Assessment of digital inclusion via the actor-network theory: The case of the Brazilian municipality of Piraí

Adonai Teles a, Luiz Antonio Joia b,*

a Fluminense Federal University, Praia de Botafogo 190, room 526, Botafogo, Rio de Janeiro, RJ 22250-900, Brazil
b Brazilian School of Public and Business Administration at Getulio Vargas Foundation and Rio de Janeiro State University, Rua Carvalho Azevedo 40/501, Lagoa, Rio de Janeiro, RJ 22471-220, Brazil

A R T I C L E  I N F O
Article history:
Received 31 March 2009
Received in revised form 20 August 2010
Accepted 14 September 2010
Available online 22 September 2010

Keywords:
Digital inclusion
Digital exclusion
Digital city
Actor-network theory
E-government
Brazil

A B S T R A C T
This paper presents the results of the analysis of processes aimed at digital inclusion in the municipality of Piraí in Rio de Janeiro state, Brazil. This city was chosen for this purpose due to the notoriety achieved by the Digital Piraí program, the origins of which date back to 1996. An approach based on the actor-network theory (ANT) was applied to evaluate the program. ANT was used to develop a model of digital inclusion, as well as investigate the formation of heterogeneous networks of actors around the components of the aforementioned model in Piraí. After collecting data in Piraí related to its digital program, interviewing several inhabitants, public administrators and merchants based in the municipality, with respect to their perceptions regarding this endeavor and analyzing this material vis-à-vis the digital inclusion model developed via the actor-network theory, it can be concluded that digital inclusion is a reality in Piraí, despite the fact that its effects do not benefit all segments of the society equally. The municipality presents different levels of appropriation of the advantages of information technology (IT), from the municipal executive body, students and teachers of the public school system – who have already progressed with the incorporation of IT in their daily lives – to the general public, including tradespeople and entrepreneurs, who are still far from reaping the full benefits of the digital inclusion movement. Lastly, some managerial and academic implications accrued from this research as well as the limitations of the study are set forth.

© 2010 Elsevier Ltd. All rights reserved.

1. Introduction

In the early 1990s, Brazil witnessed the advent of the commercial Internet and the swift expansion of its use in the country. In Brazil, as everywhere else, with the arrival of the Internet, there soon emerged the group of those who were excluded from its use. The realization that the fact that computers and networks had the potential to increase the social exclusion of a large portion of the population became increasingly clear (Avgerou, 2003; Avgerou and Walsham, 2000). Then, at the turn of the 21st century, articles appeared announcing that a program was being set up to promote digital inclusion in a small Brazilian city. It was Digital Piraí, which began in the city of Piraí, in Rio de Janeiro state, a city that sought to make its mark in the sphere of information technology (IT). In 2007, the researchers decided to concentrate their investigation efforts on understanding what had taken place in Piraí. By then, the Digital Piraí program had received several international awards.

In order to accomplish this, it was decided to apply an approach centered on a theoretical framework that would enable the researchers to immerse themselves in the digital inclusion process in Piraí. This framework took shape for the authors...
with their contact with work based on the actor-network theory (ANT). It was believed that by understanding how actor-network grids have developed in the Digital Piraí program, it would be possible to obtain a good overview of how Piraí was faring in its digital inclusion process. Additionally, however, it was necessary to have a model that would allow the researchers to focus on elements relevant to the analysis of digital inclusion processes, avoiding commonplaces and simplifications, such as statistical evaluations concerning access or the number of computers per inhabitant, for example. This quest did not lead the authors to any widely used digital inclusion model, such as (OECD, 2000, 2001; NTIA, 1999, 2000, 2002), to name only a few.

To understand the exclusion/inclusion combination there do not appear to be many analysis tools that provide more aspects than those related to equipment and Internet access. Barzilai-Nahon et al. (2006) considers indices created on the basis of analyses focused on access or number of computers, for example, to be mono-typical. On the other hand, there are broader indices, which Barzilai-Nahon et al. (2006) calls comprehensive, although they usually neglect local aspects of digital exclusion at the level of communities and individuals. None of the models based on these tools, such as those developed by Robinson et al. (2003); Lenhart and Horrigan (2003), would enable the authors to conduct an analysis of the type that they envisaged. The option, therefore, was to use the heuristic dynamic digital inclusion model (2iD) proposed by Joia (2004) as a starting point to establish a comprehensive analytical tool and deploy it in Piraí, as this model tackles the digital inclusion process dynamically and systemically, addressing some dimensions discarded by other digital inclusion models (e.g., Lenhart and Horrigan, 2003; Mason and Hacker, 2003). Thus, this work sought to describe the digital inclusion process in Piraí, showing the involvement of different segments of local society in its construction and the effects it has had on each segment.

This paper’s structure comprises a theoretical background encompassing the actor-network theory (ANT) and the heuristic dynamic digital inclusion model (2iD) developed by Joia (2004). These two streams were then merged in order to develop an enhanced and justified version of the heuristic 2iD model, referred to as 2iDj. After that, the research method was defined in order to reveal how the enhanced and justified model would be applied to investigate the digital inclusion process in Piraí. The Digital Piraí program was then analyzed vis-à-vis the 2iDj model and the results accrued from this were revealed. Finally, some conclusions were set forth.

