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Theoretical Study for Improving the Performance of Carbon Nanotubes Networks

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Abstract. Progress in graphene carbon nanotubes manufacturing processes and their tremendous applications directed the research groups all over the world towards investigating the performance related to their specializations. The carbon nanotubes networks (CANETs) are a promising target for any related nanonetwork sensors application fields. In this paper, the overall CANETs performance is firstly studied. Higher bandwidth and data rate are achieved under some selected properties of network elements. The carbon nanotubes (CNTs) are essential part of these nano-networks. For that, the isotropy of CNTs into the CANET is studied under various CNT angle, lengths, numbers and CNTs adjacent distance in x and y directions and at various connection probabilities values for random distribution. From the obtained results, higher isotropy is assigned when the CNTs angle equal $\pi/2$. Also, certain square peaks are noticed at assigned angle values in the range. These peaks describe the ability to exchange, store, and process data into CNTs intersections, nanonodes, between the terminals. Theoretical description of the dependence of Field Effect Transistor (FET) conductance into CNTs parameters is derived. i.e., to discover the effects of CNTs parameters more in the behavior of CANET performance, FET conductance value as function of angle values, adjacent distance deviations are separately discussed. In the first case, conductance peaks are noticed at periodically values of angle such as $2.6, 11.6, 20.6, 29.6, ... \frac{\pi}{2} \pm \Delta\theta°$. These accurate determinations of angle value can be assigned for information transformation via the CANET. In the second phase, the conductance are studied as a function of CNTs adjacent distances deviations for two values of CNTs numbers while the other parameters are held constant. From the obtained results, increasing the CNTs number will decrease the conductance value and adjacent distance deviations. It is preferable to adopt the CANET parameters to preserve the data rate and encoding process which attributed in CNTs angle phases.

Keywords: *Networks, Carbon Nanotube, Maximum Capacity, Isotropy, CANET, FET Conductance Behaviors.*

1. Introduction

Any recent research work becomes important when it has attractive applications in practical life. Nanotechnology devices have distinguished contributions in various fields of life. One of them is the carbon nanotubes networks (CANETs) that are utilized to establish connections in versatile industrial fields, such as engineering, medicine, military, physics, computer networks and others. One of the advantages of CANETs is that they can match the operation with other various nanoscale devices, especially in emerging applications such as early diseases diagnoses, drug delivery and novel directing and tracking of nanocapsules into the human body [1 -3]. Multi-core processors will utilize optical networks on-chip for global interconnections as considered in [4]. The power supply of these on- chip integrated devices can be saved by utilizing modified CNTs network as electrode in Li-ion batteries [5-8].The CNTs play an important role in establishing and enhancing the network performance and devices. One of these devices is the photodetectors that are fabricated from carbon nanotube FETs that realize tunable bandgap and wide spectral region [9-15]. They are fabricated from rolled up of graphene [16-19]. As this article is concerned about the investigation of the effects of some CNTs parameters, such as radius, angle direction, numbers, and different lengths and spaces, into the nano-network behavior, unique properties of them should be considered firstly. From electrical characteristics point of view, they have a high current density that arise from metallic and semiconducting properties. As a result, they can be established as a base in FET which is the main feature in CANET behavior, as it can be seen in the following section. From mechanical characteristics point of view, they have a high tensile strength, elastic modules, and sharp resonance peak [20]. In fact, the electromagnetic and electric unique properties of CNTs make them the first priority for nanontework operations in various fields [21]. Modern experimental and theoretical treatments ensure that one of the CNTs can be adapted to work as a four essential components of nanonetwork circuitry, i.e., modulator, demodulator, tuner, and antenna [22]. CNTs network transistors also can be utilized for logic applications such as inverter, NOR, and NAND gates [23]. A nanoscale commutation networks based on CNTs has special properties, especially its size to be utilized in new applications such as nano-integtrated tiny devices to penetrate a cell and operate in the blood stream without exciting the cell’s defensive response.

Now the attention will be directed to how the CNTs can be constructed for establishing nanonetwork. In this investigation, the CNTs are distributed randomly in the CANET. Their distribution, the phase angle, and the total numbers are studied to clarify and select appropriate values for this nanoscale networks. In recent research works and technologies, the CNTs networks are utilized as a semiconductor material to establish a single FET transistor [24]. For building legacy network equipment, many FET transistors are required. From nanocommunication aspects point of view, these FETs equipment includes nano-scale networks internal of each transistor, determine the FET gate conductance between source and drain, which can be more effective for CANET behavior. The network from CNTs is constructing this nanocommunication media. The links, which are used to connect these networks, are individual nanotubes themselves. The scale of CANET is down to the molecular level in comparison with the traditional networks. The nanonetwork protocol depends on the controlling of the access of users via a range of different resistances. This means that sense each user (probe) will have a specified channel or path; he will have a certain resistance depending on the path length between input/output probes, nanotransmitter and nanoreceiver. In the following section, the dependence of various channel resistance or conductance into the CNTs parameters will be investigated.

The model description and mathematical derivation are presented in Section (2). The numerical results and discussions are stated in Section (3).The paper is finalized by reporting the important notices and facts, related to the results and assigned numeric values for proposed CANET model parameters, in the conclusion section.

