RESEARCH

Enhance Honduras Development with Technology Transfer of High Performance Computing

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Abstract

Background: – The government of Honduras needs to improve economic efficiency due to a general crisis. To this end, the development of a high performance computing (HPC) infrastructure is needed; because it will make bureaucracy economically efficient. This paper expose the need to deploy HPC, and for that is needed technology transfer, which is defined as the process by which knowledge for problem solving is transmitted from a developed partner to a less one. From this point of view, who receives technology can face present and future problems through joint systematization of experiences.

Methods: It consists to review some successful cases of technology transfer and its benefits to citizens locally, regionally and internationally. Also describes how HPC technology can be integrated in the workflow of government and how can be used by it. To do this, it was necessary to find in the official gazette of the republic by publication of agreements and decrees are commencing technological projects from 1980 to the present. Only those initiatives that were completed were considered for this article.

Results: It is necessary to retain control, ownership and investment of public utilities by Honduran government, because that would prevent a gap on access and It will bring better income to the public finances. Also this strategy will help to reduce the technological divide and It will boost research and development, as result of a more efficient bureaucracy.

Conclusions: High Performance computing (HPC) implementation can be achieved through technology transfer with participation of strategic partners, this is widely described as opportunities for development using computer science applications. Also, research and innovation are forgotten lines in cooperation for developing countries, making them in need permanently of foreign support. HPC can play a key role in improving living conditions in countries with poor economics and social welfare.

Keywords: High Performance Computing; Honduras; Technology Transfer; Technological Divide; e-Government

Background

Science is an often-neglected aspect of development. This article shows the benefits of investment in a public high performance computing (HPC) infrastructure by the government of Honduras. This could bring benefits to all levels of society by providing better state services and expanding scientific research opportunities.

In the last five years, several papers by the Honduran academia have reported the advantages of using HPC in diverse applications. However, Honduras has a large and growing technological divide. Current efforts made by local government and private institutions to reduce this divide have been ineffective. In order to overcome this situation, we propose infrastructure that will benefit the country through e-services. We outline a HPC platform suitable for third world countries. This platform will handle the processing of data and central processing unit (CPU) intensive applications, giving academic and scientific communities the tools required for modern research, as well providing for the needs of government and society.

In 2013, 60.4% of the population of the American continent could access the internet. In Honduras, however, only 17.8% had access. This represents a very low rate of use of technology, software and computing [1,2].

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Currently, Honduras suffers from a widening digital divide that is forecast to continue to increase [3].

Traditionally, Honduras is a consumer, and not a provider of technology. For example, there are no software or technology exports [4]. Recently, the government has encouraged the establishment of call centers and technical support operations, in a similar way to their past support of the textile manufacturing industry [5]. This paper shows how technology transfer could substantially enhance national development, especially via science and government applications. This could be achieved by providing public access to computing resources that are produced and consumed locally within Honduran communities.

Studies report that a HPC infrastructure is required to improve national performance at all levels. This is demonstrated by a series of articles published recently [6, 7], in which Honduran researchers' use of computer applications requiring a lot of processing power were evaluated. The indicators used for Honduras are taken from national reports from state agencies such as the INE - National Statistics Institute [8], CONATEL - National Telecommunications Commission [9], BCH - Honduras Central Bank [4] and Hondutel - National Communications Company [10]. We also used data from multiple editions of the HDR - Human Development Reports of the United Nations Development Program [11]. These emphasized the value of access to, availability of, and information on technology and communications.

There are many dimensions to the term technology transfer. Firstly, it is related to ideas and concepts that move from the laboratory to the marketplace [12, 13]. Secondly, it refers to the transfer of knowledge and concepts from developed to less technologically developed countries [14, 15]. Thirdly, it allows the transfer of incentive activities to secondary users [16].

For current purposes, we merged the last two definitions of technology transfer, because both can be adopted as processes for deploying HPC facilities. These could support Honduran development, meeting the technical and societal challenges of exploiting computer performance for multi-purpose applications in agriculture, medicine, e-government, and so on. Nevertheless, in this paper, no single definition of HPC as a technological concept and architecture is available. We consider HPC broadly, as a key enabling technology for the case of Honduras. Such technological infrastructure is a catalyzing solution to several societal challenges, e.g., low agricultural productivity; low pre- and post-disaster response rates; lack of data storage and analysis capabilities; high political corruption due to weak monitoring of transactions, and other local issues.

