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Design and Simulation of a Proposed Location Management Model for Cellular Networks

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Abstract: In this model, a 4-layerd (3 hidden layers and 1 output layer) are used Artificial Neural Network (ANN) with three inputs (BS1-BS3) and two outputs (x and y). The three inputs of the ANN represent the signals strength of three different Base Stations (BS1-BS3) which are received by the Mobile Station (MS) and used to determine the location of the MS as a point with 2 coordinates x and y which represent the 2-outputs of the ANN then the position of MS will be send to the MSC to inform it about the exact location of the MS within the specified area. The three hidden layers consist of 3-nodes or neurons, 4 and 8-nodes, respectively and by applying a powerful learning algorithm called the Back Propagation Learning algorithm (BPL) to find the set of network weights that minimizes the network's cumulative error. The mobile unit regularly informs the MSC about its location result in avoiding the paging problem.

Key words: Component, cellular network, handoff management, neaural network, backpropgation algorithm, Iraq

INTRODUCTION

A cellular service area is partitioned into several Location Areas (LAs) or registration areas. Each LA is made up of one or more cell areas. A Mobile Station (MS) registers with the Visitor Location Register (VLR) each time it enters a new LA. The Mobile Station (MS) is free to move inside a given LA without a registration when it moves into a new LA, it registers with the network and the new location of the terminal is stored in a database in the new VLR (Location update) so that incoming calls can be routed to the correct LA (Hata and Nagatsu, 1980; Vijayan and Holtzman, 1992a). Location management is the process of discovering the position of the mobile station if it is battery powered of so the incoming call can u is routed to him if he is the intended in call process (Vijayan and Holtzman, 1992b, 1993a, b).

The mobile station sends update information about its status to the network through its serving BS whenever the MS moves into a different location area. In this way, it can note two extremely behaviors: for every incoming call, page every cell in the cellular network in order to find the desired mobile station; the MS declares the whole network whenever it changes a cell. The new location of the MS is used to make the appropriate updating at the HLR and the MSC/VLR covering the area where the MS is located. If the new subscribed mobile station is permitted to use the requested services, the Home Location Register (HLR) will send a profile of the subscriber information, needed for call control to the new MSC/VLR. Then the HLR sends a request to the old MSC/VLR to eliminate the old registration (Zhang and Holtzman, 1996; Ho and Chan, 1997). Artificial Neural Network (ANN) could be used to determine the location of a Mobile Station (MS) in the coverage area of a cellular network. The technique is based on training an Artificial Neural Network (ANN) to determine the location of a mobile from the measured strength of the signals received by the mobile station from neighboring Base Stations (BS's). Performance system evaluation and advantages of this method is illustrated in the results by checking the error between the real values and the output of the ANN. The speed and accuracy of this approach make it very useful and efficient for real-time vehicle tracking systems (Messier *et al*., 1998). A key difference between wireline and wireless communication systems is the issue of user mobility. In wireline networks, the user location is fixed and can be determined. However in wireless networks, the user is mobile and does not have a fixed location.

The aspect of user mobility has created many challenges in the design and operation of wireless communication systems. One recent challenge emerged from the rapidly growing volume of emergency calls made by mobile subscribers and the failure of automatic determination of the caller location (Hata and Nagatsu, 1980; Viyayan and Holtzman, 1993b). Previous researches efforts have used the strength of the signals received at the mobile station from neighboring base stations and combined it with the known locations of the base stations to solve for the mobile position (Wong, 1998; Marichamy *et al*., 1999, 2003; Itoh *et al*., 2002; Sarddar *et al*., 2010). The main problem with the above method is that the presence of non-line of sight, multiple access interference and shadowing makes it impossible to

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obtain an accurate estimate of the mobile location. To solve this problem, the researchers proposed in this project, a mobile location technique using Artificial Neural Network (ANN) with a training algorithm to locate the position of a mobile from signal strength measurements. So a program simulation for the handoff phases which is illustrate the mobility of the mobile station in the network and how HLR and VLR are updates with the measurement of the length between mobile station and BSCs and the handoff time.

