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ANDROID APP FOR MODELING WIRELESS NANONETWORKS BASED ON LIGHT TRANSDUCTION

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ABSTRACT

Nanonetwork is a novel field exponentially acquiring attention from the research community in the recent years. We believe that nanonetworks are not a simple extension of traditional communication networks at the nanoscale. They are a complete new communication paradigm. Since, Long-range communication in nanonetworks scenario is an unexplored research area, capable of providing unique features for several applications in biomedical, industrial and Telecommunications fields, and Light transduction can be mainly realized as the most promising technique for the wireless molecular communication in the long-range Nano-domain. Also, there is none simulation tool for nano-networks up to now. So, in this article the design of a molecular communication system in terms of a high level architecture based on the aforementioned exciting method is improved for a better understanding of nanonetworks scenarios then; simulation of that system is implemented on our Android application (Yazhraa) which is tested with Android SDK to take the advantages of Java language. Moreover, we introduce architecture of the intrabody nanonetworks for remote healthcare as a biomedical application which can use light transduction scheme to motivate the communication needs between the nanomachines. Finally, prototyping of intrabody nanonetworks with Yazhraa application have done.

Keywords: ***Android Computing Platform, Light Transduction Scheme, Nanonetworks Communication.***

I. INTRODUCTION

Nanotechnology is a cutting edge investigation area that has come out with new and unlimited applications. It's enabling the development of devices in a scale ranging from one to a few hundred nanometers. At this scale, a nanomachine is defined as the most basic functional unit, integrated by nano-components and able to perform simple tasks such as sensing or actuation [1]. Coordination and information sharing among several nanomachines will expand the potential applications of individual devices both in terms of complexity and range of operation [2, 3]. The resulting nanonetworks will be able to cover larger areas, to reach unprecedented locations in a non-invasive way, and to perform additional in-network processing.

Traditional communication technologies are not suitable for nanonetworks mainly due to the size and power consumption of transceivers, receivers and other components. In our opinion [2, 4], the most promising approach for nano-networking is molecular communication mainly because of two reasons. The first reason is the disadvantages of the above mentioned schemes. Whereas the second reason is the fact that in a near term nano-machines will be developed by following the Bio-inspired approach which will allow the use of cell receptors in a similar way that are used by cells in order to communicate among them by using molecules.

As it happens in nature, molecular communication should be tackled in different ways depending on the distance between emitters and receivers. Thus, three different approaches have been already established. Short-range (nm-µm), medium-range (µm-mm) and long-range (mm-m) molecular communication. For the short distances, two techniques, namely, molecular signaling [5, 6] and molecular motors [7] have been proposed; for the medium range (µm-mm), the use of the flagellated bacteria and catalytic nanomotors [8] has been studied and simulated. Regarding the long-range two techniques have been proposed as a possible solution [9]. The first one is communication by means of pheromones, and the second which appears to be the most promising is based on light transduction, i.e., converting the molecular signals into the optical domain.

The envisaged network architecture is composed of a cluster of nanomachines that communicate among them using short-range mechanisms, and gateways, which, taking advantage of medium and long-range techniques, inter-connect clusters.

This work, shows how implement an android application framework and simulate it on Android platform to explain the system of light transduction method as one of the most anticipated schemes for long-range molecular communication which represent the basic models for the development of future nanonetworks. Also architecture of the intrabody nanonetworks for remote healthcare as an interesting and important application for nanonetworks is prototyped and highlighted with our android simulation (Yazhraa).

II. MOTIVATIONS

Despite the current existence of simulation tools for molecular assembly, and biological and genetic systems, there is none for nano-networks up to now. Simulation tools should allow the use of different nanonetwork topologies and molecular communication schemes. It should also include the medium parameters that affect the propagation of the information molecules, and allow the selection of different carriers to transport the information. But achieving all of these requirements will be as a challenge with a single researcher. Due to nano-networks communication in long-range nano communication is an unexplored research area with unique and powerful characteristics capable of major revolutions in many applications and Light transduction [9] as the most promising technique for that range offers exciting features. For instance, it has extremely high velocity compared to molecular signals. So our research efforts have been focused on this scheme in order to validate it and provide a common ground for prototyping by means of simulation.