2. Theoretical background

2.1. The actor–network theory (ANT)

More often than not, a role is attributed to technology in the ongoing redefinition process of society. However, when one refers to the Internet, a computer, a CT scan or an information system as quasi-celebrities, one comes up against the limitation that these things, according to a large group of theories, cannot have the same level of importance as people in the structuring of social life. The actor-network theory (ANT) offers a framework to overcome this barrier (Hardy and Williams, 2007). ANT has been used to address issues related to the use of information technology in different contexts and areas of interest. Health (Bloomfield et al., 1992), public administration (Walsham and Sahay, 1999), indicators of science and technology (Canchumani, 2008), the empowerment of rural women (Rubinoff, 2005), the adoption of free software (Guesser, 2004), public digital inclusion policies (Azevedo, 2008), the rendering of services (Uden and Francis, 2009), the adoption of information systems (Tatnal, 2009), Internet in banks (Santos, 2006), to name just a few, are examples of such applications.

The central element of the actor-network theory is the actor-network, the idea of which “suggests a combination of agency and structure or context in which none of them exists independently of the other” (Green et al., 1999). Seen in perspective, the whole of society and its subsets consist of a multitude of non-human and human actor-networks, with the former being artifacts created by man. In ANT terminology, any element that is able to impose its language on others can be considered an actor in the network. Operating systems, search engines on the Internet, office automation programs, for example, are artifacts that create a field of attraction around themselves, as well as determine behavior and use of technology that influence the growth of networks centered on themselves (Hanseth and Monteiro, 1998). The network formation process is, in broad terms, the very life or trajectory of the actor who will participate in numerous processes as protagonist or participant. It is by the formation of networks, and as a result of their participation in many networks, that the actors create their social identity (what they are) and their social function (what they do and how they do it).

The fact that the theory (outlined by Michel Callon and John Law and based on the work of Bruno Latour) treats human artifacts on an equal footing with man in the possibility of being an actor-network – the principle of heterogeneity (Hardy and Williams, 2007) – made it especially attractive to those engaged in studying the use and impact of technology, including information technology, on society (Comber et al., 2003), Mutch (2002) and Nijlands and Willcocks (2003) speak of a series of case studies on the strategic formation of information systems that use ANT as the dominant theory, since it was imported into the field of information systems as an interesting way of understanding the influences and the “actions” of technology.

The main elements of ANT associated with the study, besides the previously mentioned actor and the network, are translation, enrolment and irreversibility (see, for instance, Walsham and Sahay, 1999; Sarker et al., 2006; Cho et al., 2008).

Translation is the process of negotiation, mobilization, representation and displacement between actors, entities and places. It involves the redefinition of these phenomena so that they are persuaded to act in accordance with the requirements of the network, and these redefinitions are often enrolled in heterogeneous materials that act to consolidate
the network (Murdoch, 1998, 2006; van der Duim, 2007). In this sense, the translation process is a negotiation between actors about what the focus of the actions that the network will execute is, or “the undertaking and the result of (...) aligning the interests of multiple actors” (Hardy and Williams, 2007). This process will require the co-opting or involvement and mobilization of actors and resources. Therefore, the translation process opens up the possibility for two results: the establishment of obligatory passage points (OPP), and the formation of relationships (intermediaries) by means of the enrolment of technical artifacts, texts (regulatory markers, for example), people and money (Comber et al., 2003). The establishment of obligatory passage points (OPP) is the way in which an actor-network makes its interests imperative for other actor-networks in the quest for their own goals. OPPs represent “strong points of reference in organizational fields and may take the form of central institutions, concepts or methods according to which the fundamental interests of agents are defined.” (Lagendijk and Cornford, 2000).

Networks, starting from their translation processes, are then consolidated by means of enrolment, i.e. the creation of technical artifacts that ensure the protection of the interests of an actor (Latour, 2005; Ryder, 2007). Enrolment often occurs in the life cycle of the network and contributes to ensuring the irreversibility of the network, i.e. a point after which it is impossible for those involved in the network to switch to other alternatives (Latour, 2005; Ryder, 2007). Enrolment leads to the formation of “black boxes”, a term used by Latour (1987) that expresses concepts, methods, institutions or other elements, such as power, which become dominant and unquestioned, at least temporarily, in the process of formation and redefinition of actor-networks. The term was originally used by the author to uphold the argument that the more black-boxes a theory builds – the work of Latour refers to science and scientific debate – the more difficult it is for them to be refuted.

ANT helps to understand the cyclical processes of negotiation, redefinition and appropriation of interests in networks, to the point of identifying them in the process of enrolment of technical artifacts (Hanseth et al., 1996).

By way of conclusion, permitting a priori non-differentiation between social and technical elements in a socio-technical network fosters the detailed definition of concrete mechanisms that serve to keep the network connected without there being any distraction regarding the means, technical or otherwise, that enable it (Hanseth and Monteiro, 1998).

2.2. Digital inclusion

A great deal is said about the information society of today, but precious little is explained as to what the information society really is, what its rationale is and what the possible ways of dealing with it are. According to (Zhong, 2003), human society can be categorized into four developmental stages:

   a) The Nomadic Society: In which there were no man-made productive tools.
   b) The Agricultural Society: In which static tools were the typical productive implements, and the single resources employed depended on the material used, merely permitting agricultural activities through the use of manual tools (e.g., rods).
   c) The Industrial Society: In which dynamic tools were the typical productive implements, and the sources used depended on material and energy, supporting both agricultural and industrial activities through the use of dynamic tools (e.g., engines).
   d) The Information Society: In which intelligent tools are the typical productive implements, and the sources used depend on material, energy and information, supporting agricultural, industrial and information activities through the use of intelligent tools (e.g., computers and networks).