In this study, a mobility management model is proposed that works with the HLR and VLRs and it is concerned with handling issues arising due to the mobility of the MS (such as location management and handoff). As mobiles travels across system boundaries, Intra-Cell, Intra-BSC, Inter-BSC and Inter-MSC, the network must be able to locate the mobile subscriber and automatically route the call to him or her (Call delivery). A simulation program will be programmed to illustrate how VLR and HLR are updated while the mobile moved in the network. In the simulation, two mobile station are proposed to be moved across a selected map of Baghdad which is divided into number of cells with two MSCs and it shows how the mobile station are moved from cell to cell and changing its cell according to ideal power (ideal cell are used), also an update to MSCs VLR and HLR will be updated according to the type of change of cell (Handoff).

MATERIALS AND METHODS

Mobile location techniques: A variety of techniques have been proposed and some of them have been actually used in determining the location of a mobile unit. These technologies could be categories into handset-based techniques, like that the ones based on the Global Positioning System (GPS) and network-based techniques (Vijayan and Holtzman, 1992a):

- Handset-based technologies use the global positioning system and require a GPS receiver in the handset, the cost of which can severely limit their availability to the average consumer
- Network-based techniques benefit from the cellular infrastructure by using the signal being received by a mobile to determine its location. Generally, the mobile signal is received from several base stations with known positions. After reception, some characteristics of that signal are combined with the known positions of the receivers and used to determine the mobile position

Home Location Register (HLR): The HLR is centralized network database that saves and runs all the mobile subscribers containing to a specific operator. HLR stores all the requires information for a person's subscription permanently until that subscription is canceled. It stores following information:

- Subscriber identity
- Subscriber supplementary services
- Subscriber location information
- Subscriber authentication information

Visitor Location Register (VLR): The VLR is provisionally data base that saves and runs all the subscribers' information currently located in an MSC service area.

Handoff management techniques: The process of changing cells during a call is called handoff in GSM technology. To select the best outgoing cell, the MS and the BTS perform measurement. Because the MS contribute to the handoff decision, this type of handoff is often called mobile assisted handoff. The mobile station periodically measures received signal strength and quality on its own cell and signal strength on the BCCH carriers of the neighboring cells. The measurement is carried out on the downlink while MS is in active mode. The measurement results are sent to the BTS on the SACCH at regular intervals. The serving BTS measures the received signal strength and quality of this signal on the uplink. The measurements from the BTS and MS are sent to the BSC in the form of measurement reports. Bases on these reports, the BSC decides if the handoff is necessary and to which cell. This is called locating. As soon as a neighboring cell is founded to be better the serving cell, a handoff is initiated. Another reason for initiating a handoff, apart from signal strength is when the Timing Advance (TA) used by MS exceeds a threshold value set by the operator.

This usually is done when the mobile station is moving over the cell border to another cell. When the MS has changed cells, the new BTS inform the MS about the new neighboring BCCH carriers so measurement can be taken again. If the mobile station also transferred to a new LA, a location updating type normal will be done after the call has finished. Handoff can be used for load balancing between cells. During a call initiating in a too heavy cell, the MS can be switched to a cell with a little traffic if an acceptable link quality is similarly to be obtained. Another area where forced handoff is a useful tool is a maintenance reasons. There are several types of handoff including:

- Intra-cell handoff
- Handoff between cells controlled by the same BSC
- Handoff between cells controlled by different BSCs but the same MSC/VLR
- Handoff between cells controlled by different MSC/VLRs

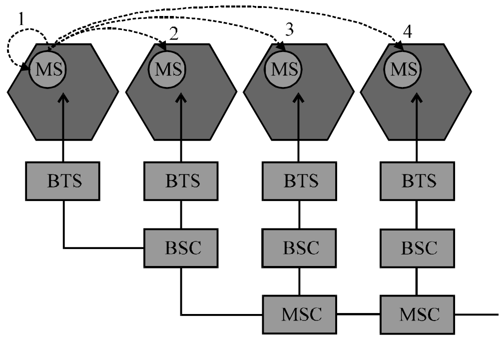

Fig. 1: Different handoff types

Each of the handoff types is described in the study. In each case, the decision to perform a handoff has already been made and a target cell has been identified. Figure 1 shows the handoff types.

Intra-cell handoff: A special type of handoff is the intra-cell handoff. It is implemented when the BSC considers the quality of the link too low but receives no indication from the measurement that another cell would be better. In that case, the BSC defines another channel in the same cell which may submit a better quality and mobile station is ordered to retun to it.

