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A Social Network to Provide Free Internet Access for Public Schools' Communities

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Abstract. We propose a social network web portal as the Internet access environment to the project "Tocantins Digital", which will provide free Internet access for public schools' communities in seven cities of the Tocantins State, Brazil. Together with complex network theory concepts, it may support initiatives to improve education and social development. The system allows network visualization of communities' profile to identify suitable multipliers and to monitor the social network evolution. The system's validation was accomplished through a simulated situation in order to evaluate its functionalities, where we applied a sample of 46 people distributed in all seven cities considering their role in the project.

Keywords: complex networks, Internet access, public school, social network, web portal.

1. Introduction

The Brazilian Ministry of Science and Technology together with the Federal University of Tocantins (UFT) are implementing a project called "Tocantins Digital" to provide for students, teachers and staff of public schools free Internet access. The University's geographical dispersion favours to host the project, that is, it has seven campuses in different cities from south to north of Tocantins State.

The main objectives of "Tocantins Digital" are to provide wireless Internet access through IEEE 802.11a/b/g technology; to improve e-Gov services access; to contribute for job and income generation; to promote programs related to informatics, data communication and messaging; to enable interactive and interdisciplinary digital video classes in schools; and to induce knowledge production and information access [1]. Clearly, providing Internet connection is not enough to attain these goals. Hence, we propose a social network web portal as the Internet access environment that together with complex networks concepts for relationship analysis may support initiatives that may help improve education and social development.

The relevance of social networks is increasing and the ways that they are structured modify their users' habits [2], [3], but we must not overlook that social networks as Facebook [4], Myspace [5] and Orkut [6] have commercial objectives. They have been influencing the social organization models, since these networks' business model are driven by advertisements based on demographic data from users' profile [7].

The proposed social network is a non-profitable environment that may support interaction and collaboration in a horizontal and non-hierarchical way among public schools' students, teachers and its staff. It might foster students to explore public speech and a participatory culture [8]. Besides, teachers may have more recognition because of activities within the social network. Also, it may aggregate a statistically valid sample of citizens, which should help knowledge discovery. Therefore, what differentiate this work from

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other web-based social networks is its social development nature, and also the functionalities to group and classify complex data, similarly to Sentinel Visualizer Analysis [9] and inflow [10].

We present some statistical information of Tocantins. It has 1.383.445 inhabitants distributed in 139 cities over an area of 277,622 km^2, while Malaysia has an area of 329,847 km^2, that is, Tocantins has approximately 84% of the size of Malaysia. Table I [11] presents the statistical information of the seven cities, and another reference is that in 2010 Singapore had 5,076,700 inhabitants in an area of approximately 694 km^2, that is, a population density per km^2 of 7,126 [12], or almost 70 times the density of the capital Palmas, which is the highest in the state.

Table 1. Statistical information of the cities in the project "Tocantins Digital"

Cities	Population	Area (km^2)	Density (inhab./ km^2)
Palmas	228,332	2,219	102.90
Araguaína	150,484	4,000	37.62
Arraias	10,645	5,787	1.84
Gurupi	76,755	1,836	41.80
Miracema	20,684	2,656	7.79
Porto Nacional	49,146	4,450	11.04
Tocantinópolis	22,619	1,077	21.00

One possible approach to study social networks is Complex Network Theory [13]. Some metrics may be used to find new information. The metrics developed as functions in the web portal are clustering coefficient and centrality metrics such as degree, betweenness and closeness. An immediate application of these metrics in the social network web portal would be to identify communities and suitable multipliers in the network. For instance, we could answer questions such as who are the most adequate multipliers to take part in a special educational training program for knowledge dissemination.

The clustering coefficient is a measure of individuals who tend to cluster together and it may be helpful to identify informal communities. This metric may be a support tool to determine sub-networks where a centrality metric would be applied.

