Available Online at www.ijcsmc.com

International Journal of Computer Science and Mobile Computing

A Monthly Journal of Computer Science and Information Technology

ISSN 2320–088X

International Conference on Mobility in Computing- ICMiC13, Organized by Mar Baselios College of Engineering and Technology during December 17-18, 2013 at Trivandrum, Kerala, India, pg.56 – 65

SURVEY ARTICLE

Kids Interactive Developmental System over Wi-Fi Direct

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Abstract— Smart classroom has been a boon in the field of education. But when it comes to individual evaluation of education and development of kids in a classroom, this would require one to one intervention. KIDS is an Android based kids educational evaluation system we propose to implement over Wi-Fi Direct to be deployed in a smart classroom environment to evaluate and help kids to improve their learning skills. When traditional Wi-Fi connectivity is supported by Access Points deployed and monitored by service providers, Wi-Fi Direct Technology presents a costless deployment of Wi-Fi infrastructure. KIDSoWFD aims to develop such a frame work and takes up an activity based approach to evaluate a kid's potential which is currently being implemented. This can be extended for speech therapy, facial expression analysis etc.

Keywords— Smart classrooms; Wi-Fi Direct; Android; Tutor; Learner; Virtual Tutor; Activity

I. INTRODUCTION

Smart classroom has been a boon in the field of education, since many years. But when it comes to individual evaluation of education and development of kids in classroom, it would require one to one intervention. Existing education system performs most of the kids early developmental activities through individual attention i.e. 1-1 tutor learner ratio to analyse and understand the capabilities of learner.

KIDSoWFD (Kids Interactive Developmental System over Wi-Fi Direct) is a smart classroom environment developed upon Wi-Fi Direct Technology to analyse the capabilities of the kid through activities, speech therapy and facial expression analysis. Wi-Fi Direct Technology acts as a layer 2 service over which network and socket communication is established to handle to and fro traffic between Tutor and multiple learners. This environment provides a Virtual Tutor which can track the kid's concentration index, speed of completion, responsiveness, facial expression evaluation etc. This Virtual Tutor can in turn communicate the details and analysis result to the Tutor's device so as to save the evaluation results for further collaborative analysis and reporting to the parents through external AP or access to the web server. Stimulating human brain can be done using behavioural patterns and analysis

can be done on the response to the patterns. This analysis gives a lot of idea about the behaviour and capability of human brain if the patterns are chosen scientifically.

The paper aims to provide general design architecture for developing a framework of kid's interactive developmental system onto which numerous developmental activities can be added. This document is a template. An electronic copy can be downloaded from the conference website. For questions on paper guidelines, please contact the conference publications committee as indicated on the conference website. Information about final paper submission is available from the conference website.

II. OBJECTIVE

The objective of this project can be summarized as:

- Provide a design frame work to establish wireless connectivity over Wi-Fi Direct
- Provide a design framework for kids to manage profile, create various activities for further enhancement and deployment
- Provide an environment to scientifically analyse capabilities of kids at different levels
- Provide an evidence based system to analyse the strengths and weakness of special kids
- Provide 1:1 attention through virtual Tutor when tutor-student ratio is low
- Provide Individualized goals for each kids based on their capability rather than assigning similar activities to students
- Provides an algorithmic approach based on the results taken from normal kid (based on age, activity levels) to categorize them based on concentration index, speed, eye-hand coordination through pattern tracing activities, identify clarity in speech (alphabet or number or object identification), facial response such as eye-tracking and physiological features (emotional face recognition)
- Virtual Tutor on KIDS can be developed to monitor the above features and communicate the results to the Teacher by making use of Wi-Fi Direct Network.
- The Teacher should also have the privilege of assigning required/selected activities to Learner to develop a collaborative analysis of the capabilities

III. SCOPE AND OPERATION

A. Scope

This project implements a real world android application framework for developing an kids education evaluation system over Wi-Fi Direct.

This system can be used by 3 categories of people

- Kids at their early stages of brain development.
- To quantitatively measure the mental ability of mentally challenged persons, train them and monitor the progress.
- To train high profile intellectuals by stimulating all areas of their brain.

