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STANDARD ARPU CALCULATION IMPROVEMENT USING ARTIFICIAL INTELLIGENT TECHNIQUES

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ABSTRACT

Recognizing how developing browsing behaviour could result in greater return for service providers through more efficient data usage without compromising Quality of Service (QoS), this paper proposes a new innovative model to describe the distribution and occurrence of behavioural errors in data usage models. We suggest: a) that the statistics of behavioural errors can be described in terms of locomotive inefficiencies, which increases error probability depending on the time elapsed since the last occurrence of an error; b) that the distribution of inter-error intervals can be approximated by power law and the relative number of errors. Comparing immersive similarities of data usage and foraging behaviours according to the Levy-Flight hypothesis, the length of the usage can be feasibly increased with less errors and eventually increase average revenue per user (ARPU). The validity of the concept is demonstrated with the aid of experimental data obtained from test software called Learn-2-Fly which sought to make browsing behaviours more efficient through user responses to stimuli created by an artificially intelligent engine. Although there were limitations on the scope of this test, a noticeable change in the user browse duration occurred over the duration of testing periods, with test subjects spending more time browsing and reacting to intended visual stimuli. The study establishes the opportunity to provide a higher quality of service to the end-user, whilst also offering a dynamic opportunity to increase revenue streams. Further consequences, refinements, and future works of the model are described in the body of the paper.

Index terms: **Quality of service (QoS), Average Revenue per User (ARPU), Levy-Flight, Power Law, Genetic modification algorithm, Human Machine Intervention, Learn to Fly.**

I. INTRODUCTION

Consumers of data, demand constant availability with high Quality of Service (QoS), which has driven the increase in competition among service providers. Data traffic has grown significantly and as service providers struggle to remain profitable, some have developed new rate plans for data usage to replace the flat-rate that caused revenue from data traffic to flat-line. The data market is saturated, limiting the opportunities for acquisitions and shifting the focus to speed up selling and cross-selling to existing subscribers. Indeed recent research analysis also shows that, on average, IT service providers have 10-30 percent untapped revenue potential with their existing users.

Current service providers have developed an emphasis on being innovate by differentiating and promoting offers that customers will pay for, while still controlling costs in order to maintain profitability. They have proven that to growth in customer revenue can be found within their customer data. In fact, many believe that customer data has surpassed the network as the most valuable asset. Unfortunately, more than ever before, existing customer models are no longer sufficient. To improve the average revenue per user (ARPU) service providers must gain a more comprehensive understanding of customers' portfolios, greater insight into their behavior and profitability, and a more targeted approach to modeling successful campaigns.

ARPU still defines the telecom industry's index of tracking data, service use, and revenue potential. However, evaluating solely by ARPU, gives a default impression that all users are subscribed to the same type of service. The most recognised technique for avoiding this over simplification, and in so doing negotiating the potential for decision making processes to be negatively affected, is that of benchmarking and more specifically Deep Packet Inspection (DPI).

Most of the current studies of similar scenarios in the telecommunication industry explore and demonstrate that there are classical methods used to create demand without compromising QoS. One such approach includes a series of bilateral commercial agreements working in parallel with current internet service models. Examples like DPI are implemented to gather information and create complex benchmarks to evaluate the current and potential revenue from a given network so that service providers can make better decisions whilst effectively managing customer experience.

With widely varying approaches, there is certainly a need for more clarity and understanding of how service providers can leverage user cognitive behaviour in ARPU improvement innovations, since using cognitive techniques are not straight forward and there are no time-tested industry practices to use as a guide.

II. TRADITIONAL ARPU MEASUREMENT

Traditionally, ARPU is measurement for profit in terms of costumers, and generally calculated in dividing total revenue by number of subscribers N_M. More precisely, the amount of accumulated usage of a given subscriber shall be calculated in terms of subscriber operation summary. Operation summary must not include last month of subscription, since last month data may not be optimized $(C(Dt - t_{n-1}))$.

Important contributor of the traditional ARPU calculation is duty-cycle (D_T) of subscriber in operation (P_U) to the type of subscription constant (T_S). The duty cycle in operation is an estimation that takes into account the typical percentage of time the subscription is in use and occupying system band-width [Equation-1].

$$ARPU_{(t)} = C(Dt - t_{n-1}) * \ P_u(D_T * T_S) \ / \ N_M$$

Equation 1 – Calculation of the Usage per Subscription.

