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IMPROVING RELIABILITY OF JXTA-OVERLAY PLATFORM: EVALUATION FOR E-LEARNING AND TRUSTWORTHINESS

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We have implemented JXTA-Overlay platform, which is a middleware built on top of the JXTA specification. The JXTA-Overlay defines a set of protocols that standardize how different devices may communicate and collaborate among them. Also, it provides a set of basic functionalities, primitives, intended to be as complete as possible to satisfy the needs of most JXTA-based applications. In P2P systems, each peer has to obtain information of peers and propagate it to other peers. The trustworthiness of peers is very important for safe communication in P2P systems. In this paper, we propose and evaluate a fuzzy-based system to improve the reliability of JXTA-Overlay platform. The JXTA-Overlay is integrated with Internet of Things (IoT) by using RFID technology and SmartBox. We evaluate JXTA-Overlay platform for e-learning and trustworthiness. The experimental results show that by using JXTA-Overlay is possible to decide the situation of learners. The simulation results have shown that the proposed system has a good performance and can select trusted peers to connect to JXTA-Overlay platform.

Keywords: P2P, RFID, JXTA-Overlay, IoT, Fuzzy Logic

1 Introduction

The Internet is growing every day and the performance of computers is increased exponentially. However, the Internet architecture is based on Client/Server (C/S) topology, therefore can not use efficiently the clients features. Also, with appearance of new technologies such as ad-hoc networks, sensor networks, body networks, home networking, new network devices and applications will appear. Therefore, it is very important to monitor, control and optimize these network devices via communication channels. However, in large-scale networks such as Internet, it is very difficult to control the network devices, because of the security problems.

In order to make the networks secure many security devices are used. The firewalls are used for checking the information between private and public networks. The information is transmitted according to some decided rules and it is very difficult to change the network security policy. Also, there are many small networks and Intranets that do not allow the information coming from other networks. Therefore, recently many researchers are working on Peer-to-Peer (P2P) networks, which are able to overcome the firewalls, NATs and other security devices without changing the network policy. Thus, P2P architectures will be very important for future distributed systems and applications. In such systems, the computational burden of the system can be distributed to peer nodes of the system. Therefore, in decentralized systems users become themselves actors by sharing, contributing and controlling the resources of the system. This characteristic makes P2P systems very interesting for the development of decentralized applications [1, 2].

In [1], it is proposed a JXTA-based P2P system. JXTA-Overlay is a middleware built on top of the JXTA specification, which defines a set of protocols that standardize how different devices may communicate and collaborate among them. It abstracts a new layer on the top of JXTA through a set of primitive operations and services that are commonly used in JXTA-based applications and provides a set of primitives that can be used by other applications, which will be built on top of the overlay, with complete independence. JXTA-Overlay provides a set of basic functionalities, primitives, intended to be as complete as possible to satisfy the needs of most JXTA-based applications.

In P2P systems, each peer has to obtain information of other peers and propagate the information to other peers through neighboring peers. Thus, it is important for each peer to have some number of neighbor peers. Moreover, it is more significant to discuss if each peer has reliable neighbor peers. In reality, each peer might be faulty or might send obsolete, even incorrect information to the other peers. If a peer is faulty, other peers which receive incorrect information on the faulty peer might reach a wrong decision. Therefore, it is critical to discuss how a peer can trust each of its neighbor peers [3, 4].

The TrustWorthiness (TW) of peers is very important for safe communication in P2P system. The TW of a peer can be evaluated based on the reputation and interactions with other peers to provide services. However, in order to decide the peer TW are needed many parameters, which make the problem NP-hard.

Fuzzy Logic (FL) is the logic underlying modes of reasoning which are approximate rather then exact. The importance of FL derives from the fact that most modes of human reasoning and especially common sense reasoning are approximate in nature. FL uses linguistic variables to describe the control parameters. By using relatively simple linguistic expressions it is possible to describe and grasp very complex problems. A very important property of the linguistic variables is the capability of describing imprecise parameters.