III. OBJECTIVES

The imitation of some real thing available or any system that involves many processes is an important feature. It generally entails representing certain key characteristics or behaviors of a selected physical or abstract system

[10]. Concerning the long-range communication based on Light transduction approach, information-theoretical already proposed in the literature [9], were meant to cover distances up to kilometers.

With respect to what stated above the purpose of this treatment will be focus on designing a new architecture for Light transduction communication system and demonstrating that system with a generic Android simulator called (Yazhraa). The primary goal beyond the use of Android platform is the ability to write the Android application once and have it run on various devices because the Android operating system is versatile and standardized for various devices. Lastly, for more in-depth understanding and further information about Long Range Nanonetworks communication based on light transducers, our android simulation (Yazhraa) offer a good framework and visualization Interface for healthcare application of intrabody nanonetworks .

IV. OVERVIEW OF THIS WORK

Use of Android devices has greatly expanded for the portability of these devices, their networking capability, computing power, available sensors (location, motion, optical, acoustic, etc.), gives them great potential for design software. More than ever, they are performing tasks that were traditionally performed on desktop or laptop computers. So, the main contribution of this research to design and implement simulation software for modeling and simulating the light transduction method is based on android platform.

We won't explore much of the Android API for this overview but here we'll get a taste for the development environment and the steps we go through. An Android application is a loose collection of Activities, Services, Content Providers, and Broadcast Receivers. These are the components from which we put together an application. Fig. 1, shows the design of the entire (Yazhraa) application, which incorporates most of the main Android building blocks.

We are going to start by introducing the Android user interface (UI) model. In its UI, Android is quite different from some other paradigms that we may be familiar with. The unique feature is its dual approach to UI via both Java and XML. Our approach will focus on best practices in UI development so that the application looks good and works well on any Android device, regardless of screen size and resolution.

First, we'll create the screen, which is an activity, a basic Android building block. Then, we'll need a way to get to that screen. For that purpose, menu system in Android is used. We will also use Intents which send intents to open up a specific activity. It turns out that some of the cool features Android services provide can make our application service much simpler. So we're going to use Alarm service to fire off these intents on regular basis. Additionally, we'll add a feature to notify the user of new action by putting a notification in the notification bar. For that, we'll use the Notification service. All this will prove to be a substantially more elegant solution to our application service need.

Finally, Lists and Adapters will tie the data to our user interface. They form a very powerful component that allows our tiny UI to connect to potentially large datasets in an efficient and scalable manner. In other words, users will be able to use (Yazhraa) application in the real world without any performance hits in the long run.

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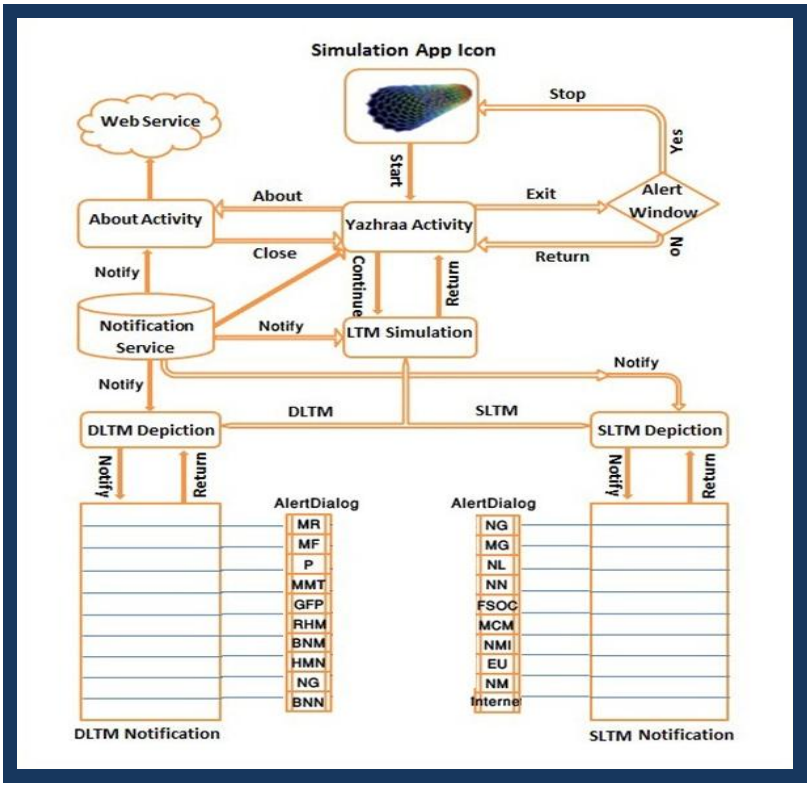