In the era of knowledge based economy, people pay more attention to service provider's quality of service. While most experiment works around the improvement of QoS and its measurement process, this experiment mostly focuses on user behaviour development, which results in advanced design of user-machine communication interface and directly affect the duty-cycle and eventually improves the ARPU.

III. EXPERIMENT PROPOSALS

In this experiment, we conducted further analysis on data usage efficiencies and described how more efficient usage can help to increase ARPU. The model that we propose combines two predominant factors to achieve efficiency increases. The first factor predicts the occurrence of errors, which is best described by contrasting two alternatives, specifically the time elapsed from previous happening and the cognitive models that cause the next. The second factor provides descriptive search guides, close to cognitive concepts of the search criteria, to help revolutionize the search efficiency during short and quick jumps. This experiment is premised on basic explanations for human cognitive reactions and the intensity of foraging behavioural responses to an artificially made stimulus. This reaction is a by-product of perceptual and motivational cognitive skills that evolved in response to a mental state related to the paradigm called "Levy Flight", as the discrimination of salient visual and audible stimulus [1]. It follows with a conceptual use of bird foraging distribution and the error interval, while searching for food. This foraging search is a geometric distribution that exhibits the variant of the exponential law relative to search criteria.

IV. EXPLANATION OF LEVY FLIGHT MODELS

Levy flight models activities that involve lots of small steps, occasionally interspersed with very long excursions, such as the foraging paths of birds. In the case of foraging paths, this result is sensible because the stopping points of a Levy flight shows fractal behaviour (objects do not change if scales of length variables, are multiplied by a common factor, so called scale invariant) [2]. In complex ecosystems, the distribution of food can be fractal as large areas might be uninhabited or barren. To avoid spending too much time in such unproductive areas, animals need to develop search strategies that generate a fractal distribution of stopping points. Careful analysis uncovers an approximate power-law distribution of trip sizes. This means jumps in a levy flight are distributed in accordance with power law [3].

The most common method for identifying Levy Flight behaviour in bird locomotion is to fit a set of candidate distributions to the observed step lengths using a maximum likelihood method. One of the most commonly used candidate distributors is the power law. The observed and established properties of Levy flight and their relationship with power law provides a useful lens to examine similar human behaviours.

The innovative model proposed in this paper uses the conceptual similarity between randomized locomotion that increases efficiency in nature and human web browsing. The gravity acceleration element is ignored, since it presents no effect on cognitive behaviours. As it is described in the results, data errors have been qualitatively minimized as appearing to be comprised of bursts of errors or, in fact, bursts of bursts of errors in addition to single, independent error events

V. PATTERNS COMPARISON

The prime reason why birds develop flying skills is Levy flights, which is proven to increase efficiency. By doing this, explained through the levy flight hypothesis, it is possible to reduce the expensive habit of “oversampling” demonstrated through revisiting previous sites and optimizing the searches around targets within a short distance. In this manner, birds also increase, through relative motion, the chance of reaching nearby targets at the cost of reaching far away targets. The implication of this is that although it is beneficial to remove longer single flight periods, raising the number of shorter flights, may still result in longer periods in flight overall.

Furthermore, it is necessary to gain an understanding of the relation between foraging behaviour and power law. Power law explains the distance and time between incidents or happenings, and in fact, helps make more accurate predictions. The pattern of bird flight is considered to be made up from instances of flapping and gliding continuously. There is a pattern in the distances between flap-gildings according to Levy-Flight. The horizontal acceleration is normally periodic and peak-trough analysis indicates its linear correspondences to a single wing stroke [Fig-1].

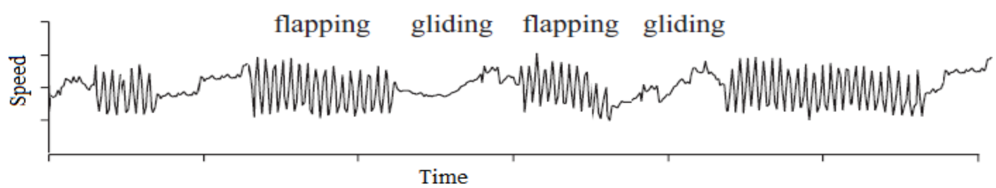

Figure 1 - Bird Foraging Captured Diagram

Further analysis on captured data indicates that foraging behaviours were mirrored in the search browsing behaviours of human beings [Fig-2].