Therefore, in the information society, information is the fundamental resource and according to (Zhong, 2003), the total number of information-based goods consumed by human society may be infinite. A roadmap for understanding the disparities within the information society in developing countries is offered within the context of social inclusion/exclusion. These refer to the extent to which individuals or groups are able to participate in society and control their own destinies, taking into account a variety of factors related to economic resources, employment, health, education, housing, recreation, culture, and civic engagement (Warschauer, 2003).

In many developing countries assistance to give a voice to socially excluded groups comes from NGOs and involves the creation of effective channels of information and communication between the socially excluded and the national institutions that surround them. According to (Macadar and Reinhart, 2002), only a small percentage of the total world population has access to the Web. Even in a huge country like Brazil, less than 30% of the total population is connected to the Internet (Neri, 2003). This is what has been named the digital divide or digital exclusion, i.e., the exclusion of people from the information society as defined above.

Takahashi (2002) says that the digital divide is one of the main challenges the world is facing today, as digital exclusion can broaden the gap between the developed and developing countries, with relation to access and use of adequate and useful information and knowledge.

As shown above, this digital divide is usually a consequence of the economic and social gap within the countries that have the power to foster these inequalities (Takahashi, 2002). However, as stated by Zhong (2003), digital inclusion can provide the developing countries with an excellent opportunity to implement the most advanced infrastructure and productive forces directly, instead of first implementing the traditional infrastructure related to industrial society. This leapfrogging can accelerate the inclusion of a developing country into the arena of developed countries. So, information technology is the
engine for the development of countries, where the digital inclusion of both citizens and organizations constitutes the starting point in accomplishing the process. For this reason, several researchers (see, for instance, Warschauer, 2003; De Haan, 2004; Martin, 2003; Norris, 2001; Wilson et al., 2000, just to name a few) call for a less technical-centered and a more holistic, systemic and dynamic approach to the study of digital inclusion.

2.3. The heuristic digital inclusion model (2iD)

Based on the premises that a more holistic, systemic and dynamic approach to study digital inclusion was needed, Joia (2004) developed a heuristic digital inclusion model, named 2iD (see Fig. 1). It was an expansion of the digital inclusion model developed by Afonso (2001). Besides pursuing a more systemic and holistic way to tackle the digital inclusion (also referred to as info-inclusion) process, the 2iD model also adds a dynamic aspect to what was originally a static model.

In accordance with the 2iD model, the following are essential conditions for the digital inclusion or info-inclusion of individuals in a community:

- Economic, political, ethical and legal sustainability of the process.
- Existence of physical infrastructure and ease of access to computers and the Internet.
- Existence of locally produced content and/or adaptation for local use.
- Education geared to the autonomy of individuals and their qualification to take advantage of the opportunities of the information society.

These conditions must respond, dynamically, to the following stages of a cycle: the Virtuous Cycle of Participation and Empowerment:

- Implementation of IT tools.
- Increased awareness of users regarding the possibilities of the use of IT.
- Increased demand for IT infrastructure and applications.
- Feedback on the process, from those already included therein, with growth both in the number of new participants and in the sense of citizenship and empowerment of those already integrated.

The 2iD model offers a basic structure for researchers to devote themselves to the task of setting up the grid of actor-networks that can influence the process of social inclusion through information technology (IT). The components of the model make it possible to follow a line of investigation to identify the actors and the processes by which networks are formed around their interests. By means of the model, the researcher can evaluate the influence of the action of people and technology on the physical and social structure of a network that consists of communication protocols, computer systems, people, social norms, interests, power and bits flowing through its circuitry.

However, this is a heuristic model. As stated by Winter (1998):

“A heuristic model corresponds to a degree of problem definition that occupies an intermediate position on the continuum between a long and indiscriminate list of things that might matter at one end and a fully formulated control-theoretic

---

**Fig. 1.** The dynamic digital inclusion model (2iD) – (source: Joia (2004)).
model of the problem at the other. Within a heuristic model, there is room for a wide range of more specific formulations of the problem, though there is also enough structure provided by the model itself to guide and focus discussion. On the other hand, a rich variety of different heuristic models present plausible approaches to a given problem.” (Winter, 1998).

So, in the next section, the actor-network theory is used to justify the rationale beneath that model, as well as to enhance it.

2.4. Justification and enhancement of the heuristic 2iD digital inclusion model: The 2iDj model

As already said, a heuristic model is characterized by occupying an intermediate position between an indiscriminate list of items that may be relevant to understand a given phenomenon and a fully formulated theoretical model (Winter, 1998). To enhance the model’s design, it was decided to use a theoretical framework that would make it possible to justify the rationale beneath each of its components and its dynamics. This framework is the actor-network theory (ANT). So, the justification for the 2iD model is the effort to relate each of its elements with aspects of ANT. Fundamentally, it was believed that each step of the construction of the digital inclusion process may be linked to the history of the formation of a network, whose central interest is associated with elements of the pyramid and the virtuous cycle.

Hence, translations, enrolments and the conquest of irreversibility (which is always transitory in ANT and which occurs until there are actors with interests and power to reopen the discussions and dismantle the “black boxes” resulting from them) are associated with each one of the elements of the model. So, an attempt is made to provide information below about how each one of them could turn into a network that contributes to the completeness of the dynamic digital inclusion model (network of networks).