Fig.1. Yazhraa Design Diagram

According to the design diagram shown in the Fig.1. Yazhraa Application composed of the following activities:

Table .1 The Fundamental components of Yazhraa application.

Activity	Description
YazhraaActivity	The main activity from which we can launch Yazhraa Application.
YaumaalbeneenActivity	The 2nd activity in Yazhraa application from which we can switch between the system of light transduction method and its demo.
SysActivity	The illustration activity of light transduction system.
ExActivity	The prototypical activity of light transduction demo.
SysListActivity	The list activity for the notifications of light transduction system.
ExListActivity	The list activity for the notifications of light transduction demo.
AboutActivity	The informatics activity of Yazhraa application.

V. YAZHRAA APPLICATION DESIGN

First, we are going to create the screen, which is an activity, a basic Android building block by introducing the Android user interface (UI) model. There are two ways to create user interface (UI) in Android. One is declarative and the other one is programmatic. They are quite different but often used together to get the job done. The best practice is to use both. We would use declarative (XML) approach to declare everything about the user interface that is static, such as the layout of the screen, all the widgets, etc. Then, we would switch to programmatic (Java) approach to define what goes on when user interacts with various widgets of the user

interface. In other words, we'd use XML to declare what the "button" looks like, and Java to specify what it does.

5.1 Yazhraa Activity Layout

Let's start by designing the user interface for our main screen (YazhraaActivity). By default, Eclipse created a file called main.xml under res/layout folder. For consistency purposes, we should rename this file to yazhraa.xml to match our activity. To rename a file in Eclipse, right-click on it, choose Refactor→Rename… and enter new name. This screen will have five components:

- Transient alert message displays for a certain amount of time and goes away using Toast.
- Button to click to continue the application. This will be a Button widget.
- Button to click to display the info about Yazhraa application. This will be via a concept called intents to invoke AboutActivity.
- Button to click to exit the application. This will be via an AlertDialog.
- A layout to contain all these widgets and lay them out one after another in horizontal fashion. For this screen, we'll use LinearLayout, one of the more common ones.

Now that we have our UI designed in XML, we are ready to switch over to Java to define what goes on when user interacts with various widgets of the user interface. Our Java class for this is "YazhraaActivity.java "and the Eclipse New Project Dialog has already created the stub for this class for us. The class is part of "yazhraa.aketheny" Java package, and as such is part of that directory. After register this new activity with the AndroidManifest.xml file, we should have YazhraaActivity run successfully and look like Fig. 2.