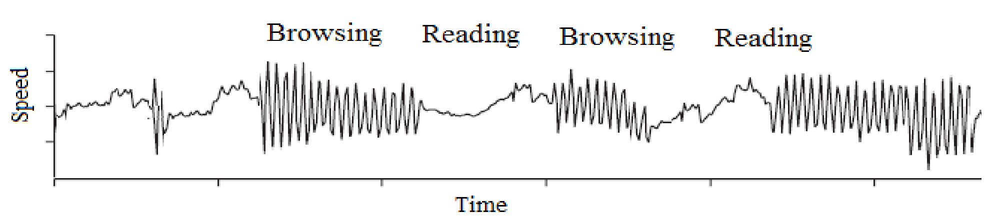

Figure 2 - Human Web Browsing Captured Diagram

Although the distance between the flap and gildings cannot be completely calculated by a geometric distributed calculation as presented in equation one. The calculated variable is statistically independent from previous happenings and is validated for further analysis in this experiment [Equation-2].

$$J_{(t)} = Qr^2(FT_n - t_{n-1})$$

Equation 2 – Calculation of the frequent happenings.

In this equation $\mathrm{T_n} - \mathrm{t_{n-1}}$is statistically independent from earlier happenings $\mathrm{T_a}$. Where $\mathrm{a} < n$.

The Levy flight hypothesis, originally presents that the optimal strategy for a bird with limited perspective range and no prior knowledge of distribution of food in the environment, is to move randomly [5].

The longer the bird travels, the more energy will be expunged resulting in either the need for more food, or an increased likelihood of premature death. Consequently, in case of internet browsing between three users, for any power law exponent less than 2, Levy flight concludes sooner. [Figure-3].

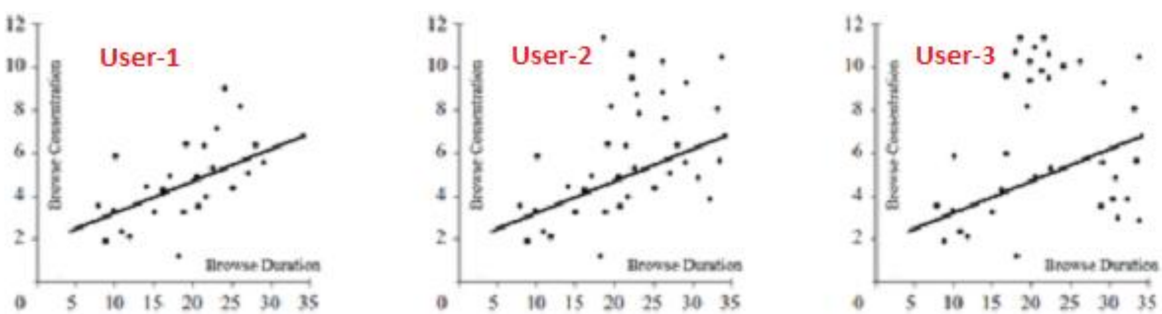

Figure 3 - Browsing Duration According to Levy Flight and Power Law

From this, the optimal prediction is for a group of short range flights /jumps which will keep the Levy flight running longer and will be more predictable. Human web browsing behaviours also indicate very similar foraging behaviour in terms of the pattern of locomotion. It consists of a readily comparable periodic pattern, while searching/loading, and gliding for the read-through time. Similarly, duration of all activities remain in a constant ratio.

The significant contribution of this research is to maximize the efficiency of locomotive actions by promoting “randomized” cognitive assisting elements. Eventually, it is proposed that browsing behaviour would change to involve longer running look ups and browsing with the power law exponent closer to 2, which guarantees the power use of the data service [6].

VI. RECENT EXERCISES

Recent studies indicate that in forager modeling steps are truncated at points where the forager finds a desired item. This is sometimes referred to as a truncated Levy flight. Similarly, almost all theoretical search engine models rely on the assumption that each new search starts with the item closest to the search border. Therefore, most search engines are able to provide suggestions for the perceptive range. Firstly, this can be thought of as representing a highly patchy distribution of items since it tries to minimize search durations by truncating the length of jumps. However, the advantage of any search prediction/suggestion strategy can be changed rapidly if each search begins with the nearest border, which is not significantly further away than the forager's perceptive range. Secondly, by bringing some sample cognitive patches slightly inside the border, without affecting the properties of the search or the observation techniques, it is possible to create an artificial stimulus to expand wining criteria by generating human-machine intervention, which can in fact improve the Levy flight efficiency [6].

