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APPLICATIONS OF UBIQUITOUS TECHNOLOGIES TO INFORMAL URBAN SETTLEMENTS AND ENTREPRENEURIAL DEVELOPMENT IN INFORMAL ECONOMIES: CASE STUDY OF MEXICO CITY METROPOLITAN AREA

Maria Elena Labastida Tovar,[1] Euel Elliott,[2] Rodrigo Reyes Greco[3]
[1 & 2]University of Texas at Dallas
School of Economic, Political and Policy Sciences
University of Texas at Dallas
Dallas, Texas 79409-1021, USA

[3]Architectural, Drafting Design and 3-D Renderings
Richardson, Texas 75080, USA

ABSTRACT

Ubiquitous, or massively distributed sensing technologies, offer great potential for dealing with an array of societal problems. Potential applications as discussed at the 2010 Society for Design and Process Science conference include applications in diverse areas ranging from health care and related health reform issues, crime and policing, and environmental and climatological monitoring. This paper addresses possible applications to the enhancement of urban ecologies. Specifically, the authors examine the usefulness of sensing technologies consistent with the Hewlett-Packard CeNSE (Central Nervous System for the Earth) proposal. We demonstrate in general terms how a massively distributed network could be deployed in order to design more effective strategies for addressing the endemic problem of informal urban settlements in megalopolises of developing countries. Furthermore, we believe this technology can be employed to provide the tools to urban entrepreneurship in a manner that optimizes capital formation and allows for the development of successful entrepreneurial growth strategies. We develop a case study of Mexico City, and propose a simple model of distributed networks that seek to accomplish the goals noted above. Extensions of the model to other urban settings, as well as possible caveats, are explored.

INTRODUCTION

Within the past few years it has become evident that many new technologies possessing the potential to affect dramatic change in our world are about to be deployed. These new technologies have the capability of re-shaping our economies and societies as profoundly as the computer and the Internet.[1] One such technology, or perhaps more accurately, ensemble of related technologies, are tiny ubiquitous, autonomous sensing systems that can be deployed on a global scale.

This paper considers potential applications of these massively distributed sensor networks to issues relating to informal urban development, economic growth and entrepreneurship in informal economies. It begins with a brief, relatively non-technical discussion of those technologies, and follows with an examination of the application of such technologies to one extremely large and dense urban area, Mexico City. The paper concludes with some final observations about the role these technologies may play in the twentieth first century urban settings. We hope that this paper will provide the initial foundations for the construction of field experiments that would allow for the implementation and evaluation of our proposals, with the aim of refining more developed models of sensor deployment and subsequent maximum exploitation of relevant data in an urban development and entrepreneurial context.

Ubiquitous Sensing Technologies

Hewlett-Packard has recently announced the launch of a major new initiative, known as the CeNSE project. CeNSE, or "Central Nervous System for Earth" represents a massive commitment on the part of this company to deploy up to a trillion tiny, pushpin-size sensors around the globe (see figure 1). These sensors would have the ability to collect and transmit data on numerous characteristics of the surrounding

[1] Biotechnology and nanotechnological systems are just two such examples.

physical environment, and transmit data to computers for analysis and interpretation (Khan et al. 1999; Gfeller & Hirt 1998; Goodman 1997; Hsu et al. 1998; Williams et al. 2005; Park et al. 2009).

CeNSE is not the only "blanket" or "ubiquitous" sensing arrangement that is being considered. A different sensor platform suggested by some researchers is the cell phone (Paulos et al. 2007; Balandina & Trossen 2006; Nath et al. 2006). Cell phones are growing in capability on a yearly basis, and have the advantage of mobility. A few billion cell phones incorporating appropriate sensor technology might be able to accomplish the same results as stationary, but far more numerous sensors similar to the HP platform. Others are conducting research into so-called "smart dust", cubic-millimeter size motes that will perform similar functions (Warneke et al. 2001; Buettner et al. 2008). We are agnostic about the advantages and disadvantages of the various platforms that may become available in the next few years, but for the purposes of this paper we assume a technology similar although not necessarily identical to that being developed by HP as part of its CeNSE initiative. Moreover, for our specific purposes, the stationary character of the sensors may yield important advantages.

