they allow complete frequency reuse in a cellular network.

Hybrid systems combining fuzzy logic, neural networks, and genetic algorithms have proved their effectiveness in a wide variety of problems. Combining these intelligent technologies it is possible to get a hybrid system that can process uncertain values and can be learned and optimized. Using fuzzy controllers allows avoiding congestions in the network. Using neural networks permits to control input calls and the quality of service. Using genetic algorithms allows optimizing the network structure.

So, in this work the genetic neuro-fuzzy controller for channel allocation in the CDMA-network has been designed. Usually the channel allocation for load balancing uses fixed thresholds in order to distinguish the status of each cell. But fluctuations may occur when loads are around the threshold. This results in wasting significant efforts in transferring channels back and forth. The resulting device inherits the advantages of fuzzy systems, neural networks, and genetic algorithms, while avoiding the disadvantages of these techniques.

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