VII. NOISE DETECTION

Current research indicates that the priorities of a random search behaviour changes few times over the search duration. Short and medium range behaviours commonly follow the Levy flight, while distance distribution is directed by power law. According to power-law, the initial priority of browsing will eventually disseminate after a few attempts of longer distance browsing due to the constant changing of priorities, hereby referred to as "Error" or "Noise".

In this work, the mechanism of error occurrence is considered in terms of probabilities depending firmly on the time elapsed since the last error occurred. Therefore, the time intervals between the error occurrences can be approximated. One classic approach to minimize errors on Levy flight duration is the training approach. The training introduced in this study is designed based on the distribution of user cognition errors during web browsing (Levy flight) and suggests that the probability of an error can be described and minimized. A further contribution of this experiment is to develop a framework to improve user locomotion and increase user real-time intervention. This will improve end-user quality of service metrics and dynamically promotes ARPU scalable improvement. This framework is designed to ensure steps similar to bird flight are followed to finally stimulate the joy of gliding.

VIII. LEARN TO FLY

The metaphor of "Learn to fly" is introduced to describe the interactive training environment. It used a demonstration version of a combined artificially intelligent engine called VOXE-01(utilizing Genetic modification algorithm), and interactively designed user interfaces. The user interacts with the Artificial Intelligence (AI) inside a chat environment by reacting to given multiple fly-persuasive analogical tasks. By following the AI sampling lead the user develops a behaviour and learns how to minimize interactive browsing noises/errors and maximize the browsing Levy efficiency and Durations.

A chat based software model named "Learn to Fly" is developed to represent a collaborative virtual browsing environment, in which an AI engine monitors user activities. It generates layers of augmented messages virtually, introducing fly-persuasive samples. The Engine stimulates a virtual link between bird levy flight and human levy browsing by generating a wide range of close flying samples during a full browsing cycle. From this a variety of cognitive problems can be processed and eventually be mapped to a machine-understandable data flow [8].

IX. DESIGN A MODEL FOR AI APPLICATION

The metaphor of "learn to fly" is introduced to describe an operation charged with combining multiple concurrent activities. As user perception is not standardized in analogical terms, the application starts with a comprehensive cognitive search of keyboard initiated user inputs, which are mapped to a predefined analogy system. By integrating the structure of user perception within the fly-persuasive analogical map from the VOXE-01 it is possible to produce a more effective user stimuli. To find analogies, the VOXE-01 implements a look-up and mapping algorithms based on low-level structural operations [11].

Analogy is a versatile method for using informal, unstructured, background knowledge. The VOXE-01 uses conceptual graphs for knowledge representation and can process different cognitive sources from the web. It eventually, finds matching transformations which are then also used to determine the precise mappings required for transforming data mash-ups into fly-persuasive behaviour representation [Figure-4]

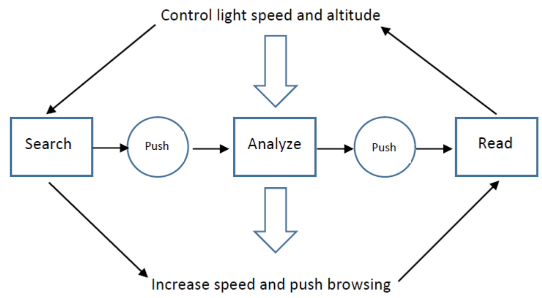

Figure 4 - Modified Conceptual Cognitive Mapping, Fly Persuasive

As an example, Figure 4 shows a physical structure that could be represented by many different data structures.