We assume that any such platform would have the capability of monitoring variables such as humidity, temperature, barometric pressure, wind velocity and direction, seismic vibrations and other environmental characteristics. One important feature would be to determine the acceleration of an object with 1000 times the sensitivity of the technology found in the Nintendo Wii. Such sensor capability could provide critical information on the speed and rate of acceleration of objects in the nearby environment, such as automobiles on a highway (Fischetti 2010). Other potential uses of appropriately designed sensors would include monitoring of seismic activity, or the presence of chemical or biological agents. With regard to the latter, it may be possible to use this new sensor technology to better understand the presence of diverse disease vectors and the existence of pathogens in the environment. In principle, however, there are few limits to the kinds of conditions that can be monitored (Warneke et al. 2001).

There are numerous technical and methodological concerns that must be addressed prior to manufacturing, and, deploying a trillion devices, which will not be costless, even assuming massive economies of scale. Once deployed, the problem of actually interpreting data from these devices and analyzing the data so that it makes sense, i.e. being able to separate "noise" from "signal", as well as having the capability of organizing the enormous amounts of data into useful categories, will be an enormous challenge. (Sutharasan et al. 2008; Rhee, et al. 2008; Sanfeliu et al. 2010). Also, as a practical matter, troubling legal and ethical concerns involving the right to privacy, property rights and the potential for such technologies to be misused are certain to be prominent as those technologies advance in their developments.

We will not concern ourselves in this paper with these issues except to the extent they might directly impact our arguments and such issues will certainly be addressed in other venues. Our contribution is directed toward public policy and related issues involving the development of this technology. Specifically, we explore the role of ubiquitous sensing in an urban environment. Urban ecologies provide an enormously rich source of data from the physical and human environment that can be mined and analyzed for purposes of improving the urban landscape from a physical, economic and aesthetic perspective.

Massively distributed sensor technologies are likely to prove useful in an array of applications, as is shown by other papers presented in this Conference. One study by Morris (2010) explored applications to crime reduction in various urban settings with important implications discussed for public policy. Loganathan's paper (2010), entitled "Healthcare on Autopilot" suggests that wireless sensor networks, possibly connected to agent-based intelligence systems as well as existing legacy systems, have the potential to fully automate many healthcare tasks that usually require human intervention. Thus, these technologies clearly have the potential to affect radical changes in health care delivery and costs. Chandrasekar et al.'s (2010) research focuses on our ability to observe, understand, predict and respond to hazardous weather events. These abilities are discussed in the context of CASA (Collaborative Adaptive Sensing in the Atmosphere) using an innovative sensing paradigm known as DCAS (Distributive Collaborative Adaptive Sensing). Their research explores applications related to radically different spatial and temporal scales, ranging from tornadoes that relatively are of small scale and extremely brief duration to hurricanes and cyclones that can develop over several days and take place over large geographic spaces.

BASIC TECHNOLOGICAL CAPABILITIES AND ASSUMPTIONS

Since we do not know precisely what the capabilities of the sensors' technology are, or might be, we have to engage in some degree of speculation regarding on what might be practical to accomplish over the next few years. However, we believe most of our assumptions are well within the technological parameters and capabilities of the various systems being discussed by HP and others. We begin with the basic assumption that 1) the sensors can be deployed over a relatively large geographic space. As in the case of Mexico City, we expect the relevant project area will be about 1.3 sq km (0.50 sq ml). 2) We assume that large numbers of sensors (around 13,000) could be available for measurement use. Of course, the capabilities of the system will vary depending upon the density of the deployment, which will depend on cost and the practical ability to analyze and utilize the data received in an effective manner. 3) We assume that routine problems of sensor degradation and failure, and the likely need to upgrade systems over time, are carried out by project managers.