The degree centrality is a local metric that represents the number of links in a node. It may be understood as the risk that a node has of catching whatever information is flowing through the network. In the social network, the node is a person and the degree centrality is the number of people he or she is connected to. Consequently, someone who has a high degree centrality may be a good multiplier. However, it does not consider the structure of the community or its heterogeneity, i.e., a person in Arraias may not be as influential as another person in Palmas, both with the same degree.

The betweenness centrality is a metric that measures the number of shortest paths between two individuals of different communities. If it is normalized then it may be understood as the probability of a message passing through it, assuming it would go through the shortest paths. It may be used to find the person with direct access to other people in a community. Consequently, information should go faster to the extremes of the community, and that would be an eligible individual for spreading some information. It is worth noticing that Palmas' population is constituted by many citizens with relatives in other cities of Tocantins. That means these particular types of citizens are natural bridges between communities in different cities, that is, the betweenness centrality metric would probably help find them.

The closeness centrality is a metric that may be regarded as a measure of how long information would take to go from one individual to another reachable individual. Hence, it may also provide good candidates for multipliers.

Additionally, a web portal for Internet access would allow to map, classify and analyze the Internet individual and group usage. It would provide information on frequency, duration and time of use, which is helpful to network management. Moreover, the prototype is not only a web portal and social network; it has

complex network analysis functionalities with a graphical view of the social network. Therefore, it is possible to observe if there are gigantic components or disconnected individuals.

The authors organized this paper in accordance to the IMRAD structure: introduction, methods, results and discussion; which is adopted as part of the Uniform Requirements for Manuscripts Submitted to Biomedical Journals of the International Committee of Medical Journals Editors, 2008 update. The authors believe that adopting this structure would help search engines in international databases to store and to retrieve information within scientific papers in order to facilitate meta-analyses and systematic reviews.

2. Methodology

Our methodology is a combined approach between a strategy for *Interdisciplinary Research Project Management* [14] (IRPM) and the *Evolutionary Acquisition* [15], and it is presented in [16]. Actually, this work's scope comprises the following topics of system design: requirements analysis, benchmarking, and system architecture, design and computer programming and debugging. What is left is the system testing in production.

IRPM follows a project management approach, that is, it has five phases: initiation, planning, execution, controlling, and closure. Hence, for an interdisciplinary research, the initiation consists of choosing a real problem and identifying two or more fields that will be used to approach the problem. The researcher or research team should study the problem regarding each chosen field in the planning phase, in order to develop a new concept or methodology. In the executing phase, they should develop a new technology and apply it.

This work is the result of part of the executing phase in IRPM. The real problem is to develop a web portal for the Internet access structured as a social network. The main fields are web-based systems, complex network theory and social networks. The new fundamental or methodology is also a new technology, a social network as a web portal for free Internet access.

Additionally, our system development methodology is the *Evolutionary Acquisition*. Therefore, in the planning phase, it started with the requirements analysis to develop a new fundamental or methodology. After defining the "general" requirements for the system and the "specific" requirements for the core, the concept of operations was elaborated. Then together with some user feedback, technological opportunity and the determination of possible evolving threats, the preliminary system architecture was obtained. From it the web portal prototype's core was developed. New definitions and developments with an operational test resulted in a new version of the core. Then with experience and use new refinements and updates requirements should be identified.

We used to develop the social network web portal for Internet access the language *PHP* – Hypertext Preprocessor [17], *MySQL* [18] as the database system, and *Joomla!* [19] to manage the content. In addition, we used *Phyton* [20] for implementing functionalities of clustering coefficient and centrality metrics, and *Python*'s package *Networkx* [21] to display the network. System's validation was accomplished through a simulated situation, where a sample of 46 people distributed in all 7 cities. It has also considered the role of these individuals in the project "Tocantins Digital". The tests were exclusively to evaluate system's functionalities.

3. Results

3.1. Network Structure

Palmas is the capital of Tocantins and it is located in its centre. Naturally, it is a state hub not only for UFT. Therefore, the University is the project's Internet backbone, and Palmas is the physical centre of the network in a topological star configuration. However, this topology neither is visible nor has any influence in the social network for the Internet user.

