Mate Marote: a BigData platform for massive scale educational interventions

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Abstract. In this paper we present Mate Marote, a web platform for massive scale educational interventions. We focus on the scaling requirements needed on these kind of deployments. We show the designed architecture, how these decisions solve the imposed requirements and the implementation. To test this development, we performed a small pilot intervention where the whole system was evaluated. We conclude that Mate Marote is ready for production deployment and enabled to middle-to-massive scale interventions. For this purpose, we have deployed this platform in CEIBAL program at Uruguay with more than 100K potential users.

1 Introduction

Worldwide initiatives are being implemented delivering low-cost laptops to every primary and secondary school students. Many countries are developing programs reaching the point where every child has her own connected laptop. For example, this is happening today in Uruguay with the OLPC CEIBAL program, where the whole population of elementary schools, about 400,000 children, are using the same digital platform [1]. These initiatives open up a new phase with massive-scale educational resources, pushing a profound reformulation of teaching and learning. This new social phenomenon is making a revolutionary change in the education of millions of children around the world.

In this context, we developed Mate Marote, a general-purpose web platform for massive-scale educational interventions, which integrates three main concepts: large-scale, educational interventions and gaming for learning. Several projects have been proposed to introduce games as a strategy to stimulate learning in children as part of the education activities [2–4]. Mate Marote serves as a general platform for integrating these initiatives in a common environment, where activities and games are updated automatically and usage statistics are collected.

This platform is available for education researchers to create novel repertoire of activities and games based on scientific knowledge about behavior and the brain. *Educational Neuroscience* combines cognitive neuroscience and behavioral methods to investigate the development of mental representations and, possibly, to use neuroscience preexisting knowledge to improve different teaching approaches [5].

Researchers may create new games which register measurements about children resolution of the task for later observation and analysis. These games can be uploaded to the Mate Marote server, and combined with other games into *Gameflows*: a roadmap throughout the games of a particular intervention, with mandatory paths, bifurcations, etc. The most common Gameflow design in educational interventions consists of a three steps route: (1) a pre-test set of games to assess a particular ability of the children before playing; (2) a training stage, which may consist in many games played during many sessions for a few weeks/months, and (3) a post-test set of games to assess the performance change compared to the pre-test dataset.

When a player enters the site – from a personal computer, tablet or mobile phone – she has to choose which game to play from the enabled options in the designed gameflow. After playing the game, she returns to the gameflow where new levels or other games may be enabled. The enabling or disabling of games is configured per gameflow by the researcher taking into account many variables such as date, time of the day or player progress.

In this paper, we present the BigData solution developed to deal with the potential fact of having hundreds of thousands of children playing games streaming gameplay statistics for latter analysis. We focus specifically in how measurements from games are generated in the client side in a distributed fashion, how these measurements are received concurrently as a stream of information and finally processed into consistent indivisible units of information, potentially useful for neuroscience research. The design of the system is based on previous experiences of Mate Marote in the OLPC platform [6] and collaborations with the PowerGames colleagues [7, 8]. We present a successful pilot intervention using the developed platform where the complete pipeline is applied obtaining results compatible to previous ones in literature.

2 Development

The context in which this platform is outh to be deployed — a system for massive-data gathering in country-wide programs — imposes a series of requirements upon the system. From the production-side of data, i.e. the children playing the games, we get the following requirements:

req 1 **Multi-platform**: Given the variety of devices deployed in government programmes of computers delivery and the desire to have as wide an audience as possible, we want the games to be playable from as many devices as possible.

req 2 **Availabilty**: We want new games and gameflows to be available as soon as possible.

req 3 **Scale**: The hardware and software behind *Mate Marote* must be such that supports providing service for hundreds of thousands as well as receiving all the measurements from the users without losing data.

req 4 **Connectivity**: Players may lose connection temporarily, but that must not imply loss of data. .

req 5 **Data-Streaming**: Given the possibility of an uncontrolled environment — children playing by themselves with an untrustworthy internet connection — we must be able to collect the measurements in the server as soon as they are produced. In particular, this means we cannot always wait for the game to have a meaningful unit of information before it sends anything. Data has to be sent in small packages and joined together later on.

req 6 **Pervasive data collection**: We do not always expect the team that develops the games to fully know what they want to measure from it. As a result, we must allow the games to record as much information as they may want for later revision. In particular we intent to have support for measurements that record everything that happened in the game so it can be entirely reproduced.

For the consumer end of the dataflow — the researchers — we must provide a way to access the collected information. On this subject, the following requirements related to the big-data context arise:

req 7 **Filtering**: Researchers must be able to filter the data they gathered efficiently.

req 8 **Summarization**: Researchers must be able to summarize the data they gathered efficiently.