This system aims to provide

- Play-based activity
- Evidence based approach towards learning
- Individualized goals
- Virtual Tutor for 1:1 evaluation
- Eye-hand co-ordination activity [4, 5]
- Early stage learning and identification activity

B. Wi-Fi Direct

The Wi-Fi Direct is a new layer 2 technology defined by the Wi-Fi Alliance aimed at enhancing direct device to device communications in Wi-Fi. Thus, given the wide base of devices with Wi-Fi capabilities, and the fact that it can be entirely implemented in software

over traditional Wi-Fi radios, this technology is expected to have a significant impact. Wi-Fi Direct builds upon the successful IEEE 802.11 infrastructure mode and lets devices negotiate who will take over the AP-like functionalities. The Wi-Fi Direct devices formally known as P2P Devices, communicate by establishing P2P Groups, which are functionally equivalent to traditional Wi-Fi infrastructure networks. The device implementing AP-like functionality in the P2P Group is referred to as the P2P Group Owner (P2P GO) and the devices acting as clients are known as P2P Clients.

KIDSoWFD makes use if Wi-Fi Direct Technology to establish network communication in a classroom environment between the Tutor and the Learners.

C. Activity

The KIDS system provides a framework for numerous activities which improves Learner's brain capability like thinking power, learning power, memorizing, eye-hand co-ordination, accuracy, concentration. Activities can be added for speech therapy, facial expression analysis in a normal class room environment etc. Learning to read and write requires the repeated execution of various activities at different levels. Activities such learning alphabets, numbers, identifying alphabets, counting objects, identifying objects, learning of phonetics, manual production or tracing of spatial patterns, support for audio when Tutor needs to communicate orally to Learners.

D. Tracing

Learning to write also requires the repeated execution of tracing activities at different levels. Tutor can produce easy, medium or difficult patterns manually. It remains unclear whether tracing or copying provides better training: tracing provides accurate and immediate performance feedback, whereas copying may require greater use of memory and recall during training. Tracing [4,5] an activity requires quite a lot of brain involvement to have proper eye hand coordination, accuracy, speed, concentration etc. Pattern templates are created by Tutor and traced by Learners to verify their eye hand co-ordination.

There can be many kinds of pattern tracing

- Parallel tracing
  Tracing a pattern with a parallax offset eg: Tracing a small "s", by looking at a big "S" and detecting the parallax error. Skills like decision making, estimation etc are improved thought this activity
- Mirror tracing
  Here the Learner traces the mirror image of a pattern. This requires quite a bit of logical ability as well. This activity can be a brain teaser in the case of complex patterns.
- Virtual tracing
  The pattern will be showed up for a limited period of time and the subject need to trace the pattern from memory. The accuracy in reproducing the pattern involves quite a lot of brain activity. This activity can improve memory power.
- Scattered tracing
  The pattern will not be very clear and will be embedded in the background. This activity improves the observation and identification skills.

The pattern tracing activity which can be part of behavioural neural science can be exploited to give proper training to the brain. Different kinds of pattern tracing activity can be used to polish specific areas of the brain. The patterns, if designed scientifically, and well placed out through a touch screen device can be used to activate all areas of brain.

E. Operation

The Tutor can create patterns or activities (based on options) that can be assigned and executed by the on the fly. The Learners connected to Tutor by means of Wi-Fi Direct is provided with the touch screen display of the tablet module that will show some pattern (an alphanumeric character of complex patterns, either static or moving) on the touch screen display. The Learner is asked to trace the pattern on the touch screen using a stylus or fingertip. The error or deviations from the system generated pattern is correlated with the actual stylus or finger movement from the Learner using a correlation algorithm that runs as Virtual Tutor in the back ground. These deviations, along with the profile of the Learner (age, sex etc.) are used to calculate the mental ability index/indices and stored in database or sent to the Tutor.

The proposed infrastructure of the system can be depicted as follows:

IV. FUNCTIONAL SPECIFICATION

The following section describes about the functional specification and operational details of the project.

A. Wi-Fi Direct Connectivity

The Tutor should always be a dedicated Tablet with much privilege than the Learners. The Tutor thus can be set as Group Owner (P2P GO) [6,7,8] whenever a class room environment is set by maintaining persistent group settings or by always setting the highest group intent value on connection. Multiple Learners can then get connected to Tutor (P2P GO) which can dynamically assign IP to Learner systems and map them to profiles of Learners (P2P Clients).

B. Pattern Generation and Tracing

This is the simplest mode of operation for the tablet module. The module should be able to generate alpha numeric characters, (simple to complex patterns) called here after in this document as Objects. The objects can be static (A static 'star') or dynamic (system slowly drawing a 'star' on the touch screen display). These characters or patterns should be shown on the touch screen display with or without a background to make the pattern or character difficult or easy to recognize or follow.