2. Mathematical Approach of CANET

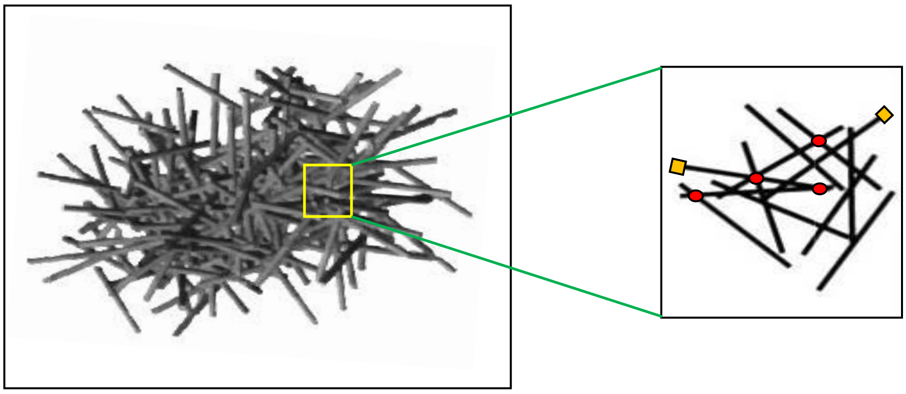
From network point of view, the reduction in size of CNTs, in nanometer scale, will increase the bandwidth (in THz range) and the network capacity. In addition, increasing the nanotubes number per unit area will enhance the number of bits in the same considered area. This will overcome the limited capacity of conventional wireless capacity considered in [25]. In our proposed model, all the nanotubes will be effectively utilized to carry the data between different nanonodes. In the considered CANET, a nanotransmitter can radiate information via nanotubes elements. The transmission and data rate more effectively depend on the type of radiation and the maximum number of allowable nanotubes. In our consideration, the type of radiation is omnidirectional in circular area, *A*, and the allowable number of nanotubes will be the case of study. To determine the maximum capacity of CANET, the following expression can be utilized:

$$Cap_{max} = \sqrt{\frac{8n}{\pi}\frac{C_{ij}}{\Delta}\sum_{k=1}^{n}\frac{\sqrt{A}}{k}} \tag{1}$$

here, *n* is the number of nanotube sensors, C_{ij} is the link capacity from nanotransmitter *i* to nanoreceiver *j* and it depends on bandwidth, the link signal to noise ratio, and the distance between the nanotransmitter and the nanoreceiver. Δ is the guard distance between various channel transmissions to ensure they do not overlap. The summation gives the expected total neighbor spaces that data must pass through from *k =1* to *n*. It essentially depends on the number of nanotubes. The effect of the omnidirectional circular area, distance between nanonodes, and number of nanotubes into the maximum capacity will be discussed in the following section. Now it is evident to study the phase angle between each nanotube and all other nanotubes. As the carbon nanotubes are randomly distributed in the CANET, it is important to study the CNTs overall directionality. It will depict each CNT angle relative to all other CNTs. Isotropy is a quantity to measure or specify the global directionality of all CNTs and can be given by:

$$I(\theta,n) = d_t n\, w_{CNT} L_i \sum_{k=1}^{n} \frac{\cos(\theta_k+\Delta\theta)}{\sin(\theta_k+\Delta\theta)} \tag{2}$$

where, d_t is nanotube density, w_{CNT} is the nanotube width, L_i is a parameter which permits to vary the nanotube lengths, and θ_k is the nanotube angle. Various ranges of angles; θ_k, is studied to select the suitable nanotubes arrangement. One can notice that the isotropy will be high or low depending on the nanotube angle and the various values of angle deviations, $\Delta\theta$. The latter parameter denotes the facility to change the range of phase angles to cover most of the angle deviations probabilities between the CNTs elements entire the nanonetwork; as depicted in the results and discussion section. Also, various CNTs lengths and densities are studied. Intersect of CNTs form vertices but themselves form edges. The schematic diagram describing the CNTs distribution in a specific area is considered in Fig. 1. From CANETs point of view, the angle of each CNT can be expressed as encoding information of nanotransmitter phase [22].



Terminals in the carbon nanotube networks

Nanodes internal connections via the information passes

Fig. (1). Schematic diagram of the Carbon Nanotubes Network (CANET) with its random pass lengths, angles and density of distribution.

Now let us explain the nanonetwork connectivity which can be expressed by the conductance between the FET source and drain. It essentially depends on the available distance between them and the probability of the nanotube (i) to connect with another one (j); P_{ij}, which consequently is a function in each of the allowed angle and nanotube lengths. It can be represented by:

$$P_{ij} = f(x, y, L_i, L_j, \theta_j + \Delta\theta) \tag{3}$$

This procedure is a role of network into the specified area, the FET conductance between source and drain can be given by:

$$G_{SD} = \left\{\frac{\rho_{CN}}{A}\sum_{i=1}^{n}\sum_{j=1,j\neq i}^{n} P_{ij}\left\{\left|v_i - v_j\right| + \left(\frac{L_i}{2}\cos(\theta_i + \Delta\theta) + \frac{L_j}{2}\cos\left(\theta_j + \Delta\theta\right)\right)\right\}\right\}^{-1} \quad (4)$$

where ρ_{CN} is the carbon nanotube resistivity, $\left|v_i - v_j\right|$is the difference between vertices in *x* or *y* direction. When this difference is small then that means more concentration of nanotubes can be achieved. The relation between the conductance and different adjacent carbon nanotubes distances and lengths will be discussed;$\left|v_i - v_j\right|$, L_i, and L_j respectively. Also, equation (4) denotes the facility to determine the allowable maximum conductance for various angle values and deviations; $\theta_j + \Delta\theta$ respectively. Different gate conductance, or routes, means different modified current flow which carries or transmits the different data above the CANET. The nano-address can arise from the combination of different gates to transmit the data from the source to destination vertices. So, gates distribution and CNTs number control the data path into the nano-network.