Universities, research centers and other institutions are the entities that can best handle the processes of technology transfer, they can move scientific and technical discoveries from one organization to another, in order to promote their development and marketing. In this sense, different geographical regions address these opportunities from diverse perspectives; some are more focused on science, and others in enterprise. In a country like Honduras, the state can guide this process for the benefit of the whole society.

Actually, the government has made and continues making efforts to reduce the digital divide and boost research and technological development by passing new laws promoting innovation [17]. These laws have funneled monetary resources to small technological and research projects that are generally under-budget, and can be viewed on the IHCIETI website [18, 19]. Furthermore, the 2004, 2006 and 2013 HDRs [11] show that from 1990 to 2010, investment in research and development was very limited or non-existent. These difficulties and ineffective policies have not prevented Honduran academics and scientists from making contributions to the international literature. It is, therefore, necessary to consider incorporating new technologies and methods for promoting economic and scientific development which can translate directly into better social conditions.

Methods

Due to the lack of documentation on technological processes, it was necessary to review the official newspaper of the republic (called La Gaceta), which publishes laws and projects approved by the government. This survey started with the editions from 1980 until the year 2015. Few cases were found, only those where it was possible to obtain statistical information in national or international sources through reports from government or supranational agencies are cited in this paper. This survey was complemented with data from public information offices in the state agencies.

In the last forty years, Honduras required technical improvement and cooperating countries transferred technology to improve internal government processes, tax collection, infrastructure, health systems and living conditions, among others. These countries and agencies solved Honduras' technological divide by providing donations and grants, by improving investment conditions, and most notably, through the systematization and transfer of knowledge. Only two relevant technology transfer processes were found, and them are detailed below.

Tax Collection: Automated Vehicle Registration and the New Fiscal Regime

A clear intention to modernize the Honduran state came with the passing of the 1992 law Modernization

of the State of Honduras [20]. This law was directed towards systematic international technology transfer facilitating automation and management control by the acquisition and implementation of information technology. Between 1992 - 1999, the automation of vehicle registration was improved dramatically, reducing corruption and saving time. At the time of writing this article, the Honduran government was working on further updates to car registration systems. The main goal of this initiative is to improve management technology and collect more taxes [21–23].

One of the biggest cultural problems in Honduras is the corruption that occurs at many levels. The implementation of information technology during the 1990s increased the tax revenue associated with motor vehicles. These related to fees for importation, transfer, discharge and feature changes. Use of an automated system allowed the state to collect more revenue. Thus, car ownership was encouraged. This generated a huge amount of direct and indirect business, employment and marketing related to automotive good and services, thereby benefitting society.

Figure 1 shows the increase in registered motor vehicles from 2000 – 2013, which was approximately 10% per year. Twenty five years since the initial technology transfer, the number of registered vehicles increased nearly five-fold between 2000 and 2013. That is equivalent to one vehicle per eight people, which is a huge increase since the beginning of the 1990s, when there was one vehicle per fifty people [8].

The use of technology has also been successful for tax collection. This improved state revenues, and was formalized by Article 57 of Decree 17-2010, called the Enhancement Act of income, social equity and rationalization of public expenditure. With it, the government was trying to increase their control over tax collection by implementing a national electronic invoice system that recorded the fiscal details of business transactions. Using a computer network, each transaction that generated a tax impact could be monitored, and tax evasion minimized [24].

Transferred technology has given taxpayers a modern platform for improved tax services through maximization of safety, document recording and payment registration. In the words of the revenue office, the new invoicing regime is defined as "a dynamic body of law that supports economic events with tax transcendence, gives tax authorities control, and regulates the issuance or extension of tax documents". The tax authorities doubled revenues in terms of sales and income taxes. The technology was also intended to expand the number of registered taxpayers, including professionals and individual traders [22].

Telecommunications and Internet: HONDUTEL

At the end of the Twentieth Century, investment in telecommunications expansion and the installation of a submarine node provided internet access via submarine cables called the Americas Region Caribbean Ring System [25] and the MAYA Cable System [26]. This effort was conducted by the state communications company [10], which is a partial owner of this international asset and the sole national owner. This investment placed the entire country at the center of communications in the Latin American region and reduced the digital divide that existed at the time. These actions opened opportunities to private companies and government agencies and benefiting the whole population.