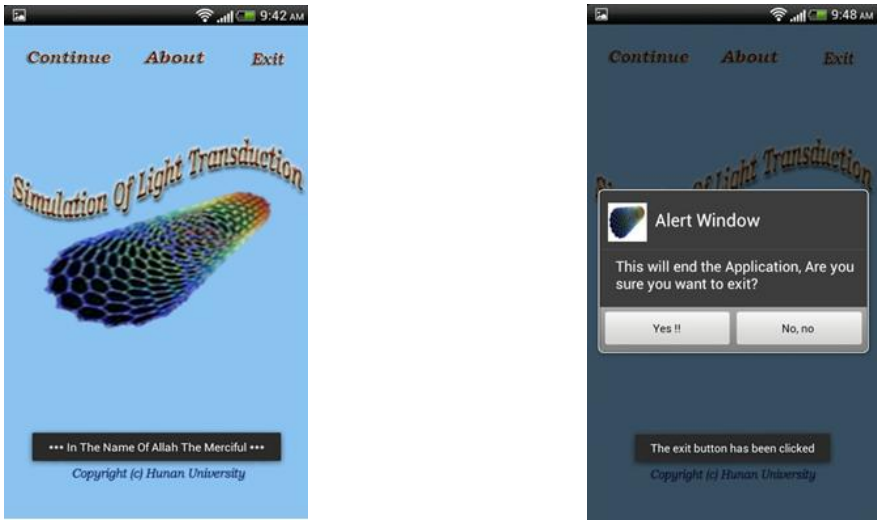

Fig.2. (a) The user interface and layout of YazhraaActivity. (b) Screenshot of the Alert Dialog to exit the application.

5.2 Yaumaal beneen Activity Layout

To enable our app to handle the switching between the simulation of light transduction system and light transduction demo, we'd have to build a screen which forces the user to select only one item at a time. While do this sounds like tricky, Android provides a RadioButton controls to help streamline working with several choices and forces them to select a single item. This screen will have three components as follows:

- Custom window title with a logo image on the left of title bar. This will be done by creating a custom xml layout combined with custom style and apply it as theme in application manifest :
  1. Create custom layout for window title in "layout" folder.
  2. Create custom style in "values" folder.
- Two RadioButton control to invoke SysActivity with the first one and to invoke ExActivity with the second one. This will be via a radio group using android.widget.RadioGroup.
- A layout to contain all these widgets and lay them out one after another in vertical fashion. For this screen, we'll use LinearLayout, one of the more common ones.

First, we'll create yaamalbeneen.xml resource file and define the source code for this layout. Next, Java class"YaumaalbeneenActivity.java "which inflates this resource file is created to be part of "yazhraa.aketheny" Java package.

By the end of this section with registering this new activity in the AndroidManifest.xml file, we should have YaumaalbeneenActivity run successfully and look like the screenshot below (see Fig. 3).

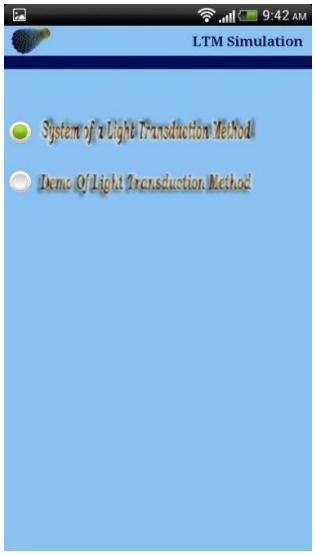

Fig.3. Screen where the user can switch between system and demo simulation.

5.3 Sys Activity Layout

The main goal of this activity is to simulate the system of light transduction approach which according to SysActivity design composed of two molecular communication media communicates with each other via light communication media. For each endpoint molecular communication media comprise the following:

1. Three of nanoscale network that can be defined as a set of interconnected nanomachines, i.e., devices in the order of a few hundred nanometers or a few micrometers at most, which are able to perform only very simple tasks such as computing, data storing, sensing and actuation .
2. Three of nano-gateway to switch from short-range mechanisms to long-range techniques and to multiplex information of different Nano-machines.
3. A set of Nano-links which connect the molecular communication nanonetworks with nano-micro interface.
4. Nano-micro interface device to convert the molecular signals in encoder endpoint to optical waves to propagate in optical domain by the usage of Fluorescent proteins or MOLED's information via Molecular Switch or Molecular Wire in the decoder endpoint.