The issues of sustainability presuppose that a series of safeguards exists in the location where the digital inclusion initiatives will take place, namely laws, rules, audits, budget, to ensure that these initiatives have ethical, political, economic and legal backing to ensure their sustainability over the course of time.

The case of infrastructure and access is that which more readily reveals the incorporation (enrolment) of non-human actors to networks and to the digital inclusion process. These arise in the form of computers, computer networks, telecenters, operating systems, computer programs, communication protocols, technology and constructions for data transmission and the link-up of locations, buildings and organizations to the Internet. The establishment of these actors requires discussion and consensus – translations – on issues of various kinds, such as the decision to opt for the use of free or proprietary software, the standard of equipment (and competition between suppliers), the role of telecenters (mere access points or technological education venues) and others. It is an important area of dispute because it involves a substantial part of the costs relating to digital inclusion programs.

The translations of education are related to how information technology is considered within the scope of digital inclusion initiatives. Its application as a tool inserted in a comprehensive pedagogical model, or its use as a kind of solution for a number of neglected educational problems, arise as a crucial point to be resolved. In the area of professional qualification and the training of the general population in the use of IT, there lies the choice of instruction initiatives for the use of programs and equipment, without specific context or local relevance. There is also the development of strategies to identify ways to incorporate the technology to the day-to-day life of citizens and promote their inclusion in a labor market with stringent demands with respect to the ability to use IT.

In the case of local content, the ability of people to interact with the technology and produce content that can be disseminated on the Internet is important. The translations here will take the form of discussions about what kind of applications are relevant in order to make the computer network useful in the daily life of the community, and even how to encourage the population to use electronic channels for discussion of issues relating to citizenship. In this vacuum of participation of the people, public authorities can step in translating specific interests – taxes, protocols, ombudsman – into services available on the Internet.

This analysis is consolidated accordingly in a synthetic way in Table 1.

Other components of the model, related to its dynamic character, were linked to only one of the mechanisms of ANT. Increased awareness by the local population and increased demand for content, education, services and access, for example, are treated separately. They correspond to translations in ANT language. This occurs because these processes demand that further discussions be incorporated to the digital inclusion process or that the irreversibility (always provisional) of some black-boxes be challenged and re-assessed by the new or already established actor-networks. The terms feedback and growth were eliminated as it was considered that their occurrence arises under the heading of implementation, which is already included in the justified model. Implementation is the moment of enrolment in the network, which takes place incessantly and, for this reason, is linked to each of the issues already discussed, occurring at different times and in different ways within each of the components of the model.

This analysis is consolidated accordingly in a synthetic manner in Table 2.

This combination of the theoretical model to the mechanisms of ANT appears to require a new graphic representation with fewer edges that depict the dynamics that the process implies. This new representation is shown in Fig. 2.

The graphical representation seeks to show that precedence between the elements is not mandatory. Once the process is in motion, new translations, enrolments and the configuration of irreversibilities will occur within the scope of each component and not necessarily require adjustments in the others. However, all of them are interconnected and their dynamics can influence and even call for further discussions and realignments in adjacent networks. Moreover, the recursive arrows
with a letter i for each ellipse illustrate the enrolment processes, which replace the indication for implementations in the original model.

The new model can be interpreted in a less rigid manner than its forerunner. The components come to reflect their own dynamics, with processes of enrolment within their own scope. The increased demand and awareness, reflected outside the largest digital inclusion ellipse, indicates that new issues can be brought into the process as a whole by actors outside the networks and that they can be incorporated into it as a result of showing interest in the subject and/or having been affected.

Table 1
Relationship between the pyramid of inclusion of the heuristic model and operational aspects of the actor-network theory (ANT).

<table>
<thead>
<tr>
<th>Elements of the 2iD Model</th>
<th>Operational aspects of ANT</th>
</tr>
</thead>
<tbody>
<tr>
<td>Political, economic, ethical and legal sustainability (Base of the pyramid)</td>
<td>Translation: Premises regarding the need for use of IT by the community (employment generation, attraction of technology-intensive enterprises, creation of technology centers)</td>
</tr>
<tr>
<td>Enrolment: Codes, standards, political agreements, legal texts, contracts, arrangements and political justification</td>
<td></td>
</tr>
<tr>
<td>Irreversibility: Approval of texts, dissemination of standards and values in the network</td>
<td></td>
</tr>
<tr>
<td>Infrastructure and access (2nd level of the pyramid)</td>
<td>Translation: Technical, economic and financial premises relating to infrastructure: types of networks, operating systems, the nature of the source code of programs, type of Internet access (private or public, paid or free)</td>
</tr>
<tr>
<td>Enrolment: Establishing networks and their standards, purchase and installation of computers, signing of maintenance contracts, supply of credit, construction of premises for access (telecenters, labs, kiosks)</td>
<td></td>
</tr>
<tr>
<td>Irreversibility: Incorporation of standards in the use of the active technologies</td>
<td></td>
</tr>
<tr>
<td>Education and local content (3rd level of the pyramid)</td>
<td>Translation: Definition of information technology as a tool for administrative and pedagogical support of education. Training of the population to work with IT. Training in the values, needs and local knowledge as relevant aspects of the use of IT</td>
</tr>
<tr>
<td>Enrolment: Pedagogical model adapted to the location, training teachers and users in general, e-government systems, portals of interest to the local population, discussion groups on local issues</td>
<td></td>
</tr>
<tr>
<td>Irreversibility: Dissemination of the use of local information by the community, pedagogical processes associated with technology, employment associated with the use of technology and production of local content.</td>
<td></td>
</tr>
</tbody>
</table>

Table 2
Relationship between the dynamic elements of the heuristic model and operational aspects of the actor-network theory (ANT).