Cognitive structures are used to represent the analogical models which can signify any kind of data stored in the artificially intelligent engine. However, the category of concepts and relations usually reflect the choices made by the user which in turn modifies the structure with regards to choices available in the original structure. Eventually, the final structure can be studied by the user and from this they can learn how to improve their cognitive responses. [Figure-5]

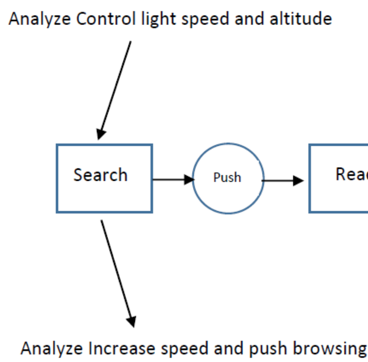

Figure 5 - Conceptual Cognitive Mapping, Fly Persuasive

Comparing the two conceptual graphs (Figure 4 and Figure 5), it is remarkable that despite representing equivalent information. They appear very different and even though some operations are similar, their positions in the graphs cause them to be treated as distinct. This variance can be explained by considering a variety of factors relating to the VOXE-01.

The VOXE-01 applies the general rules of analogical reasoning and models a cognitive structure for natural language understanding with respect to the constrained operations of language unifiers and generalization. However, exceptions, metaphors, ellipses, novel word senses, and the inevitable errors require less constrained analogies [1].

A model was needed to allow for a confined implementation of learn to fly, and a simple intelligent 'Fuzzy' control scheme was the selected solution. The selected fuzzy control engine is a demonstration copy of a commercial package for designing a fuzzy control system called: "Fuzzyworx-001". The fuzzy engine's mission would be to control the simulation, alarm the out of boundary activities, and score the reactions. The Fuzzy engine keeps browsing on the elevation that is required by Levy flight in order to maintain the power law around 2. It uses browsing time-hold statistics1 with an added input for acceleration control. The acceleration control work involving degrees of information and speed needed during different scenarios of web browsing (searching, selecting, level browsing and disturbed time measurements). The acceleration control sends a feedback alert to the VOXE-01 whenever an accelerated stimulus is required, resulting in the user's attention being attracted, encouraging an appropriate action to address the situation accordingly [12].

X. FORMULAS

The graphical layout design for the 'learn to fly' artificial wandering model is outlined in [figure-6].

The first stage only receives the user input. The VOXE-01 will act upon recognizing the input information and generate analogically similar choices related to those made by user. This analogical stimulus will be displayed and presented to attract the user's attention. The Fuzzy control engine keeps the time elapsed for each activity in relation with power law calculation, control user interaction, and push browse forward by displaying a variety of cognitive visual stimuli, created by the VOXE-01. This process simulates a real time face–to-face conversation between the AI and user. While the user interacts more competently with the guides provided by the VOXE-01, the fuzzy engines make predictions for the next stimuli generation period and assumes the normal acceleration and noise distribution is also maintained. When the user action lags behind, and the time elapsed is close to the defined boundaries, acceleration will be pushed through the VOXE-01 to revise the analogy map. This will also push the mash-up compensation allowing for a required change, and eventually the browsing duration (Days) will be calculated [Equation-3].

$$r^2 = 0.856,$$

$$BD = 1.845 + 0.562D \ \ (User1)$$

[1] The statistics are calculated by using equation number one.

AND:

$$r^2 = 0.178,$$

$$BD = 1.032 + 0.323D \ \ (User2)$$

Equation 3 - Browsing Duration (BD) - Calculated for User 1&2

Some steps simulate the bird fledgling in its early life and how the bird attempts to fly. Eventually the flight becomes a levy behaviour during the work towards independent searches for food. A similar idea is used to develop user behaviour and improve BD.