The concept of a fuzzy set deals with the representation of classes whose boundaries are not determined. It uses a characteristic function, taking values usually in the interval [0, 1]. The fuzzy sets are used for representing linguistic labels. This can be viewed as expressing an uncertainty about the clear-cut meaning of the label. But important point is that the valuation set is supposed to be common to the various linguistic labels that are involved in the given problem.

The fuzzy set theory uses the membership function to encode a preference among the possible interpretations of the corresponding label. A fuzzy set can be defined by examplification, ranking elements according to their typicality with respect to the concept underlying the fuzzy set [5].

In this paper, we integrated JXTA-Overlay with IoT by using RFID and sensor technology.

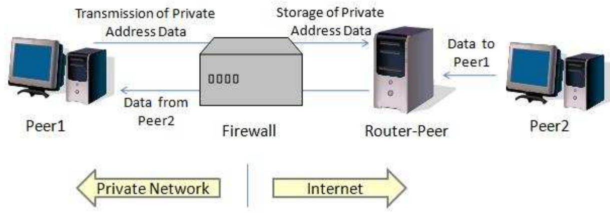

Fig. 1. P2P communication.

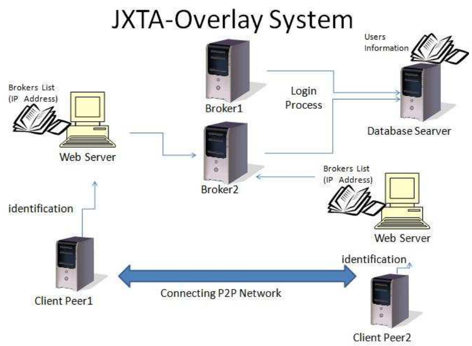

Fig. 2. Structure of JXTA-Overlay system.

We propose a fuzzy-based peer TW system for JXTA-Overlay P2P platform considering three parameters: Local Score (LS), Number of Authentic Files (NAF) and Number of Interactions (NI).

The structure of this paper is as follows. In Section 2, we introduce the Project JXTA and JXTA-Overlay. In Section 3, we present IoT. In Section 4, we introduce FL used for control. In Section 5, we present the proposed fuzzy-based system. In section 6, we discuss the simulation results. Finally, conclusions and future work are given in Section 7.

2 JXTA Technology and JXTA-Overlay

2.1 JXTA Technology

JXTA technology is a generalized group of protocols that allow different devices to communicate and collaborate among them. JXTA offers a platform covering basic needs in developing P2P networks [6].

By using the JXTA framework, it is possible that a peer in a private network can be connected to a peer in the Internet by overcoming existing firewalls as shown in Fig. 1. In this figure, the most important entity is the router peer. A router peer is any peer which supports the peer endpoint protocol and routing messages between peer in the JXTA networks. The procedure to overcome the firewall is as follows.

- In the Router Peer is stored the private address of Peer1 by using the HTTP protocol to pass the firewall from Peer1.

- The Router Peer receives the data from Peer2 and access the Private address of Peer1 to transmit the data.

JXTA is an interesting alternative for developing P2P systems and groupware tools to support online teams of students in virtual campuses. In particular, it is appropriate for file sharing given that the protocols allow to develop either pure or mixed P2P networks. This last property is certainly important since pure P2P systems need not the presence of a server for managing the network.

2.2 JXTA-Overlay

JXTA-Overlay project is an effort to use JXTA technology for building an overlay on top of JXTA offering a set of basic primitives (functionalities) that are most commonly needed in JXTA-based applications [7, 8, 9]. The proposed overlay comprises the following primitives:

- peer discovery,
- peer's resources discovery,
- resource allocation,
- task submission and execution,
- file/data sharing, discovery and transmission,
- instant communication,
- peer group functionalities (groups, rooms etc.),
- monitoring of peers, groups and tasks.

This set of basic functionalities is intended to be as complete as possible to satisfy the needs of JXTA-based applications. The overlay is built on top of JXTA layer and provides a set of primitives that can be used by other applications, which on their hand, will be built on top of the overlay, with complete independence. The JXTA-Overlay project has been developed using the ver-2.3 JXTA libraries. In fact, the project offers several improvements of the original JXTA protocols/services in order to increase the TW of JXTA-based distributed applications and to support group management and file sharing.