<table>
<thead>
<tr>
<th>Elements of the 2ID Model</th>
<th>Operational aspects of ANT</th>
</tr>
</thead>
<tbody>
<tr>
<td>Increased awareness</td>
<td>Translation, with the discussion of points previously stable (challenge of irreversibility) and new proposals for development of the process</td>
</tr>
<tr>
<td>Increased demand</td>
<td>Translation, where the discussions that evolved in a positive manner are presented as new needs for expansion of the digital inclusion process</td>
</tr>
<tr>
<td>Feedback and growth</td>
<td>Discarded as it is considered that they are, in the final analysis, part of and the result of the various processes of implementation</td>
</tr>
<tr>
<td>Implementation</td>
<td>They are relocated to within the various elements of the model, corresponding to enrolment in ANT language</td>
</tr>
</tbody>
</table>

Fig. 2. Justified dynamic digital inclusion model (2iDj).
by its expansion. This is the spirit of constant adaptation of the networks that ANT considers valuable and that it was considered essential for analyzing the digital inclusion process.

With the model duly established, the assessment of the digital inclusion program in Piraí is undertaken in compliance with the methodological procedures depicted below.

3. Research method

In methodological terms, ANT affords great freedom to the researcher, who has no a priori definition of who the actors in the organizational field study are. Thus, “there is no a priori definition or prior assumptions as to who the significant actors are, as this is revealed through empirical observation and analysis.” (Hardy and Williams, 2007). In this sense, ANT stands out as a research methodology – “the essence of ANT is not deep theory, but in the presentation of a set of methodological rules (...) the most essential of them (...) being to ‘follow the actors’” (Lagendijk and Cornford, 2000) – providing an opportunity for inclusion of artifacts and people in the networks and a taxonomy to describe in their terms – translation, enrolment and irreversibility – the elements of the 2iDj model to assess the occurrence of digital inclusion in the city.

According to van der Duim (2007), “the researcher has to follow how meanings and tasks are attributed to and distributed among people and things. He or she has to follow and elucidate processes of ordering.”

To follow this recommendation in the use of ANT as the basis for a research methodology, it was decided to use semi-structured interviews with a number of actors initially selected for their importance in the city as well as being representative of relevant social groups – political leaders (mayor and secretaries), officials of the municipal executive body, people directly involved in projects related to Digital Piraí, civil society representatives, students and tradespeople. From the initial selection, which may be associated with the stakeholders analysis, as suggested by Pouloudi (2004), other actors were located by specific recommendation by the interviewees or by being mentioned by one or more respondents in such a way as to arouse the interest of researchers in interviewing them.

Interviews were conducted with a total of 12 people: the mayor and two municipal secretaries; a local civil servant working with technology and technical IT support for the government; the person in charge of the municipal office of the employment agency of the state of Rio de Janeiro; a teacher from a municipal school; two members of the coordination of the Digital Piraí program; two attendants in telecenters¹; the representative of Sebrae² (hired by the municipal authority and on loan to the entity) in the city, and a local merchant. These interviews ranged from 20 to 80 min, with an average duration of 45 min. Five interviews were recorded and written notes were taken of all interviews. In addition to this, a lesson-interview lasting approximately 90 min was given to a 3rd year high school class. There were 37 students present and, besides the explanation on the scope of the study, a survey on Internet use among them was conducted.

The dialogue of the interviewees was analyzed from a qualitative perspective, in order to understand the existence and development of static and dynamic characteristics of the 2iDj model in the city. These analyses provided the practical basis for understanding the evolution of the integration between the actors in the municipality by means of IT and the impacts of IT on life in the city.

4. Assessment of digital inclusion in Piraí

The Digital Piraí program was officially inaugurated in 2002, but the vocation of Piraí for the incorporation of IT to the identity of the municipality began in 1996 when the municipal administration decided to draw up a Director Plan for Information Technology in the municipality. It was commissioned in 1997 from the University of Brasilia (UnB). The creation process and initial funding of the program is described at length by Sadao (2004): “The objective of the ‘Piraí–Digital City’ program is the democratization of access to information and communication technology in order to generate opportunities for economic and social development. The basic presupposition is that of the strategic vision of a local information society, in which the citizen becomes the main actor in the production, management and enjoyment of the benefits of new information and communication technologies.” (Sadao, 2004).

The Digital Piraí program has received awards on various occasions from national and international institutions linked to the theme of digital inclusion and the evaluation of digital cities. The city was chosen as one of the first four in Brazil to receive computers on the One Computer per Child (UCA) project – inspired by the OLPC (One Laptop Per Child) movement conceived by Nicholas Negroponte of MIT – sponsored by the Brazilian federal government. The UCA project was officially inaugurated in the city in September 2007.

Sadao (2004) affirms that there are results of the Digital Piraí program that are clearly visible “in the modernization of departments and public bodies; in the interest of schools to incorporate new IT as a kind of catalyst for the pedagogical project, while respecting the local culture and the speed of adaptation to be technological tools; in the broadening of opportunities for ongoing educational training in undergraduate courses and postgraduate studies; in digital inclusion on a universal

¹ Telecenters are public places where people can access computers, the Internet, and other digital technologies that enable them to gather information, create, learn, and communicate with others while they develop essential digital skills for the 21st century (http://pt.wikipedia.org/wiki/telecentros)
² Brazilian Service Support to Micro and Small Companies (Sebrae–Serviço Brasileiro de Apoio às Micro e Pequenas Empresas) is a private nonprofit organization that serves to promote the competitiveness and sustainable development of micro and small undertakings. The institution was established in 1972 as a result of pioneering initiatives focused on encouraging entrepreneurship in Brazil. (www.sebrae.org.br)
basis, guaranteeing the right of access, use and enjoyment of information to all citizens without any distinction.” (Sadão, 2004).