At the end of the first decade of the Twenty-first Century, Honduras was rapidly declining in technology indicators, as shown in recent HDR reports [12]. If we compare the growing population with the access to telecommunication services, we see a slowdown where technology is not keeping pace with the increasing population. After a decade of efforts to improve the country's indicators, there was no significant change, as shown in the HDRs of 2000, 2004 and 2013 [11]. As a consequence, and due to pressure to improve the telecommunications sector, the Government of Honduras signed and accepted the support of a United Nations Development Program (UNDP) of more than ten years that included financial assistance, systematic experience transfer and technological advice [27].

As shown in the first column of Table 1, there were only 0.02 internet users per thousand inhabitants in 1998, i.e., only 1 in 50000 Hondurans had access. Meanwhile, in 2002 and 2011, 25.2 and 111 per 50000 had access, respectively. The increase from 1998 to 2002 was higher than from 2002 to 2010, when it slowed down. It is noteworthy that over the years, internet access methods have changed and bandwidth has increased as a result of technological change.

The 2013 HDR [11] reported that 10 per 1000 inhabitants had access to a permanent, fixed connection (using a cable modem, ADSL or similar technology). These considerations were different in 2002, because the most common technology used to access the internet was dial up, in which the connection was made through a phone line using modems. Surprisingly, the information and indicators on technology access show an increase of millions of users of information technology and telecommunication services [9]. In our opinion, the actual official data is not precise, because it did not make any reference to procedures and standard methods used to measure the indicators. For these to be valid, they should have used internationally-accepted methods for collecting telecommunications

statistics [28]. However, the increase in user numbers is inversely proportional to the investment on telecom infrastructure reported at the same time.

If we observe government investment in technology at the end of the 1990s and beginning of the new millennium, it is clear that it directly affected the number of Hondurans using technology, from almost nothing to a relatively high number. It is important to mention the main devices used to access the internet at that time were personal computers (smartphones were not available at that time). Meanwhile, in 2010, the proliferation of mobile phones with internet capability was very common. This might actually have an effect on the statistics. However, we do not know the quality of mobile internet services provided to cell phone users because official reports do not mention it [29] and the data is quite confusing.

Telecommunications expansion is shown in Figure 2. Note the lower rate of phone line growth between 2006 and 2014. In these eight years that had no Honduran government investment, there was no favourable evolution. This contrasts with the very fast increase in land line numbers (with the latest technology) that occurred between 2001 and 2006. Comparing the map of 2006 with 2014, rural areas of Honduras had no improvement in access, which increased the technological divide. This did not happen in previous years. It is important to mention that the actual number of cell phone subscriptions is tending to fall [29].

Our previous statement coincides with the numbers of telephone lines (terrestrial and mobile) available in the country. In 1990 only 17 per 1000 inhabitants had access to a phone line, whereas in 1998 the number increased to 43, and by 2002 was 97 per 1000. By 2010, there were 1339 lines per 1000 people (i.e. more than one line per person) [8]. We observed that the growing number of telephone lines came after the investment in the submarine cable in 1998, and the associated national fiber system of the government telephone company, which boosted the deployment of Personal Communication System (PCS) technology [30].

The legislative decree 159-2003 [31] made possible the establishment of sub-operator companies for providing telephony services, taking advantage of the technology and infrastructure made available by the government at that time. Nowadays, the Honduran government has stopped investing in technological infrastructure and has not updated it. As a consequence, public income from this sector is decreasing. In contrast, private mobile operators have increased revenues to billions of US dollars per year. After unfavourable economic and social reports, the legislative decree 17-2010 was approved [24]. Five years later, there is no improvement or favourable situation [32]. Without government investment, the country is losing money and affecting the national budget which now has fewer resources for social needs. Figure 3 describes the profit evolution between 1989 - 2006, which coincides with the period of investment and higher profits. In the last ten years, profits have decreased so much that they have become losses. This happened when the state left the responsibility for investment and development to the private sector. It is evident that the government did not receive the same amount of taxes as was earned before with the state communications company. This model of private-public service providers did not have good results, due to the social, political and economic structure of the country. This needs to be reversed.

Technology transfer: A survey for opportunities with high performance computing (HPC)

For this section the methodology followed was to review budgets and investments in technology within the annual operational plans published by the government agencies in their websites, it was complemented with visits to their offices when the information was not clear. Subsequently, projects were sought in the universities and agencies of the cooperating countries that could be transferred and implemented in Honduras to streamline their activities and systematize those experiences in the academic and scientific community.