The architecture of the P2P distributed platform we have developed using JXTA technology has two main peers: Broker and Client. Altogether these two peers form a new overlay on top of JXTA. The structure of JXTA-Overlay system is shown in Fig 2.

2.3 Internal Architecture of JXTA-Overlay

Except Broker and Client peers, the JXTA-Overlay has also SimpleClient peers as shown in Fig. 3. The control layer interacts with the JXTA layer, and is divided into two parts: a lower part with functionality common to any kind of peer, and a higher part with functionality specific to Brokers and Clients.

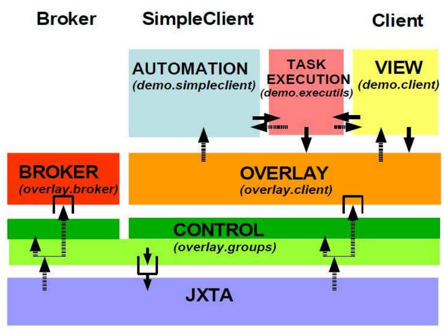

Fig. 3. Internal Architecture of JXTA-Overlay.

- The common part provides functionality for doing JXTA messaging, discovery and advertisement.
- The Broker specific part provides functionality for managing groups of Brokers and keeping broker statistics.
- The Client specific part provides functionality for managing groups of Clients, keeping client statistics, managing its shareable files, managing the user configuration and creating the connection with a Broker.

The lower part enqueues the JXTA messages to be sent. Whenever a message arrives, the JXTA layer fires an event to the lower layer, which in turn fires a notifications to the upper layers.

3 Internet of Things (IoT)

The term IoT has recently become popular to emphasize the vision of a global infrastructure of networked physical objects. IoT is a new type of Internet application which enables the things/objects in our environment to be active participants with other members of the network, by sharing their information on a global scale using the same Internet Protocol (IP) that connects to the Internet. The descriptive models for IoT are introduced based on two attributes ("being an Internet", "relating to thing's information") and four different features (only for thing's information, coded by UID or EPC, stored in RFID electronic tag, uploaded by non-contact reading with RFID reader) [10].

The IoT creates human-machine or machine-to-machine communications. In this way the things/objects are capable of recognizing events and changes in their surroundings and are acting and reacting autonomously largely without human intervention in an appropriate way. The major objectives for IoT applications and services are the creation of smart environments/spaces and self-aware things for smart transport, products, cities, buildings, energy, health, social interaction and living applications (see Fig. 4).

3.1 SmartBox

The SmartBox device is integrated with our system as a useful tool for monitoring and controlling children activities. The size of the SmartBox is $35 \times 7 \times 12$ cm (see Fig. 5). The

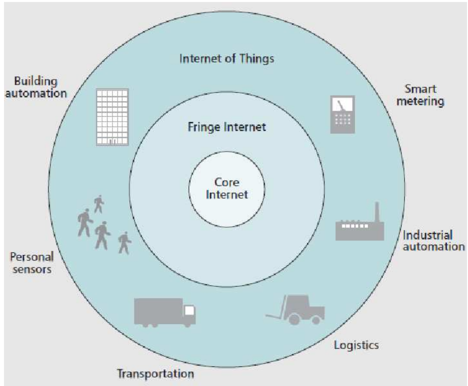

Fig. 4. IoT model.

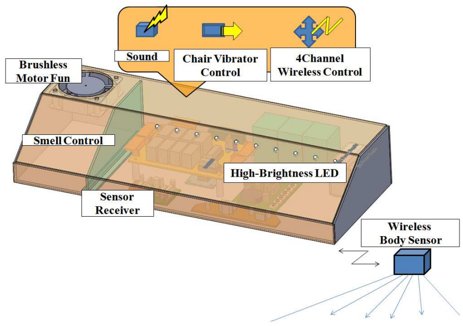

Fig. 5. SmartBox functions.