Now let us denotes some concepts about the various ranges of angles between CNTs which will be utilized for network investigation into the area; A. One of the angle range is $\theta_j \pm \Delta\theta = \left\{(0,9,18,27, \ldots .\ \frac{\pi}{2}) \pm \Delta\theta\right\}$. Each encoding data can be specified for each CNT angle. The data is stored in CNT angle and the change in CNT conductance angle denotes the data reading process. When the angular variation is great, it will permit the different CNTs to intersect. So, the value of network conductance will be a function of internal CNT resistance with intern function in its resistivity,ρ_{CN}, and its intersect length. As mentioned before, the nanotubes are distributed randomly and have different lengths ranging from 3-12µm.The nanotube density is determined by the numbers of CNTs into a specified area. The numbers of CNTs that intersect determine the number of network nanonodes. It can be represented as the FET gate between the source and drain vertices [26-28]. The aim of the previous theoretical treatments is to determine the suitable or optimal angle values and corresponding nanotubes lengths for achieving the network connections.

3. Results and Discussions

The discussion will start by the relation between the maximum capacitance of the CANET and the number of CNTs at different values for SNR for specified nanonetwork distances and radius. The CNTs are isotropy and radiate Omni-directional into the CANET area. From Figs (2-4), one can notice that increasing each of the network radius; *r*, and the CNTs numbers will contribute in the enhancement of the data rate, in the range of 10^{14}bps for the usage bandwidth value, 10THz, and then network capacity, because it will be helpful in the establishment of more nanonetwork connections as a result of increasing the CNTs probability of intersections. It means that more nanonodes and routes between the source and destination will be included. The obtained result of the effect of each of CNTs numbers and coverage area in the data rates are in full agreement with the discussion in [22, 29].When the distance; *d*, between the source and drain are longer, the maximum capacity, C_{max}, will be decreased. It returns to the data losses and dissipations when transferred from one nanonodes to other, especially in the CANETs for small values of SNR. Of course, improving the signal-to-noise ratio (SNR) will enhance the overall nanonetwork capacity, as shown in the results. One can notice that more attention is directed to study the effect of the CNTs numbers because it plays an important role in the behavior of CANET. And also this point is not covered before in the previously obtained results by one of the authors published in [30].

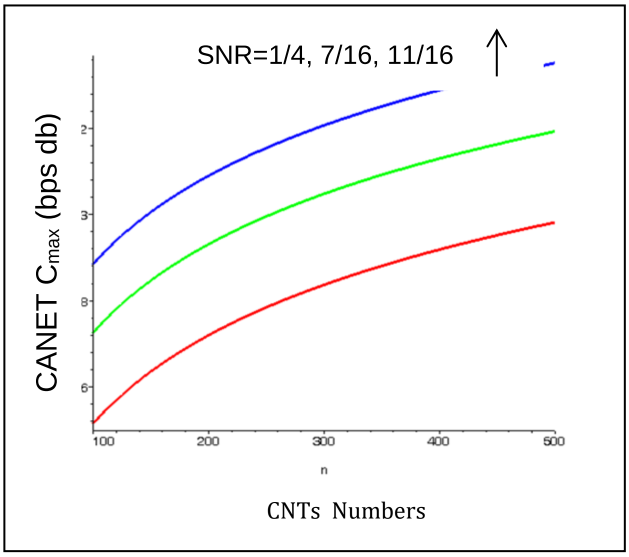


Fig.(2). The CANET maximum capacity with omni-directionally circular source radius at different values of SNR. For nanotube distance; d=5µm, r=5µm, and BW=10THz.

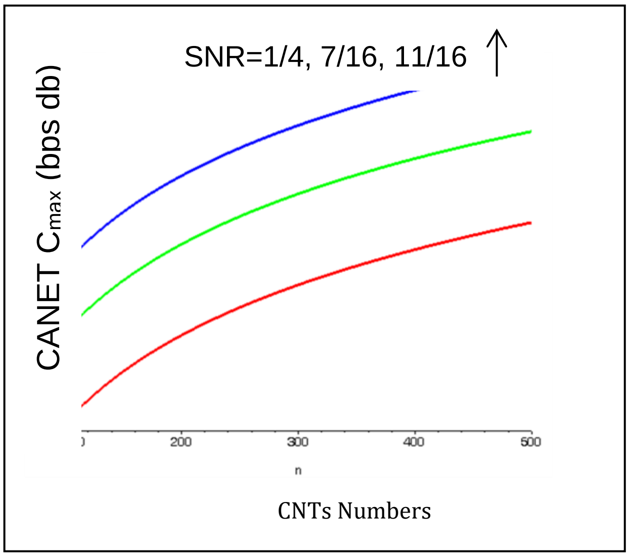


Fig.(3). The CANET maximum capacity with omni-directionally circular source radius at different values of SNR. For nanotube distance; d=20μm, r=5μm, and BW=10THz.