Learner needs to trace the object on the display using a stylus or fingertip. The speed and accuracy of the movement of stylus is recorded and is used to calculate the concentration index of the Learner.

There should be 2 modes of operation:

- Training mode.
- Testing mode.

During training mode, the deviations of stylus or finger movement from the expected (error /actual co-ordinates) is shown immediately on screen. This is done by Tutor to evaluate the kids deviation from the expected or maximum deviations allowed.

In the case of testing mode, the Learner is allowed to follow the object fully and only the final index (result) is shown (with the errors also shown).

C. Character Recognition and Correlation by voice

An alpha numeric character will be displayed on the touch screen display and the Learner is instructed to spell the character. The difficulty level of this mode can be altered by introducing a background which can make the alpha numeric character difficult to identify.

The speed and accuracy at which a person recognizes the character will be the baseline to his mental ability index.

This is intended more for training kids and for monitoring their progress.

D. Detecting eye movement to measure concentration index

The Learner is instructed to follow a dynamic object on the screen with his eyes. The eye ball movement should be captured and correlated with the object movement on the screen. This correlation can be used to generate a concentration index. The difficulty level can be altered by generating disturbances on the screen.

On an advanced level, apart from the eye movement, the face movement [1, 2, 3] and the movement of the body as a whole also should be considered to calculate the concentration index.

This use case is mainly intended for high profile intellectuals.

E. Creating and Saving Learner Profile

The tablet module should provide option to create a profile for the Tutor with some basic parameters like name, age, sex, effective age (in the case of mentally challenge person) left/right hander etc. Some of this information could be crucial in calculating the index by the correlation algorithm. The created profile should be saved to the storage device. The profile is saved to the storage device in a particular format. Each time a Learner uses the tablet module, the profile is updated with the relevant information of his/her usage session.

This stored profile data can be (later) analysed Tutor to evaluate the progress of the Learner. Basically this feature provides a usage history on a per Learner basis.

V. HARDWARE REQUIREMENTS

A. Android Tablets

The Android framework [9] provides a framework that supports touch screen display to provide more flexibility to generate complex dynamic patterns. This framework can be used to provide a colourful user interface similar to a gaming console for Learners. Android Jelly Bean OS [9] also supports Wi-Fi Direct configurations to establish Wi-Fi connectivity between the devices by forming a group in which multiple devices can participate.

B. Web Server

A centralized Web Server connected to only Tutor to upload and retrieve consolidated reports of individualized kids. This server can be the location from where reports can be sent to the parents.

C. USB Interface

An USB interface should be given to the tablet module which would have the following functions.

- Android application upgrade via USB
- Learner profile storage and Import

D. Video and Audio Interface

Video and audio interface should be provided on the tablet module. The Android framework has inbuilt APIs for supporting capturing audio and video input [1] from the Tutor or Learner to transmit the instructions or facial expressions of kids when required. The purpose of this device interface is to get good quality images of the eye, face and body of the Learner to detect his/her responses to different simulations like object movement on the screen, 3D surround sound etc.

VI. SOFTWARE REQUIREMENTS

A. Real Time Operating System

A suitable OS should be selected which can suit the above hardware requirements. Android OS which uses an embedded Linux kernel can be a good candidate.

B. Network Protocol

The layer 2 Wi-Fi Direct protocol can be implemented (over Android phones), and a communication network can be established over these devices without the limitations of external infrastructure. The goal is to avoid the infrastructure limitation i.e. to communicate and transfer information of any kind between devices, the device need to connect to cellular network or the internet. From the Android OS perspective, API 14 or higher can be used for the implementation.

The network layer is established via TCP/IP over which socket interface is created for network communication.

C. Device Drivers

Device drivers required (or reused from the OS kernel package as available in Android) for the following

- Touch screen display
- Audio interface
- Camera interface
- USB subsystem
- Wi-Fi

D. Graphical User Interface

A suitable graphical user interface is developed at the application level. This gives a canvas for the user to establish connectivity through Wi-Fi Direct through persistent group, learn alphabets and numbers, letter and object identification, trace the pattern, generate pattern, configure settings like, Learner profile, mode, trace tool, difficulty level etc. From the Android perspective, display will be colourful with horizontal or vertical orientation.

E. Correlation Algorithm

A correlation algorithm is developed which correlates the template object thrown out to the Learner by the system and the Learner's response to it. This will take different parameters in the Learner profile as well as the responses of the Learner to arrive upon an index in a scientific way. The algorithm depends upon the activities supported by the system.