SmartBox has the following sensors and functions:

- Body Sensor for detecting body and hand movement.
- Chair or Bed Vibrator Control for vibrating the chair or bed.
- Light Control for adjusting the room light.
- Smell Control for controlling the room smell.
- Sound Control to emit relaxing sounds.
- Remote Control Socket for controlling AC 100V socket (on-off control).

These functions can calm and relax students and increase concentration on tasks.

In order to keep the learner motivated in learning activities we are going to use the features of SmartBox device; the Chair Vibrator Control, Light Control, Smell Control, Sound Control.

- *Chair or Bed Vibrator Control for vibrating the chair.* Through sensory integration, physical vibrations of chair will relax and calm the child.

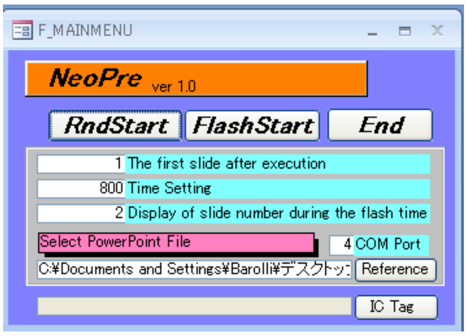

Fig. 6. GUI of our system.

Fig. 7. IC Tag card and IC Tag reader.

- *Light Control for adjusting the room light.* If the child is a visual learner, in order to capture child's attention we can use the computers screen to show colored images and use the light control for changing the room light.
- *Smell Control for controlling the room smell.* If the child likes certain smells/perfumes we can put the perfume of that smell to get the attention.
- *Sound Control to emit relaxing sounds.* If the child accepts auditory stimuli we can use this to get his attention and maintain focus in learning.

3.2 RFID-based System

The GUI of RFID-based system is shown in Fig. 6. Tagging physical objects to find and analyze data about the object is one way the IoT can be used in education. Using our proposed and implemented system, a child or leaner can learn new words through touching

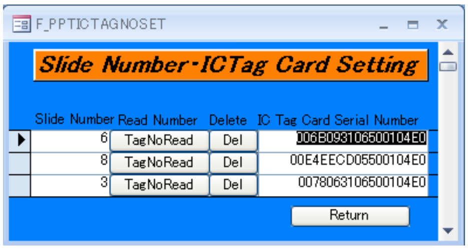

Fig. 8. Saving information in IC Tag cards.

the physical objects that are in their vocabulary list. Each physical object would have a RFID tag placed on the item (see Fig. 7). When this tag is read by a RFID reader or scanned by an application running on a computer or mobile device it would prompt the device to open up a page of information or send a command for an action to happen (see Fig. 8). RFID tags can be created and attached by the parents for each of the physical items in the vocabulary list. When the child places the RFID card on the RFID reader, it will say the word for the item in their native language. Touching the item will give to the child another sense to be engaged and may help them learn new words faster.

4 Application of Fuzzy Logic for Control

The ability of fuzzy sets and possibility theory to model gradual properties or soft constraints whose satisfaction is matter of degree, as well as information pervaded with imprecision and uncertainty, makes them useful in a great variety of applications.

The most popular area of application is Fuzzy Control (FC), since the appearance, especially in Japan, of industrial applications in domestic appliances, process control, and automotive systems, among many other fields.

4.1 FC

In the FC systems, expert knowledge is encoded in the form of fuzzy rules, which describe recommended actions for different classes of situations represented by fuzzy sets.

In fact, any kind of control law can be modeled by the FC methodology, provided that this law is expressible in terms of "if ... then ..." rules, just like in the case of expert systems. However, FL diverges from the standard expert system approach by providing an interpolation mechanism from several rules. In the contents of complex processes, it may turn out to be more practical to get knowledge from an expert operator than to calculate an optimal control, due to modeling costs or because a model is out of reach.

4.2 Linguistic Variables

A concept that plays a central role in the application of FL is that of a linguistic variable. The linguistic variables may be viewed as a form of data compression. One linguistic variable may represent many numerical variables. It is suggestive to refer to this form of data compression as granulation [11].