Academia and research

Subsequent to the fall of the Berlin Wall in 1989 (now called the globalization era) technology is a key element in the economic development of a country. Never before has it been so easy to make new structures that strengthen relationships between producers, distributors and customers [33]. At present, research and development plays a major role in the relations between industry and universities. These relationships are constantly increasing [34]. In the case of the Republic of Honduras, the UNAH - National Autonomous University of Honduras [35], a government owned and financed higher education institution, carries the responsibility of managing technology transfer efforts and providing business and government solutions by creating value and optimizing resources.

Since 2010, within the UNAH, a number of papers have been published on scientific applications requiring high performance computing, with encouraging results and modelling applications ranging from science [6] to multimedia-oriented applications [7]. As expected, new requirements and applications have been identified for HPC. That was the main reason for the signing of the 2013 agreement between the University Santiago de Compostela (USC) and the UNAH. This agreement

focused on HPC research and technology transfer for use with different processing needs [35,36].

Additionally, the UNAH established a biomedical imaging center [37] and a university hospital [38] in Tegucigalpa with state-of-the-art equipment, resulting in a growth in computational analysis and storage capacity linked to the storage of image files and related activities. A HPC infrastructure with applications in medical imaging is required, and the Honduran academia should propose solutions for use by the state in similar situations. Health scientists, in the short term, will need to process very complex datasets of diverse origin. For that, a technological solution is required. Also, the country is in need of a nationwide medical health reporting system. This could not only save lives, but also allow more efficient management.

An HPC infrastructure would aid the development of simulation and modeling technologies, due to the fact that they can exploit parallel computing on a massive scale. Numerical methods can be designed, and adapted via algorithms, to make use of HPC in any area of knowledge. In a short time, we will undergo the complexity revolution of BigData. Government and society will need to process a lot of information of different natures, which will require data-intensive applications running on high-end computers. Researchers resolve problems using scientific methods. With HPC, solutions to multiple phenomena can be obtained faster, because simulations and modeling can be conducted rapidly. In this way, innovation in Honduran industry can take advantage of HPC technology. If it is integrated into their workflows, optimized manufacturing processes and continuous improvement can be realized.

Public health services

One of the most important applications in national health is the possible use of HPC technology to increase rates of study of neurological diseases, especially cerebral small vessel disease [39], a common affliction of the Honduran population. For over twenty years, local scientists have published multiple papers on the genetics and epidemiology of epilepsy in Honduras [40–42]. Neurological research requires the processing of digital magnetic resonance images using computer-intensive applications (e.g. FreeSurfer [43]). In this field, high performance computing produces results more rapidly, and become a viable and useful alternative to existing solutions, this is of increasing importance due to the pandemic of zika, chikungunya and dengue that threaten the country.

Currently, the reform process in the health system requires the development of the Integrated Health Information System (SIIS) and a Health Information Sub-System (SICS), which should be linked to the development of new information, to allow in real time to connect patients, professionals and institutions, having access to large and timely volumes of data, which is a condition to establish an efficient, timely and successful health quality system; Which would take advantage of computing processing capabilities for prevention and diagnosis of patients. The statistical data available on SIIS could assist in the decision-making of policies and budgets. HPC will become a key technology to achieve the implementation of these initiatives.

Disaster prevention and better life conditions

The geographical location of the Republic of Honduras makes it particularly vulnerable to natural disasters and phenomena resulting from climate change [44]. It has recently installed weather radars in order to measure climate more accurately, but lacks the ability to process the large amounts of data that these devices generate. In contrast, other countries with better computers have better weather forecasting abilities [45–48]. If the government uses HPC to improve forecasts, the country would be better able to avoid economic losses due to climate change, and could plan agriculture more efficiently. Agricultural researchers can simulate land use with map servers and implement geographical information systems to aid farmers through modelling. Currently, the National Institute of Agriculture [49], does not have these solutions. They could develop models by using techniques that process images of crop fields [50], for example. As such, HPC is a key enabling technology for improving food production.

If the country population keeps increasing, so it is necessary to face new challenges in cities, especially those oriented with control vehicular and air traffic. The country is developing new roads and airports, and the management and planning of these are inefficient with current methods. An HPC solution could reduce accidents rates and loss of life by planning “intelligent” cities with more efficient traffic, water and security systems, etc.

E-government

Financial applications are another field where HPC can be very useful. Honduras has reached a critical point in government finances, where automation and computer applications (such as simulation tools, transaction records and database query optimization) have become solutions for reducing government operating costs, increasing efficiency and, in turn, benefiting ordinary citizens, and banking and tax collection operations. E-government initiatives such as the Open Government Partnership [51] could use a future HPC center to develop and deploy democratic and transparent

processes, taking as a reference the solutions implemented in Estonia [52]. A sample application is electronic voting, which has been shown to be a fast, cost-effective and reliable tool for democracy, especially in the implementation of participatory democracy [53] with the benefit of auditing.