As for light communication media, it comprises the following components:

1. Micro-Gateway device which enables the remote control of the entire system by connecting to the internet over free-space optical channel, and here we can add several techniques that would increase the propagation distance of electromagnetic wave such as the usage of (Bioluminescence Resonance Energy Transfer (BRET) or Nano-machines with higher antenna gain and better directivity could be designed. Finally, the usage of semiconductor mixers to convert the optical frequencies to MHz instead of hundreds of GHz is another solution to reach much further distances.
2. External user who can remotely control and keep track the location and status of Nano networks (e.g., displays, oscilloscopes, cardiograms) via wireless connection in an effortless fashion.

The following screen (Fig.4) illustrates what a finished product could look like after registering SysActivity in the AndroidManifest.xml file:

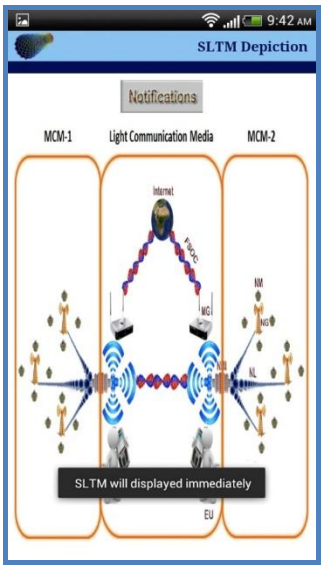

Fig. 4. The user interface and layout of SysActivity.

5.4 Ex Activity Layout

In this activity we elucidate using of Light Transduction mechanism in biomedical application to provide a pathway between intra-body nanonetworks (e.g., between heart monitoring nanonetwork and breathing system subnet) and macro device (e.g., Pacemaker). Moreover, the interconnection of different nano-systems can be achieved by taking advantage of this long-range technique. Lastly, we propose molecular motors technique as a method to realize communication among Nano-machines in the short range (intra-body nanonetworks). The main components which used to create this activity are summarized by the following:

1. Heart Monitoring Nano-network that can be defined as a set of interconnected biological nanomachines via molecular rails called microtubule filaments which can be used to transport the information (molecule) by the molecular robots (e.g., kinesin, dynein, and myosin) . It's worth noting that molecular robots defined as proteins or protein complexes which can transport a data packet (molecule) along a pre-established path (microtubules) to reach the destination at a nano-scale according to molecular motors technique for Short-range Nano networks.

2. Breathing System Subnet (Breathing Nano-network) which can be defined as a set of interconnected biological nanomachines via microtubule filaments to transport the information (molecule) by the molecular robot according to molecular motors approach.
3. Nano-link between the aforementioned molecular communication nanonetworks and nano-micro interface device, namely, the green fluorescent protein.
4. Green Fluorescent Protein which composed of aminoacids that fluoresce at certain wavelength when exposed to different wavelengths. It's proposed here as a transduction mechanism (novel solution) for allowing the conversion from the molecular signals to optical waves to propagate in the optical domain.
5. Pacemaker device to help control abnormal heart rhythms and prompt the heart to beat at a normal rate. It works as a micro-gateway device by sending the information to the healthcare provider hence, enables the remote control of the entire system.
6. Remote Health Monitor who can remotely control and keep track of the location and status of Nano networks from the macro scale devices (e.g., pacemaker) over the Internet in an effortless fashion and via free-space optical channel. Here, we can also add several techniques that would increase the propagation distance of electromagnetic wave such as the usage of (Bioluminescence Resonance Energy Transfer (BRET) or Nano-machines with higher antenna gain and better directivity could be designed. Finally, the usage of semiconductor mixers to convert the optical frequencies to MHz instead of hundreds of GHz is another solution to reach much further distances.

By running the resource XML file and java code that we could use for showing ExActivity layout after registering ExActivity in the AndroidManifest.xml file we should have the result screen look like Fig. 5.