The same effect can be achieved by conventional quantization, but in the case of quantization, the values are intervals, whereas in the case of granulation the values are overlapping fuzzy sets. The advantages of granulation over quantization are as follows:

- it is more general;
- it mimics the way in which humans interpret linguistic values;
- the transition from one linguistic value to a contiguous linguistic value is gradual rather than abrupt, resulting in continuity and robustness.

4.3 FC Rules

FC describes the algorithm for process control as a fuzzy relation between information about the conditions of the process to be controlled, x and y, and the output for the process z. The control algorithm is given in "if-then" expression, such as:

If x is small and y is big, then z is medium;
If x is big and y is medium, then z is big.

These rules are called *FC rules*. The "if" clause of the rules is called the antecedent and the "then" clause is called consequent. In general, variables x and y are called the input and z the output. The "small" and "big" are fuzzy values for x and y, and they are expressed by fuzzy sets.

Fuzzy controllers are constructed of groups of these FC rules, and when an actual input is given, the output is calculated by means of fuzzy inference.

4.4 Control Knowledge Base

There are two main tasks in designing the control knowledge base. First, a set of linguistic variables must be selected which describe the values of the main control parameters of the process. Both the input and output parameters must be linguistically defined in this stage using proper term sets. The selection of the level of granularity of a term set for an input variable or an output variable plays an important role in the smoothness of control. Second, a control knowledge base must be developed which uses the above linguistic description of the input and output parameters. Four methods [12, 13, 14, 15] have been suggested for doing this:

- expert's experience and knowledge;
- modelling the operator's control action;
- modelling a process;
- self organization.

Among the above methods, the first one is the most widely used. In the modeling of the human expert operator's knowledge, fuzzy rules of the form "If Error is small and Change-in-error is small then the Force is small" have been used in several studies [16, 17]. This method is effective when expert human operators can express the heuristics or the knowledge that they use in controlling a process in terms of rules of the above form.

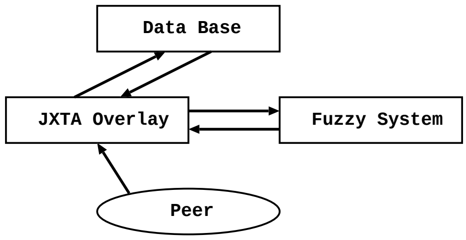

Fig. 9. Proposed peer TW system.

4.5 Defuzzification Methods

The defuzzification operation produces a non-FC action that best represent the membership function of an inferred FC action. Several defuzzification methods have been suggested in literature. Among them, four methods which have been applied most often are:

- Tsukamoto's Defuzzification Method;
- The Center of Area (COA) Method;
- The Mean of Maximum (MOM) Method;
- Defuzzification when Output of Rules are Function of Their Inputs.

5 Proposed Fuzzy-Based Peer TW System

To complete a certain task in JXTA-Overlay network, peers often have to interact with unknown peers. Thus, it is important that peers must select trusted peers to interact. The number of interactions that a peer has with other peers in JXTA-Overlay P2P network is a very important factor that affects the TW peers. Another parameter related to TW peers is the number of authentic files. In every transaction, peers receive a file and evaluate TW of the senders with local score from the file. Selfish peers that benefits from the system without contributing any resources to the network have a low TW. Every time a peer joins JXTA-Overlay, parameters are fuzzified using fuzzy system, and based on the decision of fuzzy system a TW peer is selected. After peer selection, the data for this peer are saved in the database as shown in Fig. 9.

In [18], we proposed a TW peer system with two parameters. In this work, for peer TW, we consider three parameters: LS, NAF and NI. These three parameters are not correlated with each other, for this reason we use fuzzy system. Every time a peer joins JXTA-Overlay, three parameters are fuzzified using fuzzy system, and based on the decision of fuzzy system a reliable peer is selected. After peer selection, the data for this peer are saved in the database. The membership functions for our system are shown in Fig. 10.