When comparison is held between Figs (2, 3, and 4), one can recognize the importance of cover wide area, long radius, with small distance between the nanotransmitter and nanoreceiver [29].These mentioned constraints will contribute in obtaining high maximum capacity. Moreover, matching between CANET parameters such as radius, the CNT lengths and angles and the available CNTs numbers should be achieved for constant values of bandwidth; BW=10THz. On the other hand, one can distinguish between the distance, d (μm) and CNT length, L_{CNT} (μm) which will be discussed later. Along the CNTs lengths; multi intersections can occur to construct the nanonodes and vertices, as depicted in Fig. 1.

Investigation of the isotropy plays an important role for any established networks. It measures quantitatively the directionality of CNT angle relative to all other CNTs.

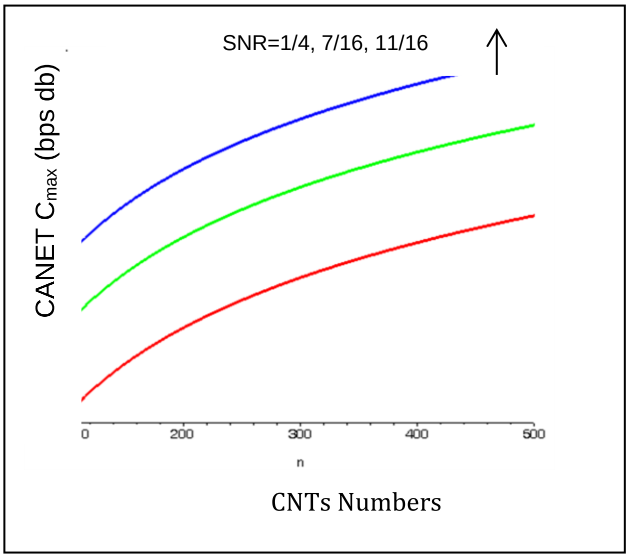


Fig. (4). the CANET maximum capacity with omni-directionally circular source radius at different values of SNR. For nanotube distance; d=5μm, r=20μm, and BW=10THz.

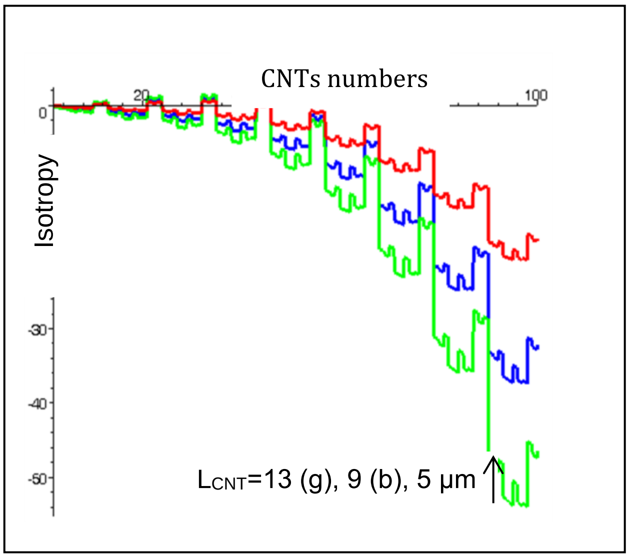


Fig. (5). the CANET isotropy vs CNTs numbers. For initial angle; θ= (-π/4), radius=1.2nm, d_t=1.2/μm^2 , Δθ=2-200°.

The dependence of this parameter; (θ, n) , as a function of CNTs numbers at various angle, angle deviation and CNT lengths is denoted in Figs (5,6, and 7). The difference between the obtained results is the initial angle value for the angle range from (0 ± θ to 200 ± θ). The step between each angle deviation and the next one is two degrees. It covers most or probably all of possible values of nanotubes angles. In all cases, the CNTs numbers has an obvious effect in the value of isotropy. A good choice of the required CNTs numbers will contribute into the construction of the CANET. It is one of the important CANET parameters, as defined in Equation (4), for determining the conductance values later. For first one, Fig. 5, the initial angle value; θ, is equal to (-π/4), one can notice that the isotropy of various values of CNTs numbers has a semi square negative values. When increasing the tube length, more isotropy value is obtained. For Fig. 6, θ=π /4, the higher negatively isotropy values are obtained. While at θ=π /2, the positive values are obtained for the same range of CNTs numbers. One can recognize that the behavior is not a straight line; it looks like a semi-square and changes simultaneously at various nanotube numbers for the same CNT lengths, L_{CNT}. The behaviors denote the facility to choose a suitable CANET distribution and determine the suitable parameter choices for high isotropy as shown in Fig. 7. Also, different isotropy Eigenvalues can be assigned for corresponding CNTs numbers. One can notice that for θ = π /2, a distinguished positive behaviors are recognized. Then the total range will be from (π /2 ± 0 till (π /2 ± 200 degrees) with two degrees increasing in each step. It means low angle entropy between CNTs. So, the probability that each CNT intersects with other is increased and correspondingly the number of nanonetwork nanonodes and vertices are increased. This will contribute in decreasing the distance between the nanotransmitter and nanoreceiver.