F. Analysis Algorithm

Analysis algorithm takes in generated co-ordinates, the time data and the system pattern to create analyser result. This algorithm developed will calculate several factors based on profile of the Learner and trace settings given by Tutor along with the error index calculated using the correlation algorithm is used to calculate the accuracy, concentration and speed indices.

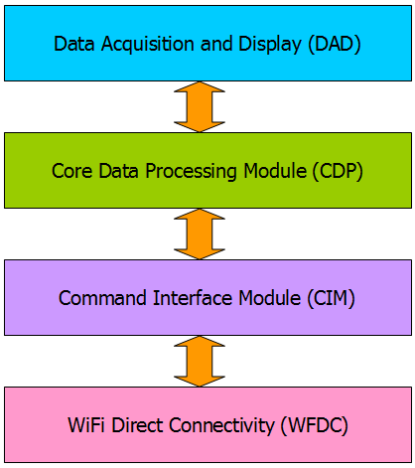
VII. DESIGN SPECIFICATION

There are two modes of operation for this architecture namely:

- Tutor mode
- Learner mode

The total project is divided into four major modules which are interfaced by the Java Native Interface (JNI) provided by the Android Framework.

- The Wi-Fi Direct Connectivity Module (WFDC)
- Command Interface Module (CIM)
- The Core Data Processing Module (CDP)
- The Data Acquisition and Display Module (DAD)



A. Wi-Fi Direct Connectivity Module

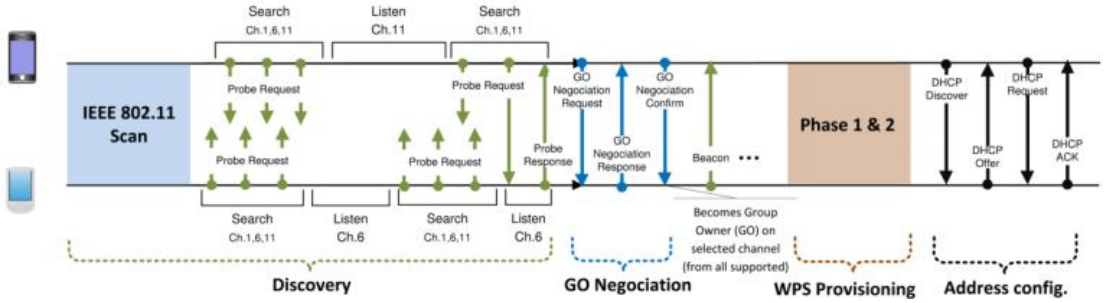
This module is responsible for establishing network connectivity between Tutors and multiple Learners in a class room environment. This layer handles the Wi-Fi Direct communication including discovering peers, connecting peers, and maintaining Wi-Fi Direct connection status. There is also a Broadcast Receiver that monitors any event changing and informs the higher layers. From the connectivity perspective, the system can be configured to work in Tutor's mode or Learner's mode. In Tutor's mode, the Wi-Fi Direct connectivity is established by setting the group intent to highest possible number so as to become the Group Owner of the P2P Group formed. Here we need to create a persistent group however; first connection would be in the standard way.

The Wi-Fi Direct Group is formed in 4 stages of operation [6,7,8] namely:

- Device Discovery
- GO Negotiation
- WPS Provisioning
- Address Configuration

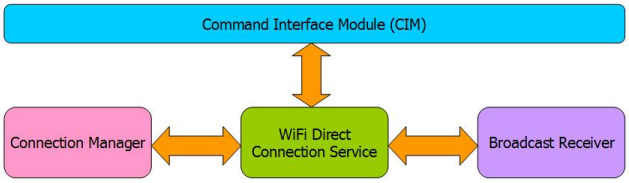
Typical frame exchange sequences in the Standard, Autonomous and Persistent Group formation procedures are given below:

P2P Standard Group Formation



From the implementation perspective, the system or device set as Tutor will always be the Group Owner on connection establishment so that multiple P2P Clients can connect to it. The DHCP Server would be running on P2P GO on connection establishment to provide unique IP address for each P2P Client.

The WFDC module comprises of Wi-Fi Direct Connection Service, Connection Manager and a Broadcast Receiver.



The Connection Service sub module performs various Wi-Fi Direct connectivity operations by making use of Wi-Fi P2P service, channel listener, connection information listener to handle connection and disconnection of peers from the group and process intents that are caught by the Broadcast Receiver. This module uses the services of Connection Manager to identify new clients, start server socket on successful layer 2 and layer 3 connectivity, handle data from other peers, send data to other peers etc.