In Table 1, we show the fuzzy rule base of our proposed system, which consists of 27 rules. The input linguistic parameters are: NAF, LS, NI, while the output linguistic parameter is Peer Reliability (PR). The term sets of *NAF*, *LS*, and *NI* are defined respectively as:

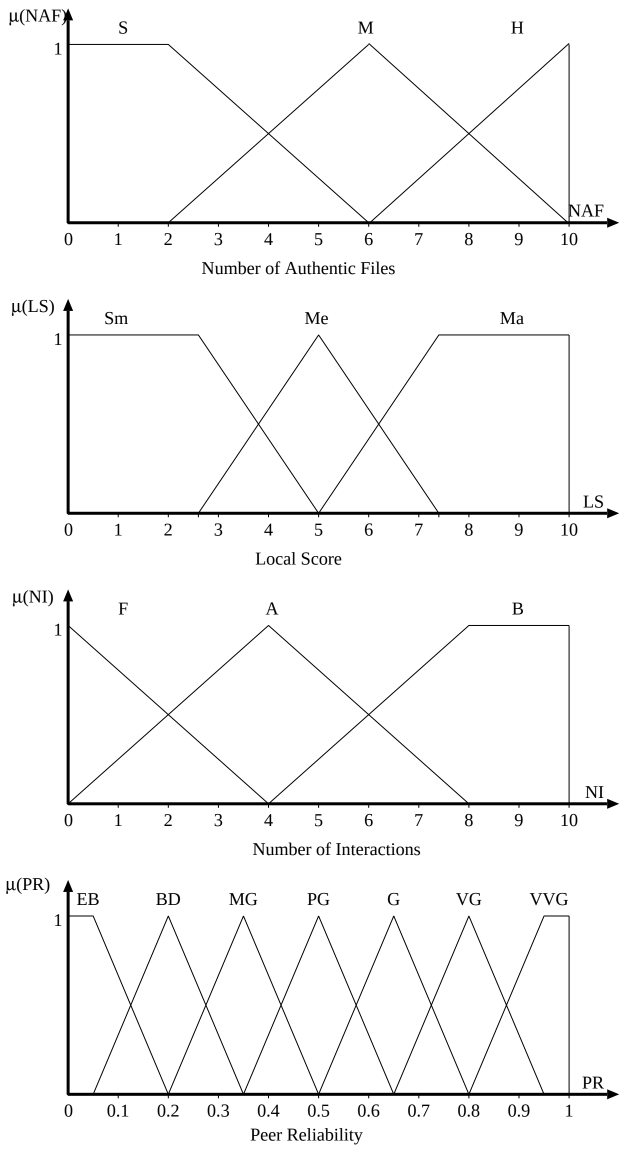

Fig. 10. Membership functions.

$$
\begin{aligned}
\mu(NAF) &= \{Small,\ Medium,\ High\} \\
&= \{S,\ M,\ H\}; \\
\mu(LS) &= \{Small,\ Medium,\ Many\} \\
&= \{Sm,\ Me,\ Ma\}; \\
\mu(NI) &= \{Few,\ Average,\ Big\} \\
&= \{F,\ A,\ B\}.
\end{aligned}
$$

and the term set for the PR is defined as:

Table 1. FRB.

Rule	NAF	LS	NI	PR
1	S	Sm	F	EB
2	S	Sm	A	BD
3	S	Sm	B	MG
4	S	Me	F	BD
5	S	Me	A	MG
6	S	Me	B	PG
7	S	Ma	F	MG
8	S	Ma	A	PG
9	S	Ma	B	G
10	M	Sm	F	BD
11	M	Sm	A	MG
12	M	Sm	B	PG
13	M	Me	F	MG
14	M	Me	A	PG
15	M	Me	B	G
16	M	Ma	F	PG
17	M	Ma	A	G
18	M	Ma	B	VG
19	H	Sm	F	MG
20	H	Sm	A	PG
21	H	Sm	B	G
22	H	Me	F	PG
23	H	Me	A	G
24	H	Me	B	VG
25	H	Ma	F	G
26	H	Ma	A	VG
27	H	Ma	B	VVG