To answer *req 1* we decided making Mate Marote a web platform, with games developed in *javascript*. Javascript is a flexible language that runs fast on the web and has libraries for graphics rendering, such as *CreateJS* [9]. By using modern responsive web features we managed to have a website that adapts to different screens and works both for touch and mouse interfaces. Having Mate Marote as an online platform also solves *req 2*, since users perceive configuration changes almost immediately. The backend providing the services both for players and researchers was developed in *Java*, given the already existing framework stack for web applications. The java web application is hosted in a *Jboss application server* (figure 1) on servers on the cloud, which also fulfills *req 3*.

Even though game developers are given as much freedom as possible, a *javascript* library is provided to be used as a framework for game loading and measurement reporting. This library has embedded the concept of a *trial*. In the field of neuroscience experimentation, a trial refers to the minimum unit of evaluation. It is often a question to be answered. In the case of games, a trial is commonly a level in the game. The library facilitates preparing the trial information, loading the elements of the trial on-screen and sending measurements and player progress to the server.

As depicted in figure 1, the *JBoss application server* communicates with a *Postgres sql* database that is used to store all user information, gameflows

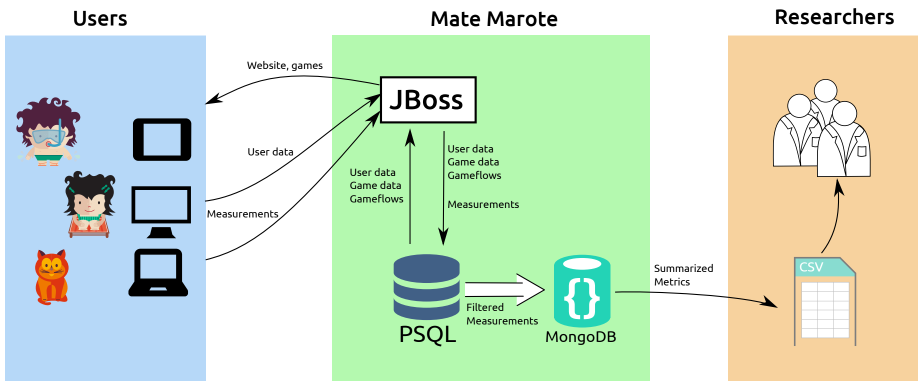

Fig. 1. MateMarote architecture. Users interact with JBoss Application Server which provides games. As users play the games, measurements are streamed to the server and stored in a PostgreSQL database. When researchers ask for data for analysis, stremed data is filtered into consistent units, and stored in document format in a NoSQL database – MongDB – from which CSV files are generated for data analysis.

configurations and game metadata. Games data is stored in folders within the server as provided by the developers. For *req 4* and *req 5* we take most of the responsibility out of the client and move it into the server. This is done by having games sending measurements in an incremental way. That means the game does not need to have the entire relevant unit of information (normally, a trial configuration and it's results) ready before it can send it. The responsibility of reassembling these batches into the one relevant information unit is done afterwards, when researcher queries for information. The measurement reporting methods provided by the javascript library previously mentioned, together with the methods that manage trial start and end, attaches sufficient information to each measurement package so it can be joined with the rest of the trial information. This library also keeps a persistent local storage to resend any information in case of connection problems, or the user quitting the game unexpectedly.

The last data collection related requirement (*req 6*) is currently answered by the PSQL database design, which has no issue receiving measurements (even incomplete trials) and providing requested information to the clients.

Finally, from the researcher end of the measurement dataflow; the collected data must be processed before getting to the final user. First, a subset of the measurements are collected from the Postgres database with an sql query; for instance, all data collected in school *Foo* (req 7). Then, filtered data is grouped by trial, reassembling the information into consistent units – i.e. trials – previously mentioned. The unstructured data of each trial is assembled into one json object, i.e. a document, and thus have one document per trial per game. These trials are uploaded into a NoSQL MongoDB upon, where we can perform further summarization of the measurements taken and obtain the exact metrics the researches look for (req 8. This ends up in a nice-to-work-with table provided in `csv` format.

3 Results

As a case study of the full software stack, we present a recent intervention where *Mate Marote* was successfully used. The intervention was done under the frame of a collaboration project between the Mate Marote team and Gobierno de la Ciudad de Buenos Aires, supported by Intel Corporation.

The intervention was held in one elementary school of CABA, with a total of 48 children from 5 to 6 years old. Children were splitted in 4 different groups of 12 children each, where each group was assigned to play different gameflows (see figure 2 for a detailed description of intervention gameflows)