The social network has a hierarchical structure divided in three layers. Each layer is a set of nodes in the network that represents users. Each one of the seven cities has a Network Operational Centre (NOC) in charge of monitoring and managing the network. The Palmas' NOC is the root of the network for the star

configuration, and as a consequence it is in charge to manage the network growth. Therefore, conceptually the layers are:

- Network root: which represents Palmas' network, where all other cities are connected.
- Manager's network: which represents the NOC of each city except Palmas, in charge of managing the city network.
- Final users: which are the students, teachers and school staff.

3.2. System Description

Herein the social network system has 5 modules:

- User registration: it is responsible for user creation to web portal access and profile data.
- Forum: at this point users can debate topics, share information and files.
- Album: sets of image and pictures that may receive comments.
- Relationship network: this module contains the system basic information because herein are the users' connections and functionalities related to interactivity among users.
- Analysis: it stores the complex theory metrics and visualization tools.

Furthermore, there are 6 categories represented as classes:

- Class school: it represents the public schools, state and municipal, which participate in the project.
- Class faculty: it represents the faculties, departments and courses of the university.
- Class contact: it is used to system messaging to users.
- Class BasicInformation: it provides basic information about the user.
- Class FriendsNetwork: it composes the relationships among users.
- Class Profile: it gathers all other classes to provide the connection status on the network.

The main or home page of the web portal is similar to many websites; it has a menu on the left and a banner on the upper part. News and useful information are in its central area. Besides, it has a dedicated part to the social network for registration and authentication. Figure 1 shows the web portal layout.

(a) (b)

Fig. 1: Example of the web portal layout.

3.3. Complex Network Analysis Functionalities and Graph Viewer

This part of the system allows displaying graphically relationships among users and also to calculate the centrality measures from the database. It also exports network data as described in [22]. In Figure 2 – (a), we present a simulated example to illustrate the complex network analysis functionalities and the graph viewer. In particular, it represents the centrality degree through the graph viewer. The total connection density is 0.074, that is, from all possible connections in the network, we have only 7%, which makes this network sparse. The highest degree in the network is 7 (node 2) and the lowest is 0 (node 42). A degree 7 might be considered the most popular or influential individual in the social network, hence a suitable candidate to be a knowledge multiplier.

Another example is represented in Figure 2 – (b), where the centrality degree – "Grau", closeness and betweenness measures are calculated and presented through the graph viewer. The graph viewer allows displaying the network. Still in Figure (2) – (b), the simulated response to all metrics is nearly the same, i.e., the individuals between nodes 23 and 29 are more central, this interval is the most appropriate to choose another multiplier. In Figure 2 – (c), colour intensity shows connections relevance and a gigantic component can be detected, that is, it may be considered an informal community, where is important to identify multipliers. Also, in Figure 2 – (d) the graph viewer allows to exhibit communities.