Installation and Distribution of the Sensors

Sensors will be distributed over a geographical space and installed individually on every lot frontage (street level measurement) to provide information to be relevant to a specific physical location without movement. We do not believe is possible to distribute sensors by deploying tiny airborne objects due to variables such as climate conditions. This would cause sensors to be improperly and unevenly distributed, resulting in potentially erroneous data. Similar to other geographical information systems, data would be collected through aerial-satellite digital photography, alongside actual surveys and related statistics to create the most accurate and up-to-date information. Thus, for the purposes of the research outline of this paper, the sensors must be physically stable to accurately measure relevant variables. Thus, is noted earlier, the HP platform or something similar has important advantages.

A geographical space would be divided on a framework grid of approximately 10,000 sq mts. (2.47 acres) to be considered as a working cell. This cell will host around 100 censors. An average lot frontage in irregular urban settlements is around 10 meters (32 feet) and the proposed distribution would be 1 sensor per area of 10 x 10 meters = 100 sq mts (1076 sq ft). In this case study the existing total area is approximately 1.3 sq km (0.50 sq ml) and it will require around 13,000 sensors to be installed on lot frontages. Overall, the Mexico City metro area (9,560 sq kms / 3,691 sq mi) would require around 95.6 millions of censors to be distributed.[2]

Monitored Variables

Once sensors are in place, the most common and straightforward variables to measure are certain environmental factors such as climate, temperature, natural resources and topography. This last factor triggers other variables such as existing water usage and discharge, natural reservoirs contamination, existing irregular construction over flood zone areas and other restricted easements for government use. The sensors will also monitor pollution, density, materials, utilities, traffic, zoning, land and buildings use. These variables are key players in determining the possible existence of informal economies in specific areas of the settlement.

Data Collection and Analysis

The sensors will capture the overall existing conditions of an informal settlement to provide enough information to model the growth and avoid future negative consequences. The sensors will be able to capture through analyses of materials how settlements have been evolving over time. They will analyze when certain materials were installed in place, such as street pavement, utilities and basic building structures. This data will allow progressive growth in the past and calculate future development. Sensors will also be able to understand the land and building use by the type of activities, energy consumption, human density, temperature and other use of urban utilities. Using all these data and interfacing with a computer modeling system, the application will be able to predict future growth and trends for land use such as informal commercial zoning. With this valuable information, urban planners will be able to predict, adjust, and mitigate the term "informal" in order to give a different direction to future growth. It will help policy makers to maximizing the beneficial impact of streamlined and low cost regulatory initiatives.[3]

This system will also have a positive impact regarding natural resources and sustainable development due to the fact that adjustments to growth will not disturb natural resources as well as topographical areas such as flood plains. We have witnessed in the media how poor neighborhoods and informal settlements in developing countries are subject to natural disasters such as landslides and flooding.[4] By collecting and analyzing appropriate data, it will be possible to predict future growth, and settlers' lives can be better integrated with the natural and social environment.

AN APPLICATION OF UBIQUITOUS TECHNOLOGIES TO INFORMAL URBAN SETTLEMENTS AND ENTREPRENEURIAL DEVELOPMENT IN INFORMAL ECONOMIES:

[2] If we were to cover the land area of the earth following this same model, the number of sensors needed would be around 1.4 trillion.

[3] Informal work arrangements are a rational response by micro-entrepreneurs to over-regulation by government bureaucracies.

[4] Some recent examples in the Mexico City metro area are Chalco's floodings on February 2010 and Iztapalapa's landslide on January 2009.

CASE STUDY OF MEXICO CITY METROPOLITAN AREA

A Case Study: Mexico City Metropolitan Area

This study looks at two related potential applications of CeNSE or related technologies; first, the problem of informal settlement and growth particular as it applies to developing countries. A related area of analysis is the application of CeNSE to the development of informal economic sectors where, in some countries, up to 60% of the labor force is deployed. (Alderslade et al. 2006).