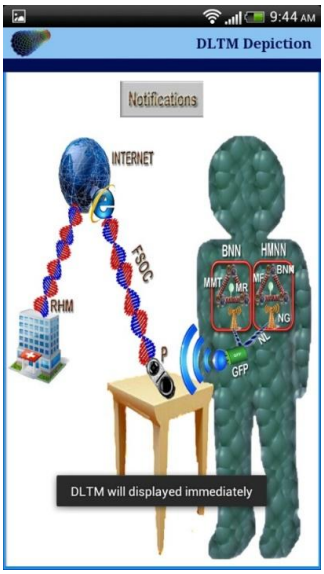

Fig.5. The user interface and layout of ExActivity.

5.5 Sys List Activity Layout

When we click on the notification button at the system layout we should launch this list activity for showing the notifications of light transduction system. Android provides the view “ListView" which is capable of displaying a scrollable list of items. "ListView" gets the data to display via an adapter which must extend "BaseAdapter" and is responsible for providing the data model for the list and for converting the data into the fields of the list. Android has two standard adapters, ArrayAdapter and CursorAdapter . "ArrayAdapter" can handle data based

on Arrays or Lists while "SimpleCursorAdapter" handle database related data. The following description will focus on ArrayAdapter and how to develop our own adapter. We can directly use the "ListView" in your layout as any other UI component. The steps to create a ListView for our application will be:

1. Create the following layout file "sysnotifications.xml" in the res/layout folder of your project to define own layout for the rows and assign this layout to row adapter. We will add a graphic to each list entry.
2. Create a new java class under the name "SysListActivity "with the following source code to form the list activity which we need for notifications.
3. Create the class "MyArrayAdapter" which will serve as our adapter and implement it to inflate "sysnotifications.xml" resource file.
4. Register this new activity with the AndroidManifest.xml file.
5. Provide a way to start that activity from the rest of the application.

Here's what a finished product screen could look like after running the source code of this layout.

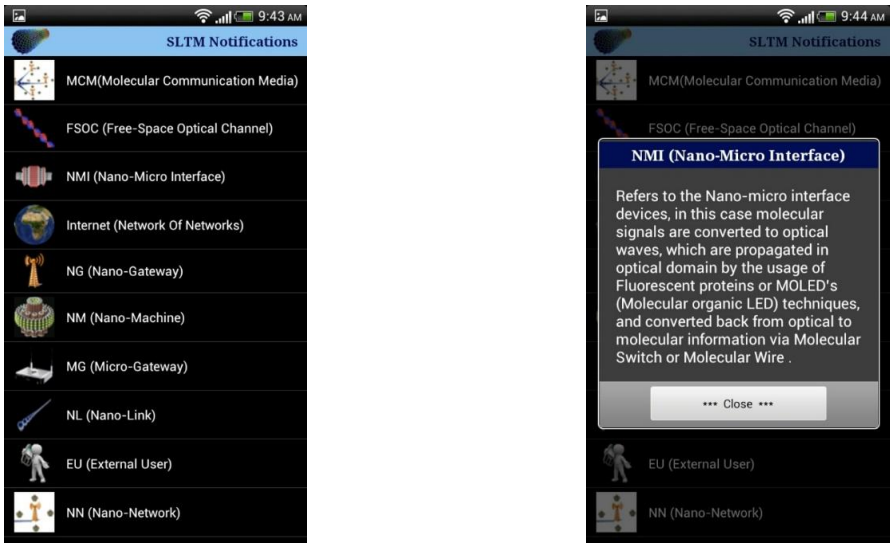

Fig.6. (a) Screen where the user can be acquainted with the system notifications.
(b) Screenshot which presents more details about each symbol.

5.6 ExListActivity Layout

The list activity for the notifications of light transduction demo is start up by clicking on the notification button at the example layout. This is almost the same coding as in the previous layout, the only difference is that we are using our own layout in the ArrayAdapter and telling the adapter which UI element should contains the text without adding a graphic to each list entry.