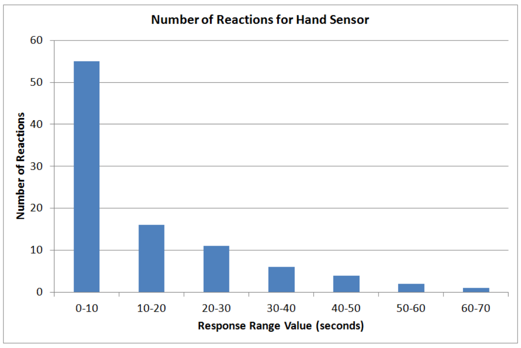

Fig. 11. Number of reactions vs. response range value.

$$\mu(PR) = \{Extremely\ Bad,\ Bad,\ Minimally\ Good,\ Partially\ Good,\ Good,\ Very\ Good,\ Very\ Very\ Good\} = \{EB,\ BD,\ MG,\ PG,\ G,\ VG,\ VVG\}.$$

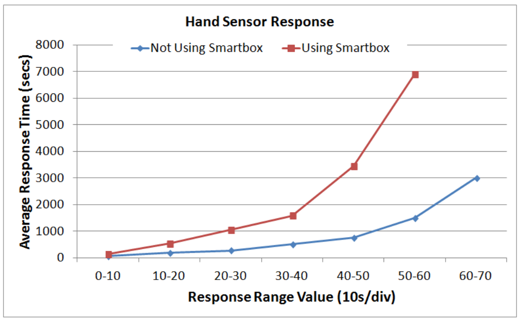

Fig. 12. Average response time vs. response range value.

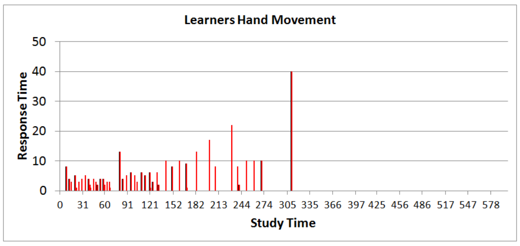

Fig. 13. Response time vs. study time without SmartBox.

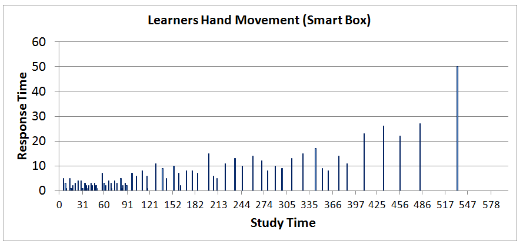

Fig. 14. Response time vs. study time using SmartBox.

6 Experimental and Simulation Results

6.1 Experimental Results

We conducted experiments using our proposed system with a student who is diagnosed with autism. Before doing the experiments we discussed with the parent and the therapist about the ability to study. The student is going under speech therapy and likes working with math problems. The student has a short span attention and this really affects his progress in learning new skills. Through our proposed system, we intend to get and maintain the child's attention by obtaining the calm-alert state window in which the ability to function is maximized [16]. In this state the child's nervous system is sufficiently aroused for peak attention and task performance which enhances a person's ability to register and orient to sensory information.

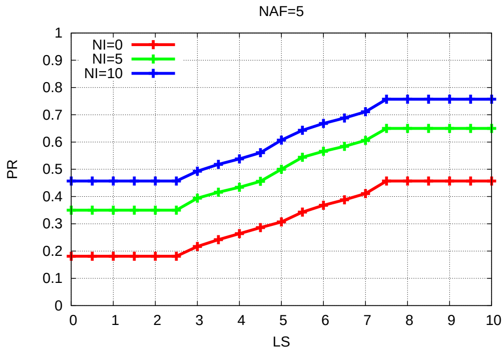

Fig. 15. Peer TW for NAF=5.