Handoff between cells by the same BSC: When implementing a handoff between two cells governed by the same BSC, the MSC/VLR is not involved. However, the MSC/VLR will be informed when a handoff is required if the handoff includes different LAs, location updating is performed once the call is finished:

- The BSC orders the new Radio Base Station (BTS) to active a Traffic Channel (TCH)
- The BSC sends a message to the MS, via the old BTS, containing information about the frequency and time slot to change to and also the output power to use. This information is send to the MS using FACCH
- The MS tunes to the new frequency and transmits handoff access bursts in the correct time slot, since the MS has no information yet on TA, the handoff bursts are very short (only 8 bits of information)
- When the new BTS detects the handoff bursts, it sends information about TA. This is also send via FACCH
- The MS sends a handoff complete message to the BSC via the new BTS
- The BSC notifies the old BTS to release the old TCH

Handoff between cells controlled by different BSCs but the same MSC/VLR: When another BSC is involved in a handoff, the MSC/VLR must also be involved to establish the connection between the two BSCs:

- The serving (old) BSC sends a handoff-required message to the MSC containing the identity of the target cell
- The MSC knows which BSC controls this cell and sends a handoff message to this BSC
- The new BSC orders the target BTS to activate a TCH
- The new BSC sends a message to the MS via the MSC and the old BTS
- MS tunes to the new frequency and transmits handoff access burst in the correct time slot. Since, the MS has no information yet on TA. The handoff bursts are very short (only 8 bits of information)
- When the new BTS sends information about TA
- MS sends a Handoff complete message to MSC via the new BSC
- MSC sends the old BSC an order to release the old TCH
- The old BSC tells the old BTS to release the TCH

Handoff between cells controlled by different MSC/VLRs: Handoff between cells governed by variety MSC/VLRs can only be implemented within one PLMN and not between two PLMNs cells governed by variety MSC/VLR also means that they are controlled by variety BSCs:

- The serving (old) BSC sends a handoff-required message to the serving MSC (MSCA) with the identity of the target cell
- MSC-A identifies that this cell belongs to another MSC (MSC-B)
- MSC-B allocates a handoff number to reroute the call. A handoff request is then send to the new BSC
- The new BSC orders the target BTS to activate a TCH
- MSC-B receives the information and passes it on to MSC-A together with the handoff number
- A connection is set up to MSC-B, possibly via PSTN
- MSC-A sends a handoff command to the MS via the old BSC
- The MS switches to new frequency and transmits handoff access bursts in the correct time slot
- When the new BTS detects the handoff bursts it sends information about TA
- The MS sends handoff complete request to the old MSC via the new BSC and the new MSC/VLR
- A new path in the group switches in MSC-A is established and a call is switched through
- The old TCH is deactivated by the old BSC (not shown in the picture)
- The old MSC, MSC-A, keeps main control of the call until the call is cleared. This is since that it has the information about the subscriber and call details such as charging

- After call release, the MS must implement location updating because a LA never belongs to >1 MSC/VLR service area. The HLR is updated by the VLR-B and will in turn tell VLR-A to all information about the mobile subscriber

Proposed location management model: In the model, the researchers used a 4-layerd (3 hidden layers and 1 output layer) Artificial Neural Network (ANN) with 3-inputs (BS1-BS3) and 2-outputs (x and y) as shown in Fig. 2. The three inputs of the ANN represent the signals strength of three different Base Stations (BS1-BS3) which are received by the Mobile Station (MS) and they will be used to determine the location of the MS as a point with 2 coordinates X and Y which represent the 2-outputs of the ANN then the position of MS will be send to the MSC to inform it about the exact location of the MS within the specified area.

The three hidden layers consist of 3 (neurons), 4 and 8-nodes, respectively and researchers will apply a powerful learning algorithm called the Back Propagation Learning algorithm (BPL) for finding the set of network weights that minimizes the network's cumulative error. The mobile unit regularly informs the MSC about its location result in avoiding the paging problem. The proposed location management model is build from several parts (modules) as shown in Fig. 3, these modules are described as follows:

Mobile station module: This module is connected to one BSC/BTS only at a time and it also monitors other BSC/BTS signal strength.