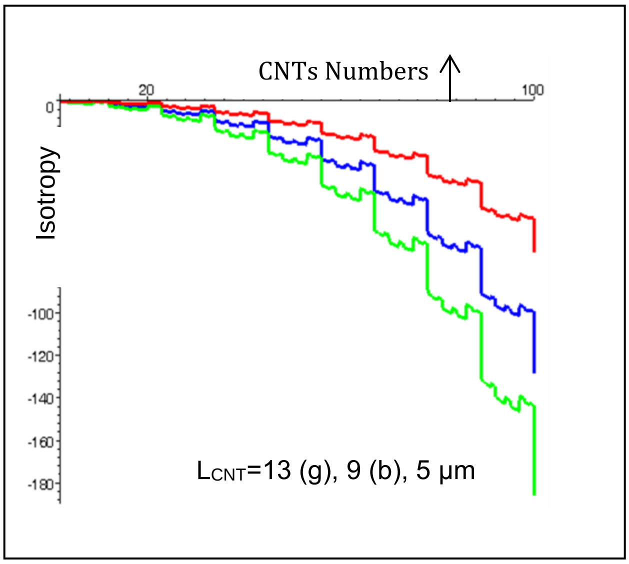


Fig.(6). CANET isotropy vs CNTs numbers. For initial angle; θ= (π/4), CNT radius=1.2nm, Δθ=2-200°.

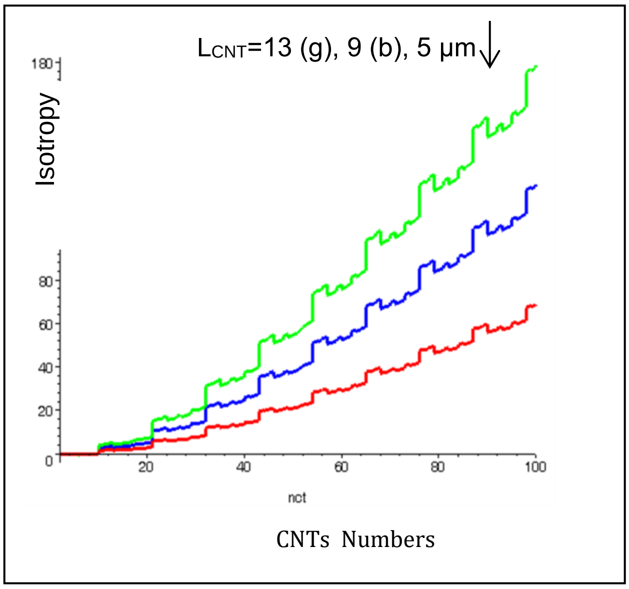


Fig.(7). CANET isotropy vs CNTs numbers. For initial angle; θ= (π/2), CNT radius=1.2nm, Δθ=2-200°.

From the network point of view, one can wonder that increasing the nanonodes will contribute in delaying the data rate. But in the CANET, it is expected, from our opinion, that increasing the nanonodes will denote behavior differ than traditional network. It returns to the information can be encoding according to the amount of phase angle between each CNT and other. So, the data losses will be decreased and the SNR will be increased. Also from the obtained results, as the nanotube length becomes longer the isotropy becomes higher. Higher values of isotropy imply that the CNTs intersections are increased. This means greater angular variations, (encoding process), cause the CNTs adjacent distance relatively decreased; hence CNTs will be nearer to each other and then intersect. The considered methodology produces the CANET protocol used for connect each CNT with all other CNTs to construct the nanonodes, routes, and information exchange procedure between nanonodes.

After discussing how the CNTs intersect directionality measured by isotropy. It is evident to discover the conductance (resistance) between the nanotransmitter and nanoreceiver. Previous study concern the average CNT film conductance is preformed in [31]**.** Here, the main reason for studying the conductance behavior is to select the appropriate CANET parameters or properties that aid to increase the information rate between the source and destination nanonodes or terminals. In other words, to connect between the nanotransmitter (source) and nanoreceiver (drain) nanonodes, the FET gate conductance value should be high as possible. The dependence of the FET conductance on the CANET properties such CNTs angle range

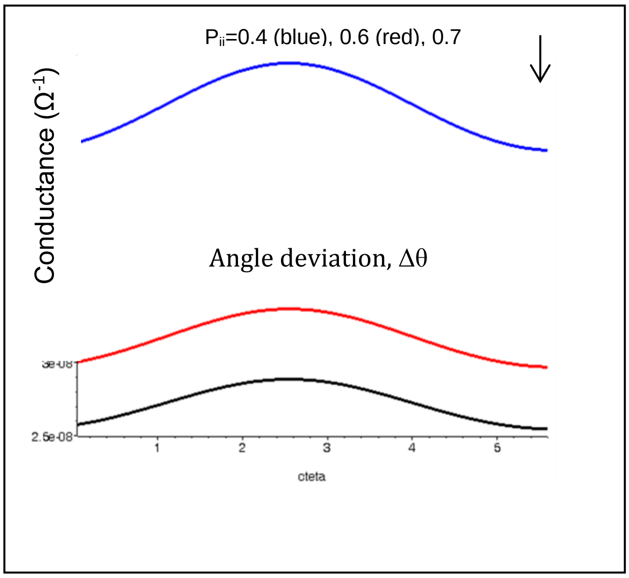


Fig.(8). CANET conductance vs CNTs angle deviation. For CNTs resistivity=0.13 mΩcm, θ= (π/2).