The analysis undertaken, based on the 2iDj model and the structuring of networks of actors, seeks to expand and further ratify the assertions of Sadão (2004) and present an updated position on the digital inclusion situation in Piraí and will be presented by detailing the components of the 2iDj model. The analysis of each item is followed by a table that summarizes the impression of the authors on its presence in the digital inclusion process in Piraí. Thus, Tables 3–6 have entries corresponding to each component of the 2iDj model and one or more comments on each one of them.

4.1. Sustainability

From the legal standpoint, the framework of sustainability of the technological option in Piraí is the Director Plan of Information Technology (PDI), developed with assistance from UnB in 1997, which is the legal basis for structuring the IT coordination actions in the municipality. Thus, the initial translation of the premises for the changes in Piraí was enrolled through the PDI in the incipient digital inclusion network of the municipality. In the words of the municipal mayor:

"In 1996, we began a process of diversification of options for generating income and employment in the municipality. We believed that technology should play a role in this change and that it also included the modernization of the municipal administration. In 1997, already during the government of Pezão3, the staff of UnB came to help us and organize our valid ideas."

Between 1997 and 2007, other political backing actions regarding the issue of digital inclusion were implemented, and it was an initiative by the City Council in 2003 that gave rise to the first telecenter in town. However, there were some difficulties in the translation of some premises that impaired the sustainability of the process. For example, the National Telecommunications Agency (Anatel) did not allow City Hall to charge citizens and companies for the provision of public internet access. City Hall needed to choose between creating a company to provide the service for a price or offering it free of charge to all residents. The option for paid service is in line with the wishes of the municipal authorities to ensure that individual Internet access in Piraí is self-sustainable. But this issue remains unsolved and universal Internet access through the municipality network is still denied.

3 A former Piraí mayor.
Currently, the financial sustainability of public access in telecenters and kiosks is defrayed by the Municipality through its tax revenues, and by its partners. The savings in funds can be included under the item of financial stability. According to the coordinator of the IT Division subordinated to the planning department:

“The savings that we have made on software licenses alone that we did not renew or buy over the past few years is enormous. We use Linux distribution geared to education, which also serves perfectly well for the various organs of City Hall. Telephony over IP (VoIP) is another area of saving we are using in public buildings and in communication between the population and City Hall.”

On the other hand, economic sustainability linked to the generation of revenue for the digital inclusion initiatives seems tenuous in the aspect of fostering the installation of companies dedicated to operating services in the IT area. Pirai does not yet appear to be in a position to win over companies in this segment.

The political sustainability of digital inclusion actions to date has been guaranteed by the same political group remaining in power for four consecutive municipal terms. The mayor at the time of the visit to the city was reelected in 2008, for a further mandate that will end in 2012.

Ethical sustainability with respect to digital inclusion in Pirai, the assessment of which is the most subjective among all the subjective evaluations of this study, deserves to be positively evaluated, as those responsible for the Digital Pirai program are aware of the criticism regarding the program, especially from the tradespeople. The ethical environment for the program to move forward with the participation of the various interested actors appears to be present in the municipality, despite the low popular participation observed.

Thus, Table 3 below consolidates these findings.

4.2. Infrastructure and access

This is the easiest item to comment on in the 2iDj digital inclusion model. The IT coordination unit of the council promptly provided the numbers and figures for the physical deployment of the network for Internet access in the municipality.

This network – a hybrid, with metal pairs, cables and wireless transmission – features 1050 computers, including the 430 of the UCA project, distributed across 87 public buildings. Among these, there are the six telecenters, nine kiosks and laboratories of municipal schools. Two more buildings were included in the network by the end of 2007. Regarding the speed of access, the attendant at the City Council’s telecenter said:

“Here, at the telecenter in the city council, the venue is frequented by many young people who are conducting school research, which is not common in all telecenters. However, the problem during the day is the slow internet access ... sometimes the connection fails completely and it is necessary to wait a while before being able to browse again, but in general it allows them (the students) to do what they need.”

The technological upgrade of the network and enhancements ensuring its optimization, as well as the need for increasing Internet access bandwidth, has been a constant concern for the IT coordination unit. Access to the municipal network is available throughout all public offices, and Internet access is available in all public buildings, schools and public access points. The telecenters, towers, protocols used, licensing, distribution and computers are all clearly focused on this venture. But, it is naturally exposed to some translation processes, which occur precisely in the definition of exactly which languages, systems and protocols will be selected. The decision to use free software is a translation clearly enrolled in the Pirai digital inclusion network, as well as the option of a specific Linux distribution. It is also clear that these artifacts turn into actors, as foreseen in ANT, to the extent that it is possible to see the effect they have on web users. They also have an impact on the training of professionals, as well as affecting local economic aspects such as savings of funds for the municipality, and can influence the choices of other cities and businesses that are inspired by this example.

Thus, Table 4 below consolidates these findings.

4.3. Education and local content

Regarding education, there are reasons to be optimistic. A section of the population, namely the students and teachers of the municipal education network, is benefiting from the computerization of schools and the adaptation of the pedagogical project to put informational technology to good use in the relationship between students and teachers for education purposes.