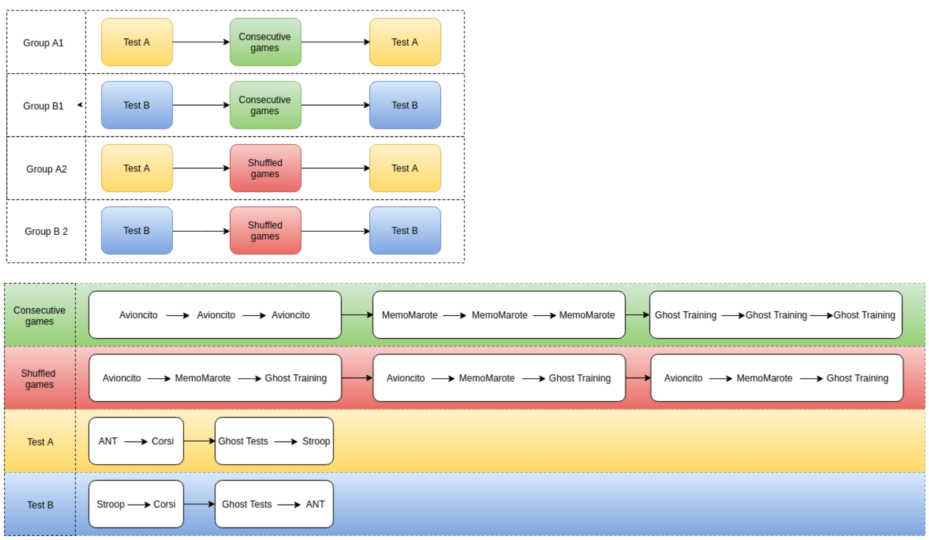

Fig. 2. The 4 gameflows assigned to each group.

The obtained data is currently being analyzed and studies are being conducted. For the purpose of this paper, we present a very first result obtained from only one of the intervention games: Avioncito. The Avioncito games is a well known game, which focuses on attention and inhibitory control [10]. The game consists trials where stimulus of two kinds – congruent and in-congruent, see Fig. 3, 4– appear in the screen. Then, the player has to determine to press the congruent or in-congruent button depending on the stimulus as fast as possible. When a congruent stimulus appear in the screen, the player must press the button that is pointing to the same direction as the stimulus; otherwise, when

Fig. 3. Congruent stimulus

Fig. 4. In-congruent stimulus

a in-congruent stimulus appear in the screen the player must press the opposite button.

It very well described that for those trials where players answer correctly, the reaction time is about 100 milliseconds faster in congruent stimulus than in in-congruent stimulus [6,10]. This result, was successfully obtained in this intervention (see Figure 5) where the mean reaction-time for congruent is near $150ms$ smaller than reaction time of in-congruent stimulus (Kolmogorov–Smirnov test, $p < 1e - 9$).

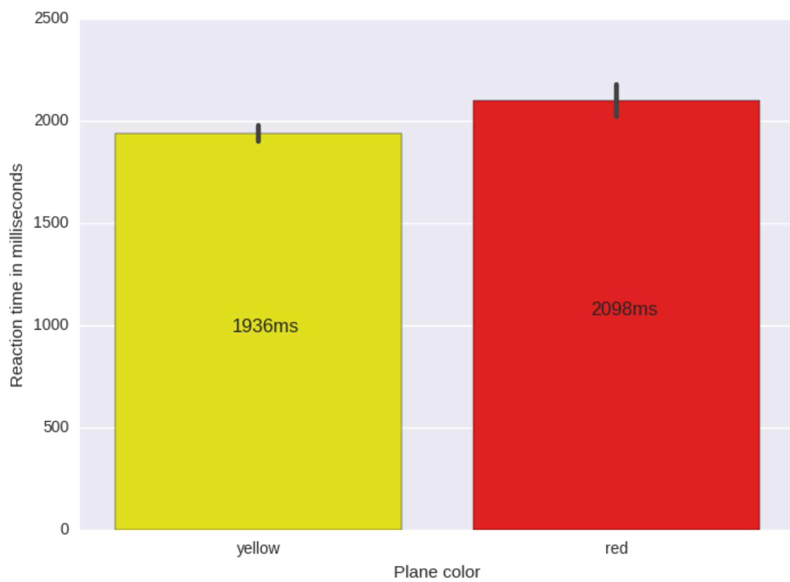

Fig. 5. Mean reaction time of correct trials for congruent (yellow) planes and incongruent (red) planes.

4 Conclusion and discussion

We showed a first validation of the *Mate Marote* platform for educational interventions. During this intervention, children played games without bigger issues, the measured data was sent correctly to the Jboss server and saved into the PSQL database. Finally, data was successfully processed using mongoDB and coherent results where obtained in the game Avioncito. There was not missed data during the whole dataflow process.

Since this intervention was the very first pilot and the internet connection was performing under the average connections, the offline functionalities were used and we have been able to test the proposed dataflow architecture performance in a regular scenario. Even though we have completed the intervention without missed data, we note that data size grows significantly when the information is grouped in documents by trials, even with a small amount of players as it is the case of this intervention. This is caused by the data redundancy of having full self-contained information in each trial. The grouping stage is currently done by a python script which may become a bottleneck for bigger interventions. However, this drawback may be resolved by processing data as it arrives (daily or weekly), or processing trials in a distributed fashion.

Recently, the *Mate Marote* platform has been incorporated in the CEIBAL program (Uruguay) with a considerable amount of potential children using it (more than 100K). A first stage of this intervention is in progress, where the obtained data is being continuously checked out and verified for missing data during the process.

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