The Mexico City Metropolitan Area is constituted by the Federal District -itself composed of 16 areas- and 41 adjacent municipalities of the states of Mexico and Hidalgo. Mexico City Metropolitan Area is ranked as the third largest metropolitan area in the world and the most densely inhabited metropolitan area in the Americas. Figure 2 shows the population growth trend from 2005 to 2030.

During the period 1980 to 2000, the Mexico City Metropolitan Area economy exhibited a dramatic shift from manufacturing to the service sector, with a latter by the year 2000 employing close to 70 percent of the economically active population in the conurbation. The Metropolitan Area of Mexico City's main industries are now related to trade, financial services, insurance companies, telecommunications, information technology and transportation. Despite the shifts in economic production and the decentralization of the economic activity promoted by the government, Mexico City's Metropolitan Area share of total economic activity in the country is still high: they alone produce 29 percent of the nation's Gross Domestic Product. (Montaño Salazar 2006).

Ubiquitous Sensoring to Informal Urban Settlements in Mexico City Metropolitan Area

The framework developed in this paper is designed to provide decision-makers with the tools to predict, based upon population and other changes in urban geography, the necessary public improvements such as utilities, zoning and the like for successful future urban development. Informal settlements have developed for decades in the outer skirts of Mexico City metro area, out of the City limits and in areas that were not planned for low-income housing (see figure 3). The local and federal government never predicted such growth to be in the millions of families that migrated from other States to find better work opportunities. According to some local regulations if inhabitants live on a piece of land for more than five years and there is no claim against those new settlers, then the government has the responsibility to provide public improvements and utilities to those inhabitants. It has been politicians' responsibility (especially in electoral times) to provide public utilities and urban improvements for those families, with a lack of financial resources never considered in their development budget.

Today, and after providing no better than mediocre improvements in a somewhat haphazard manner, and with each case treated differently, governments are still facing informal and unaffordable urban growth due to a factor that they cannot stop: migration. Moreover, migration occurs also inside of those informal settlements to the inner city areas as these families succeed in their economic goals.

There have been government efforts to regulate and register property rights of the majority of the informal lots and housing in order to have public records for the most part to collect property taxes. The effort is valid, especially if governments are responsible for providing improvements for their communities. But the slow pace of surveying thousands of square miles and documenting every dwelling has not been enough because growth and changes are continual. Digital satellite photography has helped to be more efficient, but still it has to be updated regularly and it does not show a pattern or trend of development (see figures 4 and 5).

Ubiquitous Sensoring to Entrepreneurial Development in Informal Economies in Mexico City Metropolitan Area

The *informal sector* refers to the economic activity that is neither taxed nor monitored by a government; and is not included in that government's Gross National Product (GNP) as opposed to a formal economy. The informal economy is often associated with developing countries - where up to 60% of the labor force (with as much 40% of GDP) works (see figure 6). Given the complexity of the phenomenon, the simplest definition of informal economic activity might be: any exchange of goods or services involving economic value in which the act escapes regulation of similar such acts. Figures 7 and 8 show representations of informal economy trade activities in Mexico City Metropolitan Area.

Informal economic activity is a dynamic process, which includes many aspects of economic and social theory including exchange, regulation, and enforcement. By its nature, it is necessarily difficult to observe, study, define, and measure. No single source readily or authoritatively defines the informal economy as a unit of study. There is a vast literature on different methodologies to measure the "informal economy". Measuring the informal economy has been a thorny task among statisticians and economists. Different methodologies have been developed not without caveats and criticisms.[5]

Johnson et al. (1998) findings show that smaller informal economies appear in countries with higher tax revenues that will tend to dissolve if enterprises are face with lower tax rates, fewer laws and regulations and thus, less bribery. Countries with a better rule of the law, which is financed by tax revenues, also have smaller informal economies.