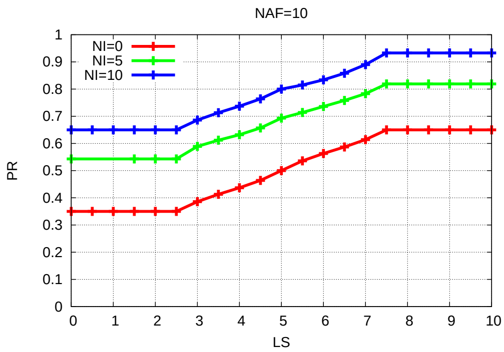

Fig. 16. Peer TW for NAF=10.

Every IC Tag card can be connected with Powerpoint slides (one IC Tag for one slide). All information is saved in an Access database. Every time that IC Tag card touch IC Tag reader (see Fig. 7), the slide connected with this card is displayed on computer screen (except computer screen also video projector can be used).

Our system can generate random presentation and flash presentation (the interval of flash presentation can be set manually). In Fig. 8 is shown how is added the information of slides in IC Tag cards. IC Tag cards can be shuffled as playing cards.

We use the language builder picture cards - nouns to teach:

- Receptive Language;
- Expressive Language;
- Matching Identical Objects;
- Matching Similar Objects;

and the mathematics skills builder cards to teach:

- Numbers;

- Basic skills, counting.

Our system detects the child's movement by using only hand sensor. We didn't measure the body movements through the body sensor because we considered in our experiment that the child tends to move the body very often even if he is not touching the RFID reader. We carried out our experiment with the child for a period of 40 minutes. When a sensor reacts, the interval time will be reset to zero. From the measurement data of the child's hand movements we considered the point of effective stimulation for the child from the sensing rate values. The interval of sensors response is very active at the point around 10-20 seconds, but it gets less active after 20 seconds and, after 50 seconds there is no reaction. The number of reactions from the hand sensor are represented in Fig. 11. In our experiments, we used SmartBox and measured the stimulation effects that the SmartBox has to the child.

In Fig. 12 is shown average response time of hand sensor when using and not using SmartBox. From the results, we can see that the average response time of hand sensor is increased when SmartBox is used.

Fig. 13 shows the experimental results of the child's hand movement not using the SmartBox. While, in Fig. 14 we show the results of the child's hand movement using the SmartBox. From the figures we can see that the child's concentration and the time amount of the study are improved. The results show that child has maintained his focus on learning for a longer period of time compared to the case not using the SmartBox.

6.2 Simulation Results

In Fig. 15, we show the relation between NAF, LS, NI and PR. In the simulation, we consider the NAF as a constant parameter. From the simulation results we can clearly distinguish 3 zones. When LS is less than 2.5 units the peer TW is very small. A middle zone (more than 2.5 units but less than 7.5 units), where the PR increases proportionally with the increase of LS. For more than 8 units there is a third zone where the PR is high. As shown by this figure, with the increase of LS and NI, the PR increases.

In Fig. 16, we increase the NAF value to 10 units. When the peer provides a big number of authentic files with high probability it can be considered as a reliable peer.

7 Conclusions and Future Work

In this paper, we evaluated the performance of JXTA-Overlay platform for supporting learning and improving the quality of life for children with autism. The experimental results showed that the smart environment can help children with autism stay focused during their learning and can maximize their ability to reach their peak attention. The leaner's task performance is enhanced and the child will be able to learn new language skills, social skills, appropriate behavior and academic skills.

In order to select a trusted peer to connect with other peers in JXTA-Overlay platform, we proposed a fuzzy-based system. We considered three parameters: NAF, LS and NI. We evaluated the performance of this system by computer simulations.

From the simulations results, we conclude as follows.

- The TW of a peer is high when it interacts with other peers to exchange their resources.
- With the increasing of the local score the TW is increased.

- When number of authentic files is high, the TW is high.
- The proposed system can select trusted peers to connect to JXTA-Overlay platform.

In the future, we would like to work with more children with different learning abilities. Also, we would like to use the proposed system with purpose of improving the quality of life for learners or students. Furthermore, we would like to make extensive simulations to evaluate the proposed fuzzy-based system.

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