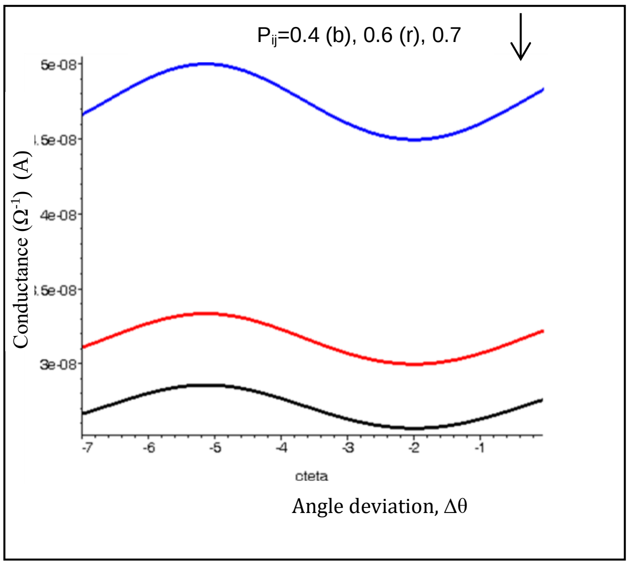


Fig.(9). CANET conductance vs CNTs angle deviation. For CNTs resistivity=0.13 mΩcm, θ= (π/2).

values, $\theta_j \pm \Delta\theta = \left\{(0,9,18,27, \ldots . \frac{\pi}{2} \pm \Delta\theta\right\}$, for certain CNT radius and assigned value of CNT resistivity, such as in [32, 33], at different values of connection probabilities is depicted in Figs (8 and 9).

The conductance values can be represented by each of probability of the nanotube (i) connect with another one (j); P_{ij}. As considered before in P_{ij} equation, the nanotube lengths, density and angles determine the P_{ij} value. For a certain values of the CANET parameters, small P_{ij} can be achieved which denotes highest peaks of the conductance for certain angle deviation, *Δθ=2.6* for range (*0 to 6*) and *Δθ =-6.6* for range *(-7 to 0*) in the considered Figs (8, 9) respectively. It is evident now to determine the allowable angle values as considered in the obtained results. When one gather the mentioned angle range and a specified angle deviation, $\theta_j \pm \Delta\theta$, by increment and decrement the ranges. Generally, the allowable angle ranges in increment and decrement are $(2.6, 11.6, 20.6, 29.6, \ldots . \frac{\pi}{2} + 2.6°$, and $(-6.6, 5.6, 14.6, 23.6, \ldots . \frac{\pi}{2} - 6.6°)$, respectively. At considered determined numerical values of angle degrees and for other specified CANET parameters, that achieve the conductance peaks, the transmitted data can be exchanged between nanonodes and further more nanocommunication between nanotransmitter, nanoreceiver and vice versa will be done. Moreover, it periodically repeated depending on the time of trans-receive data. The higher angle limit, θ= π/2, is selected for investigations in Figs (8 & 9) because it achieves a higher isotropy value assigned in Fig. 7. To describe the reason for which the higher conductance values are acquired at low connection probabilities values, P_{ij}, let us state the reverse case. When P_{ij}has a high value, it is meaning that longer nanotubes and adjacent distance are utilized which means that lower intersection will be occurred. This in turn will decrease the obtained conductance value between different nanotransmitter and nanoreceiver nanonodes. Of course ascending the chance of connection between the nanotubes will contribute in increasing the conductance value. Although various peaks are achieved for each specified probability, P_{ij} for a specified angle deviation range, the peaks can be repeated for another angle deviation ranges. These multi peaks represent the different maximum FET conductance between the nanotransmitter and receiver nanonodes. It is important to consider what this periodically higher conductance peaks means. These peaks of conductance occur at a certain phase angle which can be utilized for crossing the data from CNT to other CNTs. Same behavior is noticed in a part of experimental investigation of conductance for single walled carbon nanotube (SWNT) as a function of bending angle as considered in [34]. It indicates a semi-peak of conductance values at lower bending angle values (1- 4°) and it decreases with increasing bending angle in the considered region from (5-15°). One can wonder about the nature of nanotube distributions, lengths and angle in CANET, when taken in these investigations. Really random CNT lengths starting from 3µm to12µm and θ from (0 to π/2) are used respectively. It means that the neighboring nanotube lengths and angle are randomly arranged in the CANET network. The determination of the conductance values as a function of various adjacent nanotube distances is important because it establishes or determines the appropriate distances between randomly neighboring nanotubes. To clarify the effect of this parameter in the network connection which has an obvious effect on the FET conductance, the relations between the conductance and adjacent nanotube distance deviations are shown in Figs (10 and 11).