The following (Fig.6) illustrates what a finished product could look like:

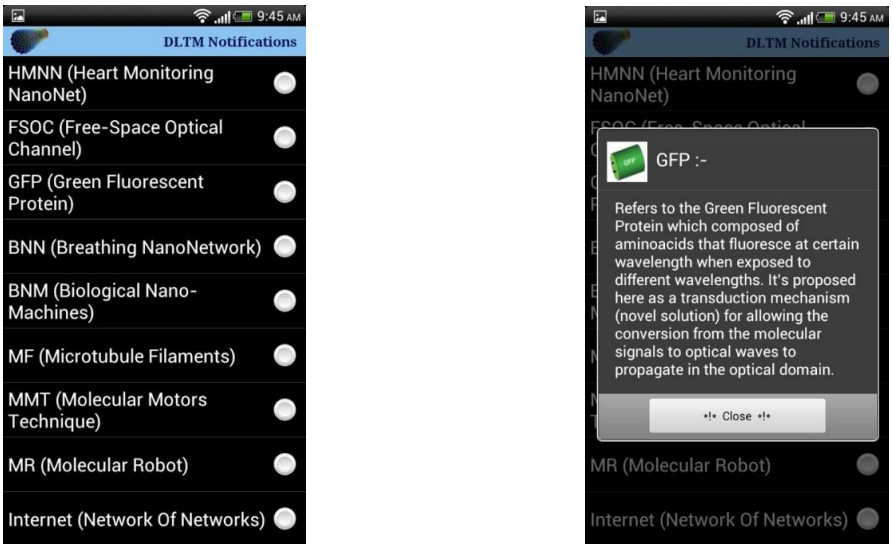

Fig.6. (a) Screen where the user can be acquainted with the example notifications. (b) Screenshot which presents more details about each symbol.

5.7 About Activity Layout

We have set up the informatics activity of Yazhraa application with a dialog theme, so it appears like a dialog and then used the simple code to create the layout keeping attention to finish the activity on dialog close/click. Here are the four steps that we need to do so:

1. Create layout resource file aboutsimulation.xml.
2. Implement AboutActivity.java file that inflates that resource file.
3. Register this new activity with the AndroidManifest.xml file.
4. Provide a way to start that activity from the start of the application by clicking on about button in YazhraaActivity.

If we run the code for this layout we should reach the result shown in Fig.7.

Fig.7. AboutActivity Layout Window.

VI. CONCLUSION

The recent explosion of research in nanonetworks as a new networking paradigm will have a great impact in almost every field of our society, ranging from health-care to homeland security or environmental protection. Also, the need for communication technologies to control these nanonetworks will be more plausible with the increased complexity of developed nano-devices. Molecular communication seems to provide efficient mechanisms for networking of nano-machines.

Despite promising progress performed in molecular communication, there is currently no molecular communication simulator which provides a practical and beneficial simulation suite to be used in the development of communication methods for nanonetworks. Thus, it is essential to develop a simulator which allows the investigation of different nanonetwork topologies and molecular communication scenarios. Since, molecular short-range nano-communication techniques cannot provide the properties that long-range applications require. When dealing with distances from a few centimeters to several meters, the signal speed, its reliability, energy consumption and hardware requirements are improved in long-range techniques.

Nevertheless, light transduction – converting molecular signal into optical information – is the most promising technique. As micro and nano elements will coexist in first nanotechnology stages, this option will act as an interface to interconnect different networks. So, this paper introduces a light transduction simulator, Yazhraa, App developed based on the Android OS to yield a better understanding of nanonetworks and their multiple possibilities. It describes some basic concepts of architectures that compose system topology, as well as possible design for the tiny nanonetwork components, that may benefit from this scheme, hence simplify the development of new communication techniques.

VII. FUTURE WORK

In conclusion, the application proposed in this paper is developed using the SDK to simulate one option of the long range techniques. Therefore, a simulation tool, integrating all these models, should be developed to analyze which of them offer better features under which circumstances. We believe that the future work on this topic can take advantage from the results presented in this article.

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