BSC/BTS module: This module is connected to the MSC/VLR module and to the main module and sends to main module the current connected mobile station and the distance from the base transceiver station to the mobile station, also it sends the mobile station location area to the MSC/VLR module.

MSC/VLR module: This module receives the location area from BSC/BTS module and updates the VLR database, sends data to the HLR module to updates its database when the mobile moves from BSC to a BSC in another MSC.

HLR module: This module controls the HLR database and sends control the MSC/VLR module when a mobile moves from MSC to another.

Main module: This module controls the overall operation of the system. when a mobile moving between cells the BSC/BTS modules receives the signal strength report and send it to the main module to analyze the signal strength

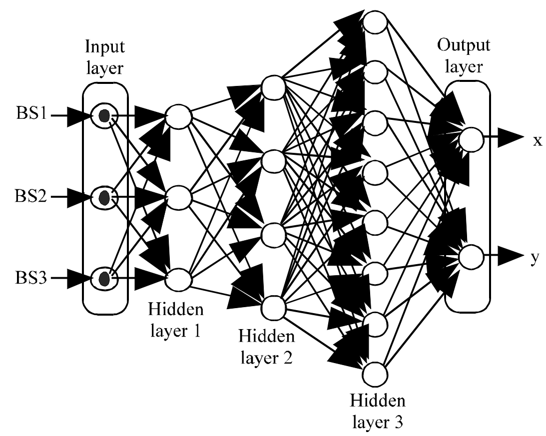

Fig. 2: Proposed neural network

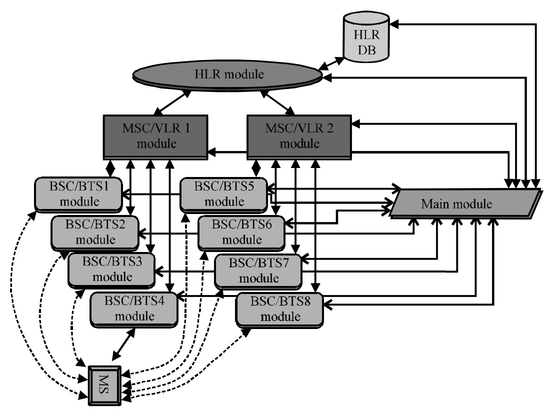

Fig. 3: Proposed location model parts

of each BTS with the mobile station and estimate the mobile station travel direction and evaluate the nearest BTS that the mobile station to be connected to while traveling in the cells. The main module shall calculate also the handoff time for the mobile when a handoff takes place.

When the main module decides what is the nearest BTS to the mobile it check this BTS in which BSC are connected (here each BSC controls on BTS) and check its MSC if the next BSC are in the same MSC the main module sends a signal to the currently connected BSC module to start an Inter-BSC handoff procedure if the next BSC are located at another MSC the main modules sends a signal the BSC to start an Intra-BSC handoff procedure.

When the inter-BSC handoff starts the MSC/VLR modules update the location area of the mobile to the current cell location area that the mobile station is now connected to, also the TMSI will send to the mobile station and stored in the VLR. If an intra-BSC the same operation of the inter-BSC handoff in the current MSC/VLR module and update the HLR database and removes the record of the mobile station from the previous VLR.