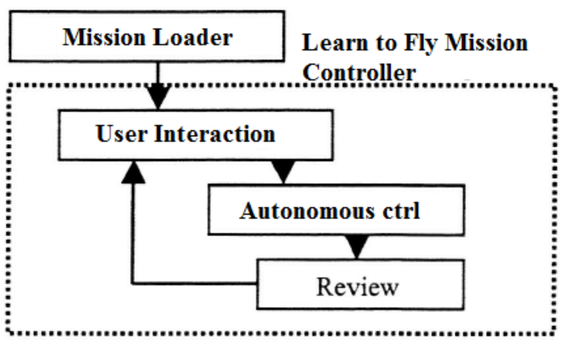

Figure 6 - Learn to Fly Autonomous Mission Controller

XI. DEFINITIONS OF INTELLIGENT DESIGN

The definitions for intelligence in this experiment has been defined as a creation of an agent, developed to assume its pre-defined role without any human interaction. As indicated in figure-6, the anatomy of the intelligent agent will be carried out by loading the VOXE-01 mission loader-planner and linking it to autonomous AI fuzzy controller. Figure-6 presents the objective of autonomy, which is expanded to the entire design of this experiment. Maximizing efficiency of browsing time is the critical concept and the mission plan will be the desired link and hold of levy samples according to power law. The VOXE-01 mission planner generates a group of simple analogies based on perceptual transparent stimulus. The Fuzzy mission controller manages the augmented environment and records the user interactive behaviour with continuous active feedback through the changing of inputs to the VOXE-01 mission planner and recording outputs [14].

XII. DESIGN OBJECTIVES AND GOALS

The major contribution of the VOXE-01 mission planner is to:

1. Shorten the single Levy Jumps and increase the group of jumps and Browse Duration (BD) by providing visual guides
2. Prevent repeated revisiting by generating visual stimulus
3. Decrease the rate of repetitive errors over the period of time.

The major contribution of the Fuzzy mission controller is to:

1. Process the user interaction time and update the conceptual graphs.[2]
2. Control the stimulus generating process by VOXE-01 mission planner.
3. Control the graphical updates and record feedbacks.
4. Update power law calculation table.

XIII. THE DISPLAY

Figure-7 represents the attempted steps to finish one full cycle of the project. In order to graphically represent the visual stimulus, an existing JAVA code was used and implemented through an 'off-the-shelf' web based application.

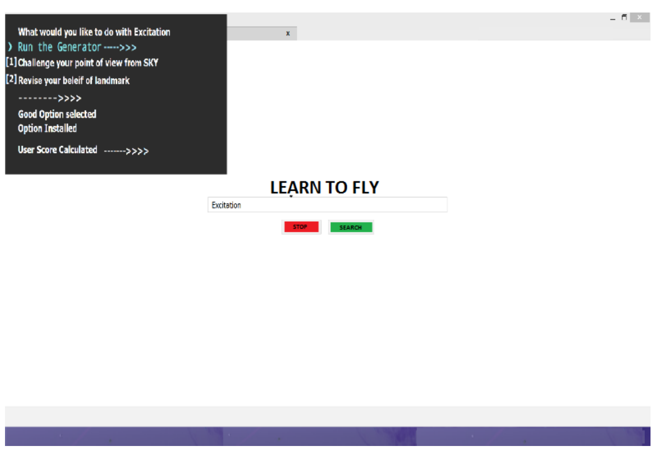

Figure 7 - Full-Cycle project representation, while searching for word EXCITATION

[2] VOXE-01 mission planner uses conceptual graphs for the knowledge representation and can process different cognitive sources from the web. Fuzzy controller then calculate according to power law.

The major contribution of JAVA code is to:

1. Graphically display the stimulus, generated by VOXE-01
2. Handle the graphical user interfaces and link with the fuzzy control engine.
3. Update screen as per guides by VOXE-01

After combining all these contributions, a scaled stimulus threshold is computed based on the last four update states of the conceptual graph and the properties of the web page. If the results are within the scaled threshold according to power law, a ray cast is performed to determine the user score. If all these tests are passed, the object is encoded into a transparent layer to over lay on the main page. For example, a generic text can be encoded, using TIP-TOOL chat from the MS-Windows original overlay tool, and inserted into the original page as a generic object [13].

This is for user training purposes using the previous success criteria road map. Figure-8 represents a brief visual summary of the web based program layout.

XIV. RESULTS

The results from the program's first live run were somewhat stable but required tweaking and filtering. Three users were selected for initial tests and they started by searching for a specific topic on our custom made browser. Since user interaction speed and degree of reaction was not exactly as expected, some degree of manual manipulation was required for smoother transitions. The VOXE-01 program output was represented through a matrix of conceptual graphs[3] and was able to achieve a direct interface with the fuzzy controller. The first test did achieve the desired outputs for both the efficiency of the Levy flight and power law were achieved. However, there was a degree of verbal guidance provided to the test subjects, beyond the intended visual stimuli. Furthermore, it is prudent to acknowledge that the reaction speeds of users will vary depending on the level of interaction with the given stimulus.