The municipality of Pirai has an education network that serves about 8000 students per annum, divided between the state and municipal networks. The latter is better equipped in terms of computer labs with Internet access, which are included in the pedagogical project of the various subjects and are administered with the support of a computerized integrated management system. In the words of the municipal secretary of education:

“Today we have all the figures from the municipal education network consolidated in a single system, which enables us to produce reports with useful and updated information quickly. This agility enables us to react immediately to problems that appear in the secretarial office. Before this occurred, it was far more complicated to obtain the data. The snack break and even the route of vehicles that transport our children to and from school have improved thanks to the system.”

Pirai currently has a public education network that, with the support of computer laboratories in schools, encompasses the spectrum from primary to tertiary education offered by federal universities that have distance learning graduate
programs mediated by the Rio de Janeiro Center of Science and Higher Distance Learning Education Foundation (Cederj), which seeks to centralize higher education in the state of Rio de Janeiro through distance learning technologies, especially via the Internet. Furthermore, the projection of the city with the Digital Piraí program, which is a veritable marketing phenomenon for such a small city, has led to several opportunities to host projects that promote educational practices with the use of IT being incorporated in the municipality.

Thus, education in the municipality, following closely behind public administration as a whole, is a segment of Piraí society that has benefited greatly from the digital option in the city.

One can also see that the content available on the Internet for the population of a small municipality in the hinterlands, such as Piraí, is indeed small. However, there are efforts to change this. The history of Piraí is on the Internet and public services are modernizing and will also be included on the network. Thus, government contributes to ensure that important content – especially that related to the exercise of citizenship – is made available to the population. One good example of an opportunity to develop local content provided by the adoption of IT in schools is the participation of Piraí’s students on the X-Cross project. X-Cross is the abbreviated name for the European and Latin American Example of Cross-Curricular Distance Learning in Science. It was conceived as a pilot project to help local communities use IT and multimedia tools, in order to improve the quality of teaching and learning at all levels. During this project, the students produced video classes about sciences, related to their curriculum. These videos are now part of the city’s digital content (See in http://bit.ly/piraixcross).

Moreover, there are factors that suggest that the currently existing local content will evolve, both in terms of scholastic and academic production – with the graduation of the first undergraduate classes in the municipality – and in the provision of municipal public services via the Internet. An official of the local office of the National Employment System (SINE), which consolidates information about the national labor market and job vacancies, said:

“I am optimistic about the future of the children of the municipality who are studying in schools where there are computers, Internet and teachers who have received guidance on how to use these tools. Unfortunately, there is a group of people in the 20–40-year-old age bracket who are no longer able to update their qualifications and are out there fighting for lowly paid jobs.”

An important moment of translation was that of transforming the desire to make the use of computers a means of achieving educational goals – and no longer a mere end in itself – which ended up being enrolled in a broad pedagogical project with the support of teaching laboratories and the training of school teachers. Again, in the words of the municipal secretary of education:

“Rather than students who use computers in a repetition of learned patterns, we want them to be able to use a spreadsheet or an Internet search engine to solve their problems and increase their knowledge on the topics of the subjects they study. For this reason, back in 2002, we started training the teachers even before the laboratories were installed.”

Thus, Table 5 below consolidates these findings.

### 4.4. Increase in awareness and demand

There is a discrepancy in the awareness of the importance of IT to Piraí between two segments of the population, namely those connected to public service, including public education on the one hand, and the general population, especially tradespeople on the other. The first group is aware of the importance of IT to the effectiveness of their actions and demands, such as the education sector with its management system and the reported initiatives of integration of health services. The quest for financial efficiency through IT and choices made regarding its use – deployment of VoIP telephony and the option for free software, for example – are indications of the extent of awareness of this segment.

The interview with the owner of a perfume store in the city shows that it is not just a question of prejudice with respect to the technology that prevents it from having a greater impact on local commerce. Despite intensive use of the Internet – with her own computer and access – for shopping, banking transactions and information in general, she sees no gain for her business from the fact that Piraí has developed the Digital Piraí program. It does not help the tradespeople, either from the viewpoint of interaction with municipal government, or in terms of the qualifications of their employees.

Judging from the interview with the Sebrae representative in the city, this attitude of mistrust towards the Digital Piraí program is not an isolated case. There is a significant group of local traders who are truly resistant to the computerization of business and totally skeptical about Digital Piraí. The local representative of Sebrae says:

“They say they are ‘projects on paper’ or ‘political issues’. People tell me that things are fine the way they are, that things were always achieved in this manner and that there is no reason to change. Some of them end up creating an email address that they never use or simply ask their children to print messages for them to read. Doing business over the Internet? Contact with suppliers? No way.”

This statement suggests that the potential for digital inclusion can still be greatly intensified in the city by the incorporation of sectors of the population whose engagement in the Digital Piraí initiatives is insignificant.

The increased demand, as well as the return on information and expansion of digital inclusion, is a result of the actions of the municipal government though it has not been accepted by the population as a whole, the exception being the case of the district of Arrozal. In this location, the community got together to request that the laboratory should support users who wished to use banking services or send their professional CVs via the Internet. So, the dynamic aspects of the process appear to be highly restricted to the public authorities and sectors of the population directly related to it, such as students and teachers of the municipal education network.