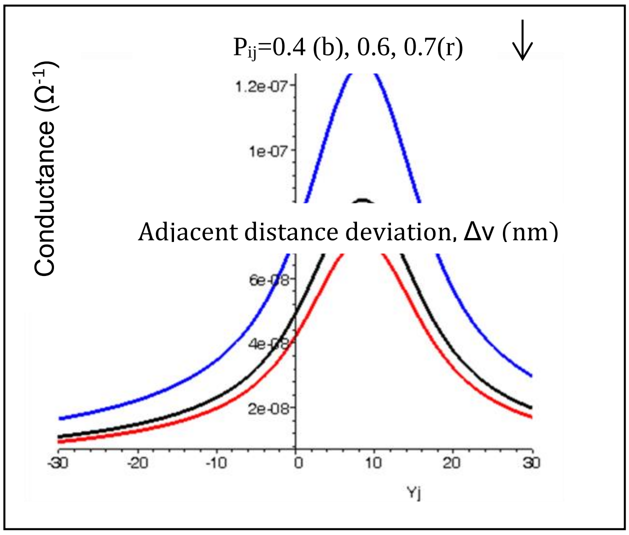


Fig.(10). CANET conductance vs CNTs adjacent distance deviation in x or y directions, for CNTs numbers, N=10, and resistivity=0.13 mΩcm, adjacent distance, v=1-12nm.

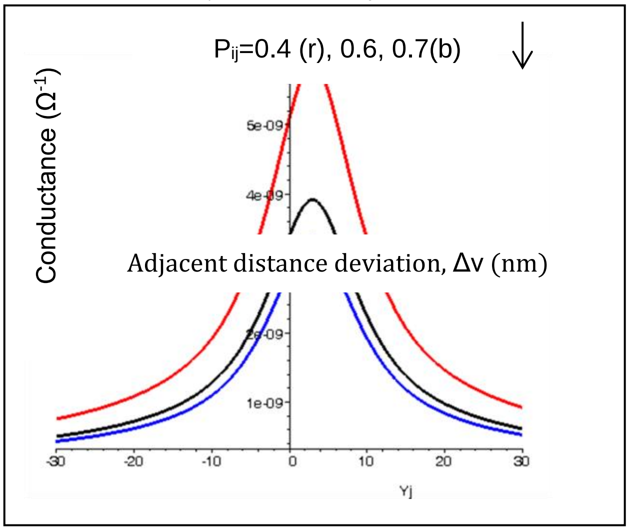


Fig.(11). CANET conductance vs CNTs adjacent distance deviation in x or y directions, for CNTs numbers, N=50, and resistivity=0.13 mΩcm, adjacent distance, v=1-12nm.

One can notice that increasing the adjacent distance will decrease the obtained conductance such as discussed in [35]. Before exploring the obtained performance, it is important to notice that most probabilities of x and y directions for CNTs positions are taken into considerations. The overall adjacent range is fixed but the deviations values are changed. For example, the adjacent distance range is from 1 to 12nm and its deviation is variable parameters can be positive or negative. Choosing the theoretical treatment for this parameter, by this way, open the facility to control the neighboring distance among CNTs forest into CANET network, i.e., if the distance deviation is negative, the previous range will be small, otherwise, it will be wide. For positive adjacent distance deviation, Δv from (1-30nm), the right hand side of Fig. 10 shows the behavior of the network conductance for three different connection probabilities between the source and drain of FET at a specified number of CNTs. It denotes and determines the amount of deviation which cause a maximum peaks for different connection probabilities, P_{ij}.These maximum peaks are around Δv = 10nm. It means that the matching range for adjacent nanotube distance, in the case of positive deviation, is from (10 to 22nm) for the carbon nanotube numbers, N=10. For Δv is negative, the behavior is different and gives an exponential increasing as shown in another left hand of Fig. 10. One can notice that the small connection probability will give high conductance and vice versa. The effect of connection probabilities values are in the same order as in the case of Figs (8 and 9).

It is evident from the previous results that the connection reliability is mainly dependent on the network elements distributions, CNTs and the coverage area. Now, let us to study the CANET performance in the case of increasing the density of CNTs forest for the same recognized CANET area with the same conditions considered before, i.e., the same carbon nanotube lengths and angle ranges. Fig. 11 depicts the conductance for positive and negative adjacent distance deviations. One can recognize that increasing the carbon nanotubes, CNTs, numbers will effect inversely in the conductance values. The same behavior is recognized for the positive and negative deviation values. The peaks are achieved at adjacent distance deviation value; Δv, equal 3nm for approximately the same Δv range from (-30 to 30nm). So the adjacent distance range, v, will be from (3-15nm). It is normally that when the CNTs have a high density, the adjacent distance to achieve maximum peaks will be decreased. On the other hand, as a result of higher CNTs will be in the way between the nanotransmitter and nanoreceiver or source and drain, conductance values in this case will be decreased. And also, more possibilities of CNTs directions, more angle deviations, for the same range of CNTs lengths. The effect of CNTs angles are studied before and also in [35]. Comparison between Figs (10 and 11) denotes that the peaks are shifted left toward the zero. Which meaning the deviation will be small for the high specified number of carbon nanotubes. This is a nature fact of increasing the CNTs numbers in the same CANET specified area. The main point here is deterministic the conditions for which the conductance values can be high. This is depending on the CNT parameters such as angle, lengths, adjacent distance distribution. Moreover, the general CANET performance, maximum capacity, is described depending on the CNTs behavior into it. The future work will be directed to how to link between the CANET protocols and what are required in the various applications trends.