Likewise, cyber security is a worldwide concern. In the past few months, some government internet portals suffered various kinds of attacks, yet no official reports were made, and one can only gain the information presented in newspapers [54, 55], without any further prevention or analysis. The HPC can help to develop a system to secure the digital world of citizens and government agencies, and help to develop a national certification agency and security standards.

Conclusions

After reviewing the technological evolution of a third world country, we showed how technology transfer initiatives have helped Honduras to boost several national processes, especially those directed by the public sector. In this way, benefits are observed at main area application with trickle-down effects to other needs. Government and private business increased revenue due to technology, but most importantly, citizens also benefited in numerous ways.

Social welfare in poor countries largely depends on the role of their governments. Because of socio-economic differences among the population, privatization processes does not improve the distribution of wealth or improve governance. Information technologies, with the participation of academics, provide an alternative for customizing solutions to problems affecting undeveloped countries. Broadly, this article has shown that the effective participation of the state provides better income, which can be used to satisfy the lack of resources in social services. A high-performance computing infrastructure would provide the necessary efficiency to reduce costs and increase the profitability of state activities. This would improve their accessibility for the general population and develop science-based, medium-term solutions for improving the lives of the population.

When Honduran government does not invest in the technology sector, a lag is generated. This is especially clear in the access and implementation of new technology platforms that could help in business management and other productive activities. To reduce technological divide, our proposed solution is the development of High Performance Computing (HPC) infrastructure. This platform will assist scientific and technological development, with positive impacts such as the promotion of an electronic government, and improved healthcare, research and public administration. Other applications could include research in the fields of global warming, climate forecasting, agriculture, land management, medical data processing, education, cyber security, and much more. HPC will provide infrastructure, platforms and applications as service through wide area networking like Internet.

We see the actual problematic social situation of Honduras as a great opportunity. Academia has a chance to apply knowledge for development. This could be done by using research and technology to invigorate weak institutions. We support this conclusion after comparing the profits and losses of national public service companies and the tax department. Ultimately, improving government revenues will allow greater social welfare. For us, core elements of a system that could meet various needs of the state mentioned above are summarized in Figure 4.

At this point, we highlight that technology transfer efforts represent opportunities and advantages for Honduras. As a consequence, an infrastructure for high performance computing can offer to this Central American nation a great way to promote technological and scientific advancement by processing large volumes of data with high computational power. Within the paradigm of cloud computing and its replicability, HPC architecture can be quickly deployed through multiple institutions without specialized technical skills on the final user side. It will assist in the implementation of a digital government and a unified information management system for decision-making processes.

In near future, creation of a center for research and development that includes High Performance Computing (HPC), under the control of the Honduran academia, would be a cornerstone for economic welfare. It would be possible to help the population through more efficient and economical services due to automation and ubiquity of access. We conclude that social and technological changes must go hand-in-hand to achieve comprehensive development. The role of the central government in Honduras is crucial, especially with relation to research and development. An efficient administration with good decision-making capabilities can achieve rapid and effective change for the nation.

Competing interests

The authors declare that they have no competing interests.

Author's contributions

IZ and FGF conceived the objectives and methodology to conduct the research, they performed it and supported the analysis. AGL, MTM, EH, VLR worked together to provide support for the interpretation of results obtained from technology transfer processes. All authors contributed with important observations to technically improve the presentation of the work. Also, all authors reviewed the final version of paper and agreed with its submission to the Journal of the Brazilian Computer Society...

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Figures

Figure 1 Honduran vehicle registrations, 2000 - 2013 [8]

Figure 2 Regional increases in Honduran fixed phone lines, 1996 - 2014 [8]

Figure 3 Profit of the Honduran national phone company, Hondutel, 1989 - 2013 [8]

Figure 4 Proposed location of HPC services in the Honduras Government.

Tables

Table 1 Internet users and telephone lines per capita, 1990 - 2010 [8] [11].

Year	Number of Internet Users (per 1000 people)	Telephone Lines Mobile and Fixed (per 1000 people)	Honduran Population (in millions)
2010	111.00	133.90	8.1
2002	25.20	97.00	6.5
1998	0.02	43.00	5.9
1990	0.00	17.00	4.9