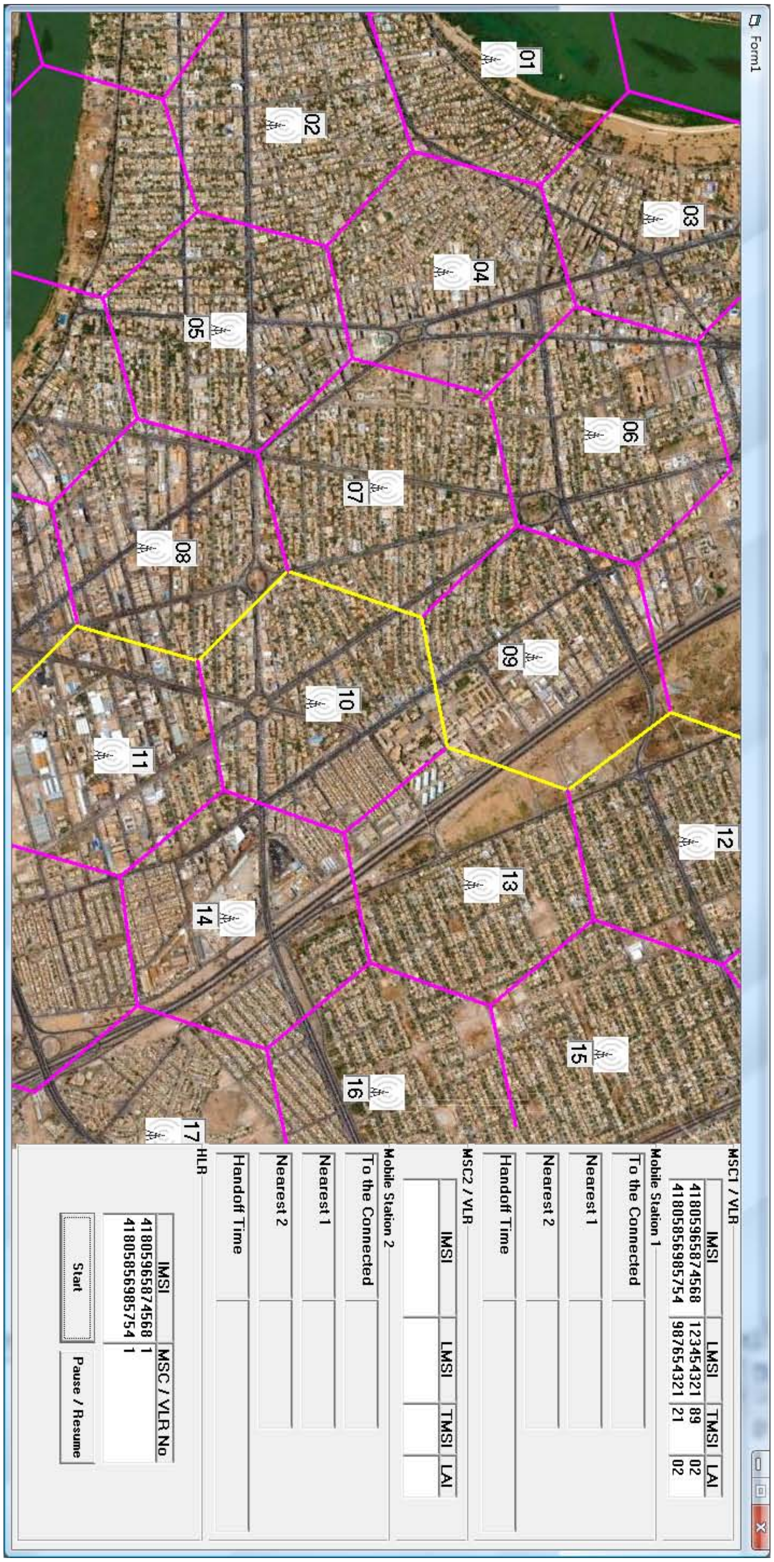

Fig. 4: Simulation program of Proposed Location Model

Table 1: The input and output values of the Artificial Neural Network (ANN)

BSS1	BSS2	BSS3	Actual x	Actual y	MSE
133.09	141.47	136.57	1	0.1	0.0000
133.13	141.37	136.18	1	0.2	0.0022
13321	141.29	135.81	1	0.3	0.0038
133.33	141.22	135.44	1	0.4	0.0000
133.49	141.17	135.09	1	0.5	0.0077
133.69	141.13	134.76	1	0.6	0.0059
133.91	141.11	134.46	1	0.7	0.0002
134.17	141.10	134.17	1	0.8	0.0012
134.46	141.11	133.91	1	0.9	0.0077
134.76	141.13	133.69	1	1.0	0.0006
135.09	141.17	133.49	1	1.1	0.0096
135.44	141.22	133.33	1	1.2	0.0012
135.81	141.29	133.21	1	1.3	0.0017
136.18	141.37	133.13	1	1.4	0.0038
136.57	141.47	133.09	1	1.5	0.0010
136.97	141.58	133.09	1	1.6	0.0024
137.37	141.71	133.13	1	1.7	0.0131
137.78	141.84	133.21	1	1.8	0.0020
138.19	141.99	133.33	1	1.9	0.0017
138.6	142.15	133.49	1	2.0	0.0010
139.01	142.32	133.69	1	2.1	0.0042
139.42	142.50	133.91	1	2.2	0.0005
139.83	142.69	134.17	1	2.3	0.0021

Total MSE = 0.0044

RESULTS AND DISCUSSION

Table 1 shows the input and output values of the Artificial Neural Network (ANN). The simulator is building in the research using Visual basic 6.0. The simulator is divided into several parts (modules).