4. Conclusions

Carbon nanotube networks, CANETs are a prospective media for many users in various fields of life. Firstly, the manuscript deals with the overall performance of the CANET according to the required coverage area and radius for a certain values of SNR. The most important result is that the higher BW can be achieved in the nanoscale range, 10THz. After that the required network data rate is assigned. Secondly, the manuscript is directed to establish the effect of carbon nanotubes, CNTs, parameters and distribution into the CANET behavior. The CNTs parameters that are investigated in this stage are CNTs lengths, radius, adjacent distances, and angles. Range of CNTs lengths from 3-12μm are assigned. The fixed value of radius is used according to previous studies. The main work is devoted to study the effect of CNTs random distribution probabilities in the CANET. These variations of CNTs directions will cause intersections. Nanonodes and vertices will be constructed as a result of intersection. Isotropy measures quantitatively these CNTs directions. The data will be carried, stored and transferred at a specified value of the angle phase between the CNTs. Various phase angles are investigated. The higher isotropy are achieved when the phase angle equal $\pi/2$. Assigning the phase angles aid in determining the FET conductance value between the nanotransmitter and receiver. From the obtained results, there are peaks for the conductance varied periodically with a certain CNTs phase angle. The CANET information can be exchanged in nanonodes or extracted at the terminals at these peaks. Also, the effects of the CNTs adjacent distance into the behavior at different CNTs numbers are studied. Also, peaks are achieved at a certain values of adjacent distance. Increasing the CNTs numbers from 10 to 50 denote the same behavior but cause to decrease each of adjacent distance deviations and conductance values, from (10nm to 3nm) and from (1.3×10^{-7} to$7\times10^{-9}\Omega^{-1}$) at connection probability equal (0.4) respectively. The main result is that it is important to choose the required CNTs numbers that preserve each of the information inflow and high conductance for assigned SNR value.

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دراسة نظرية لتحسين الأداء لشبكات الأنابيب النانوية الكربونية

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ملخص البحث. إن التقدم في صناعة الانابيب النانوية الكربونية من الجرافين وتطبيقاتها المميزة والعديدة وجهت المجموعات البحثية عبر العالم في اتجاه فحص الاداء كلا في مجال تخصصه. إن الشبكات النانوية الكربونية (كانيتس) تعتبر هدف واعد لأي تطبيقات للشبكات النانوية ذات الطبيعة الكشفية في المجالات المتعلقة.

في هذا البحث، مبدأيا الاداء الكلي للكانيتس قد درس. تلاحظ ان نطاق عريض ومعدل عالي لتدفق المعلومات وذلك لقيم معينة للخواص المختارة لعناصر الشبكة قد حققت. إن الانابيب النانوية الكربونية (سنتس) يعتبر العنصر الرئيسي لهذه الشبكات النانوية. ولذلك فإن الايزتروبي لهذه السنتس في الكانيت قد درست وذلك تحت قيم مختلفة لزوايا والاطوال والمسافات المتاخمة – في الاتجاهات السين والص– للسنت وعند قيم متغيرة لاحتمالية التركيز وذلك للتوزيع العشوائي.

من النتائج المحصول عليها، قيم عالية للايزتروبي قد حددت عندما تكون الزواية بين السنتس تساوي ٩٠ درجة. ايضا قيم معينة للقمم المربعة قد لوحظ عند قيم محددة لقيم الزاوية في النطاق المحدد. هذه القمم توصف او تعبر عن امكانية تبادل، تخزين، ومعالجة المعلومات وذلك خلال تقاطعات السنتس والعقدالنانوية وذلك بين طرفين الاتصال. شرح نظري لاعتماد توصيلية ترانسسيتور تأثير المجال (فت) على معاملات الستس قد اشتقت. وبمعني آخر، لكي يتم اكتشاف تأثيرات معاملات السنس وذلك على سلوك اداء الكنيت، قيمة توصيلية ال (فت) كدالة في قيم الذواية وانحراف المسافات المتجاورة قد درسا منفصلين. في الحالة الاولى، قمم التوصيلية قد لوحظو عند قيم دورية للزوايا مثل ٢٩,٦،٢٠,٦،١١,٦،٢,٦,... $\pi/2\pm\Delta\theta$° . هذا التحديد الدقيق لقيمة الزاوية يمكن ان يخصص لنقل المعلومات عبر الكنيت. اما في الحالة الثانية، التوصيلية قد درست كدالة في انحراف المسافات المتجاورة وذلك عند قيمتين لعدد السنتس بينما بقية المعاملات تظل ثابتة.

من النتائج المحصول عليها، زيادة اعداد السنتس , سوف يقلل قيمة التوصلية وانحراف المسافات المتجاورة.

إنه من الافضل ضبط معاما

خلال أطوار زوايا السنتس.