Thus, Table 6 below consolidates the results.
5. Conclusions

It is seen how the combination of the 2iDj model and ANT – the latter seen as both the language to describe the formation of heterogeneous networks and method of description of such networks – provides a thorough and comprehensive analytical tool to assess the digital inclusion process in Pirai. The application of the 2iDj model indicates that the presence of elements that promote digital inclusion is a reality in Pirai. Nonetheless, digital inclusion is not uniformly implemented in all segments of the Pirai population, though it is important to remember that this is a process that only formally began in 2004. During this period, it succeeded in bringing about some important changes in the profile and prospects of the city, especially with respect to the area of education.

In Pirai, there is a network of actors who also interact via IT and the Internet. For the past five years or so, students and teachers have been experimenting with changes in relationships among themselves and with the subjects and activities of the school curriculum. One of the interviewees, a Pirai resident since childhood, stresses the current possibility of studying in Pirai with the assistance of computers from primary through high school as a benefit that he himself did not have in his days as a student. Human actors, such as public administrators in general, as well as teachers and students, interact through computerized and integrated systems to reap benefits in a scenario that is constantly influenced by technology and in particular by IT.

The application of the 2iDj model suggests that a path has been defined and there are points to be improved for a future of true universal digital inclusion in the city, especially with the generation of relevant content for the local population and its emergence as a generator per se of content to meet their needs and objectives as a community.

Digital inclusion exists in Pirai, though as yet at an insufficient level for the city to attract companies with a focus on technology or demand for professionals trained in IT. This digital inclusion reaches the public only partially, being mainly focused on public administration and the students and teachers of the municipal system of education, though the process as a whole has been in existence for a little over 10 years, with the bulk of its most important actions only occurring after 2002. Over these past 10 years, purely as an indirect measure of the extent of progress made in terms of digital inclusion, the city increased from two to over a thousand computers. These are connected to a public network that did not exist before, which hooked Pirai up to international projects such as X-Cross and included the municipality among the first to receive computers from the federal UCA project.

As already mentioned at the beginning of this work, the aim of this paper is to assess the Pirai Digital Program by using a heuristic digital inclusion model supported by the actor-network theory, rather than understand the rationale that led certain segments to go further than others in the institutionalization of the program. However, it can be perceived that both the public educational realm and public administration have achieved success in translating their aspirations, as well as enrolling them in obligatory passage points (OPPs) that means that the actor-network process becomes irreversible. Conversely, other segments – especially the business area – didn’t succeed in developing a sustainable network of actors in order to translate and achieve their main targets. In this manner, these segments have not taken advantage of the digital inclusion process in Pirai.

These main findings highlight the key role the public sector plays in the deployment of a truly digital city, as it can more readily back the translation and enrollment stages of ANT, leading the digital inclusion program to become irreversible.

5.1. Academic and managerial implications

As already stated, this study aims at presenting the possibility of using the actor-network theory (ANT) to assess programs of digital inclusion such as the one developed in the city of Pirai. As already pointed out, ANT deals with both human and non-human actors, such as computer networks, PCs, softwares, etc. (Hanseth and Monteiro, 1998; Comber et al., 2003). Thus, this new approach can be considered to be a contribution of this research to Academia. Moreover, this study sets forth a new framework for assessing digital inclusion in municipalities, such as Pirai. As already said, existing literature on digital inclusion models is very much technical-centered and based on the number of computers deployed, number of Internet accesses by the population, etc. (Barzilai-Nahon et al., 2006). The 2iDj model developed opens up a new path to assess digital inclusion projects in a systemic, interdisciplinary and dynamic way. This approach can be useful to politicians, civil servants and policy-makers when designing and assessing digital inclusion programs in municipalities.

5.2. Limitations of the study and future research

As in any study, there are some limitations in this research that must be cited. First of all, the research adopted the original heuristic digital inclusion model (2iD), as developed by Joia (2004), in order to justify its rationale and enhance it using the actor-network theory (ANT). Although it is explained why that specific model was used to convey to the 2iDj digital inclusion model, other digital inclusion models might be used. This can be done in future research and must be considered a research limitation.

Secondly, the article does not conduct any in-depth investigation as to why the outcomes accrued from the Digital Pirai Program were so asymmetric. In other words, it did not formally appraise why the public education and administration...
sectors embraced the program so readily, whereas the business and tourism sectors remained at arm’s length from it. This can also be fully investigated in further research, though it should also be seen as a further limitation of this research.

Finally, interpretation of the results accrued from analysis of the Piraí program vis-à-vis the 21Dj model of digital inclusion was based on the authors’ perceptions, which is another limitation. According to (Scandura and Williams, 2000; Bertucci and Ambiente, 2005), this limitation is due to the possibility of many varied interpretations of a situation perceived by the authors, in their attempt – not necessarily conscious – to paint a good/bad picture of the Piraí program, to limitations in terms of information available while they analyzed the results, and to the epistemological model of the authors.

In conclusion, Piraí is not the perfect digital city, with unrestricted access for any citizens who wish to use their laptops to surf the internet via a wireless network from downtown, or wherever else there is a local arrangement devoted to the development of technologies for use in cyberspace that bring together countless computer engineers and technicians. Piraí is indeed a veritable proto-digital city in a country such as Brazil with major inequalities and with a great deal to be done in terms of disseminating the use of IT among the population. It is a city that is striving to be included in the circuit of service companies that require skilled personnel and structure to access the global network. In this manner, a contingent of the local population will be in a position to enjoy the quality of life of a small municipality with access to the boundless potential of virtual space.

References