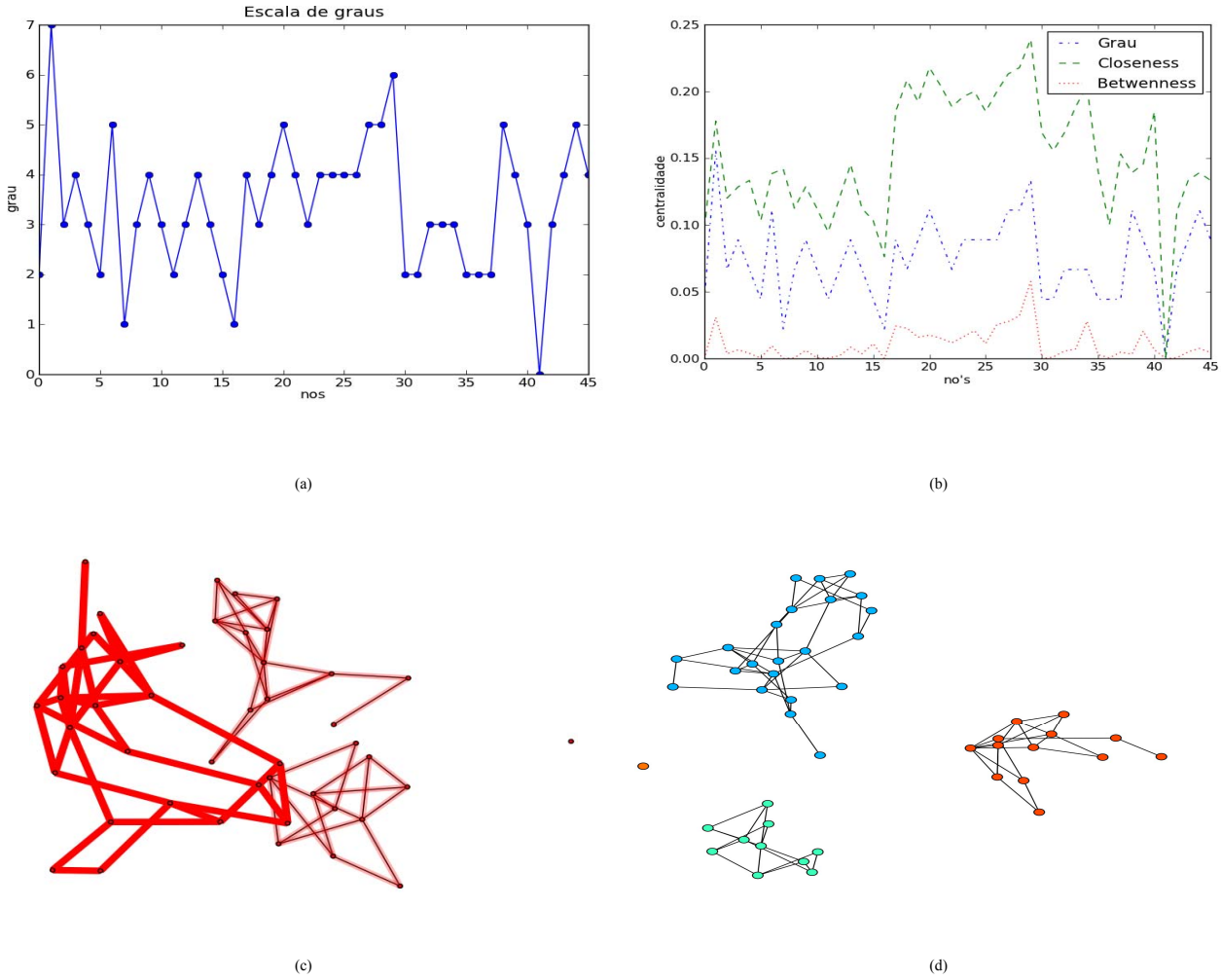

Fig 2: (a) Degree centrality example; (b) example displaying all three centrality measures together, both through the graph viewer; (c) example displaying the network through the graph viewer; (d) example of network communities at Palmas.

4. Discussion

The main objective of "Tocantins Digital" is to foster economic development by providing Internet access to communities related to public schools. However, an unarticulated approach is unlikely to promote it. Hence, this work proposed a social network Internet access web portal for supporting coordinated initiatives to knowledge dissemination, to improve e-Gov services access, and to contribute in job and income generation

Our social network web portal may change some features of its users' life. It may alter their interpersonal relations and community participation, causing a new social organization and structure. Hopefully, public schools' communities will naturally generate and exchange information and knowledge. Because of that, simplicity was a major concern in the system's design to encourage and facilitate its use. If that does not happen naturally, then the system allows network visualization to identify suitable multipliers and to monitor

the social network evolution. Also, the implemented complex network theory metrics convey to individuals that may link communities and to foster that should increase information flow in the social network.

Future works and developments include: to put the system in production and to evaluate the social network with real data; to implement new metrics; to apply new algorithms for detecting assortativity (attachment preferences) among individuals; and to elaborate a control model when creating a new profile, in order to protect the social network from fake profiles that aims bulling or users defamation.

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