As shown in Fig. 3, BSS1-BSS3 represent the base stations' signal strength (the inputs of the ANN). Actual x and actual y represent the coordinates of the mobile station (the outputs of the ANN).

A Mean Square Error (MSE) function used to evaluate the performance index for comparing the true locations and their obtained estimates:

$$\sqrt{\frac{1}{N}\sum_{n=1}^{N}(\hat{x}_n - x_n)^2 + (\hat{y}_n - y_n)^2}$$

Where, N is the number data taken for simulation examination. From Table 1, the researchers notice that there is no significant difference between the true locations and the estimated locations.

Figure 4 shows the program interface for the simulation which composed of the geographical map taken from google earth, view of data collected and control to start, pause and resume the running.

CONCLUSION

It is discussed in the research the importance of location management and its associated problems are highlighted. The proposed mobile location management system showed that there is no significant difference between the true location and the estimated location. As a compared to the Global Position System (GPS), the proposed location estimation system based on neural network will be cheaper, software based system, low power consumption, does not consume network resources and finally can work at any place and under any condition.

REFERENCES

Hata, M. and T. Nagatsu, 1980. Mobile location using signal strength measurements in a cellular system. IEEE Trans. Vehicular Technol., 29: 245-252.

Ho, K.C. and Y.T. Chan, 1997. Geolocation of a known altitude object from TDOA and FDOA measurements. Trans. Aerospace Electr. Syst., 33: 770-783.

Itoh, K., S. Watanabe, J.S. Shih and T. Sato, 2002. Performance of handoff algorithm based on distance and RSSI measurements. IEEE Trans. Vehicul. Technol., 51: 1460-1468.

Marichamy, P., S. Chakrabati and S.L. Maskara, 1999. Overview of handoff schemes in cellular mobile networks and their comparative performance evaluation. Vehicular Technol. Confer., 3: 1486-1490.

Marichamy, P., S. Chakrabarti and S.L. Maskara, 2003. Performance evaluation of handoff detection schemes. Proceedings of Conference on Convergent Technologies for the Asia-Pacific Region, October 15-17, 2003, Kovilpatti India, pp: 643-646.

Messier, G., M. Fattouche and B.R. Petersen, 1998. Locating an IS-95 mobile using its signal. Proc. Int. Conf. Wireless Commun., 11: 562-574.

Sarddar, D., S. Maity, A. Raha, R. Jana, U. Biswas and M. Naskar, 2010. A RSS Based adaptive handoff management scheme in heterogeneous networks. Int. J. Comp. Sci., 7: 232-238.

Vijayan, R. and J.M. Holtzman, 1992a. The dynamic behavior of handoff algorithms. Proceedings of the 1st International Conference on Universal Personal Communications, September 29-October 1, 1992, Dallas, TX.

Vijayan, R. and J.M. Holtzman, 1992b. Analysis of handoff algorithm using nonstationary signal strength measurements. Proceedings of the Algorithm using nonstationary signal strength measurements, December 6-9, 1992, Orlando, FL.

Vijayan, R. and J.M. Holtzman, 1993a. A model for analyzing handoff algorithms. IEEE Trans. Vehicular Technol., 43: 351-356.

Vijayan, R. and J.M. Holtzman, 1993b. Sensitivity of handoff algorithms to variations in the propagation environment. Proceedings of the 2nd International Conference on Universal Personal Communications, October 12-15, 1993, Ottawa, Canada.

Wong, K.T., 1998. Adaptive geolocation and blind beamforming for wide-band fast frequency-hop signals of unknown gop sequences and unknown arrival angles using an electromagnetic vector sensor. IEEE Int. Conf. Commun., 1: 758-762.

Zhang, N. and J.M. Holtzman, 1996. Analysis of handoff algorthms using both absolute and relative measurements. IEEE Trans. Vehi. Technol., 45: 174-179.