B. Command Interface Module (CIM)

This module defines a generic communication protocol between the Tutor and Learner from the application perspective over which supports enhancement of the system. This packet format or structure can be used to communicate between devices and also to communicate between various modules.

A typical message format is as follows:

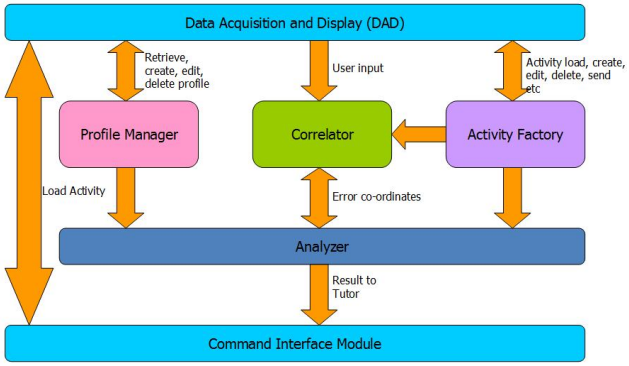
Tutor/Learner ID	Category	Sub-category	Message Length	Message

C. Core Data Processing Module (CDP)

This module is responsible for processing the data acquired by the Data Acquisition and Display module (User Interface).

The CDP module on Tutor's mode is responsible for setting the activity settings, profile management, correlation algorithm to be used for tracing patterns, session management etc. The user interface layer (Data Acquisition and Display) takes the input from the user to create

the profile which is passed on to the analyser. User interface takes in the desired pattern from the Pattern factory. The same pattern will be fed to the Correlator as well as the Analyser.



The Corrrelator takes in the Tutor created trace pattern as well as the System pattern to generate the Error coordinates. These error co-ordinates will be given to the Analyser for analysis.

The analyser takes in the generated error co-ordinates, the time data and the system pattern to create Analyser Result.

Analyser result, which contains the indices, is passed on to the user interface to be shown to the Learner.

D. Data Acquisition and Display (DAD) Module

Data acquisition and Display Module is responsible for the following functionalities.

- Show up the pattern generated by the system to the Tutor.
- Create and save custom patterns.
- Provide a canvas to trace over the pattern
- Provide an interface to the Tutor to create/edit a profile.
- Provide interface to user to apply display/trace settings.

The DAD pushes the following data to the Core Data Processing (CDP) module via the JNI interface.

- Custom patterns.
- Learner profile.
- Display/Trace Settings.

The DAD module consists of a Pattern Generation Activity which is the main class for this module. This Activity comprised of 2 User interface components called as Titles Fragment and Content Fragment. The Titles fragment gives the list of titles like ‘Create Pattern’, ‘Display Settings’ etc which is shown as titles for user to select.

Once the user selects a particular title, the information is passed to the directory. Directory picks up a Directory Entry, which contains the layout id for the corresponding layout. Exact layout is chosen and is passed to the FitCentreFrameLayout class, which inflates the layout and positions centrally on the Content Fragment.

Layouts like CreatePattern and TracePattern are data bonded to the DrawPatternView class as it involved drawing and canvas functionalities.

The KIDSActivity communicates with the Core Data Processing module via the JNI interface and pass information like Profile, Pattern and Settings. It also registers event handlers to receive notifications from the CDP module via JNI interface to display the results

on the screen. This also registers for capturing various networking connectivity events through Broadcast Receiver.

VIII. CONCLUSIONS

This project has high social relevance and usefulness and is thus being implemented. Children have a great deal of potential to live and work independently as adults. One of their curriculum focuses is typical school-readiness skills such as letter recognition, counting, identifying pictures, tracing patterns, speech recognition and clarity, social facial expressions etc. This can be used for the treatment of kids suffering from Autism or mentally challenged kids during their early stage development.

Using a scientific approach in selecting the shape, dimensions, speed of movement of the object on the screen through activity based approach and also in the development of the correlation algorithm, the brain capacity of a person can be quantitatively analyzed using this module. This helps in bringing up brilliant and sharp young generation, improve the metal ability of the mentally challenged people, educate them and to scientifically improve the intellectual capabilities of high profile professionals.

ACKNOWLEDGMENT

We would like to express my sincere gratitude to Dr. C.R. Rene Robin, Head of the Department, Department of Computer Science and Engineering, Jerusalem College of Engineering, for his guidance, constant encouragement and support. We would like to thank numerous authors who have provided their knowledge and being a foundation for the project. We bestow thanks to our family, friends for their motivations and encouragement.

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