This is similar to holding a hand out of the window of a moving car. At slow speeds one can turn the flattened palm at different angles whilst keeping the arm still. When at higher speeds, the arm becomes unstable and moves out of control when the angle of one's palm is altered. In reality, there is a limitation on the scope of this approach as the locomotional rules of this form of modeling is limited to the dynamics between VOXE-01/Fuzzy control connections.

[3] As explained in model design section.

The same three users were further tested on a number of occasions following the first attempt. The results show that the browse duration (BD) increased with the number of days since the first time test attempting (day) and eventually cause the duty cycle improvement for users Figure [8].

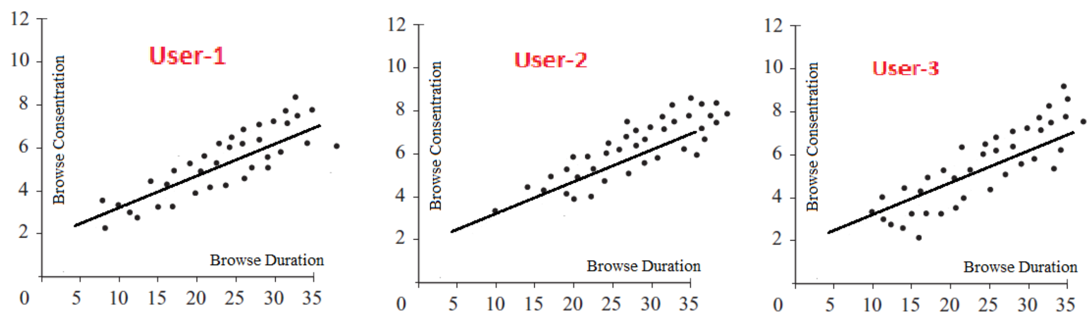

Figure 8 - Captured Final Results

As represented4, the distance between successive happenings will be predicted, although the number of happenings (Browsing-Searching-Understanding-gliding) are not dramatically changed by this experiment, the distribution of happening has changed incrementally within the same time frame (compared with original measures). This in fact helps to explain the distance and time between incidents or happenings, and in fact, help making close predictions on browsing behaviour. Number of clicking attention on perceptual stimulus has increased and related links has more browsed since start of the search.

The results of the experiment show a possibility of improving end-user quality service metrics and dynamically increasing ARPU.

XV. CONCLUSION

AI techniques can be greatly expanded with further work based on this development. Attempts can be made to expand the use of AI techniques so a comparison can be made against a greater range of user behaviours and attention controls. While this paper only described the accomplished work, significant time was spent installing and learning how to compile the interactive codes between all the different sections. The compilation of a protocol handler between JAVA and the fuzzy controller, and also between the fuzzy controller and the VOXE-01, was an expansion of an original protocol handler and provided a substantial challenge. The

[4] Distance between happenings are calculated by using equation number one.

setup and protocol for the communications was the primary blockade during this project assignment. Once these tools are further developed, the combination of the code, allied with the ability to analyse results in real-time through a visual demonstration of the performance, will provide a strong, practical, and low cost platform for experimentation with AI techniques as they are applied to cognitive control.

XVI. FUTURE WORK

Future work in this area should focus on the perceivable dramatic system speed for both the common user and user specific stimuli. As was demonstrated in this experiment, this must be followed by adapting innovative techniques to improve speed perceptions, reduce lag between action and feedback, and minimize errors in the transportation layer of Fuzzy/VOXE-01 interfaces.

Achieving innovative characterizations and modeling of human behaviour, including accurate descriptions of human movements, are very important to quantify the role of cognitive proximity on the creation of behavioural models for network operations. These are, in turn, the substrate for a large spectra of techniques, ranging from mobile routing problems and quality of service to programming language dynamics.

The Lévy behavior has received considerable attention from researchers, but its impact on interrelated theories of human cognition, fractal movement patterns, and decision making has been largely neglected. From the cognitive perspective, identifying exploration and retrieval patterns could have a significant effect on the understanding of behavioural un-efficiencies. It has also been argued that the universality of patterns observed for mental searches could impact not only Cognitive Science, but also Behavioral Economics.

In conclusion, Lévy flights appear to be applicable not only among foraging animals, but also in human behavior and cognition. This manifests both in areas of individual locomotion, and cognitive searching. For humans, it seems clear that the adoption of a Lévy strategy in both the physical world and in mental representation is beneficial.

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