According to Schneider's (2002) overall conclusion, "wealthier countries of the OECD, as well as some in Eastern Europe find themselves in the "good equilibrium" of relatively low tax and regulatory burden, sizeable revenue mobilization, good rule of law and corruption control, and [relatively] small unofficial economy. By contrast, a number of countries in Latin American and the Former Soviet Union exhibit characteristics consistent with a "bad equilibrium: tax and regulatory discretion and burden on the firm is high, the rule of law is weak, and there is a high incidence of bribery and a relatively high share of activities in the unofficial economy." (Johnson et al. 1998).

According to the Organization for Economic Cooperation and Development "Informal workers in developing countries make up more than half the workforce. They receive low wages and no formal contracts or benefits, yet often represent the most dynamic part of the economy. The likely surge of informal jobs due to the economic crisis makes the management of informal employment even more challenging and topical. Responding to this emerging challenge is critical, not only for the well-being of millions of workers but also for sustainable development."[6] It is in the dynamic informal economy where entrepreneurs emerge as part of spontaneous orders -in Hayekian terms-[7] as a result of inefficient regulations that governments are unable to enforce, tax burdens, taxpayers' attitudes toward the state, restrictions on the labor market, bad quality of government institutions and over-taxation. An increase in the size of the informal sector harms growth by preventing capital accumulation and the efficient use of public and private resources.

Muhammad Yunus, Managing Director of Grammen Bank and recipient of the Nobel prize in 2006 for successfully implementing a system of microcredit in Bangladesh, categorically asserts: "all human beings are entrepreneurs… the seeds of poverty are embedded in the deficiencies of our institutions, policies and concepts." (Yunus 2009, 127). Informal economies proliferate in every country because people are natural entrepreneurs ready to sell their goods and services where they are needed. Entrepreneurs in the informal economy face obstacles similar to those experienced by entrepreneurs in the formal economy. However, informal entrepreneurs are more vulnerable in relation to these problems. Some of those relate to infrastructure, institutions and economics. One of the applications of the ubiquitous sensoring devices will be to capture data that will assist to policy-makers, government administrators and urban planners to address some of the problems faced by entrepreneurs in informal economies.

Distributed sensors networks will capture information about unofficial and deficient physical infrastructures such as transport, storage facilities, water, electricity, gas, and sewage supply among others. Once these data are captured, institutional and other obstacles like the following can be overcome: limited access to land and property rights, limited access to formal finance and banking institutions and the reliance on self-supporting and informal institutional arrangements, too restrictive or cumbersome taxation systems and labor laws, excessive government regulations in areas such as business start-up, time demanding and costly procedures for business registration, limited access to employers´ organizations (therefore limited possibilities to exercise influence), lack of access to official social security schemes, lack of information on prices, viability of products, etc.

The underprovided physical infrastructure in informal urban settlements result in faulty institutional infrastructure, which brings as a consequence subsistence markets where entrepreneurial effort is wasted and wealth is not accumulated. Excessive registration and transaction costs of starting or operating businesses, limited access to technology, lack of opportunities for bulk purchase of inputs, lack of working capital (credit has to be obtained from informal sources such as friends or relatives or non-banking financial agencies with unfavorable terms) and insufficient funds that do not allow for further investments, among others, result in low incomes and/or lack of regular income as household consumption competes for the use of business earnings. This is a constant for entrepreneurial activity in informal economies.

The sensors will capture data through time about the development of physical infrastructure, housing and informal markets areas that will serve to anticipate the growth of the informal urban settlements.

[5] See for example Frey and Pommerehne (1984); Thomas (1992); Loayza (1996); Pozo (1996); Schneider and Enste (2000) and Schneider (2002).

[6] "Is Informal Normal? Towards More and Better Jobs in Developing Countries" (2009) OECD provides evidence for policy makers on how to deal with this issue and promote more and better jobs for all.

[7] Spontaneous order is the spontaneous emergence of order out of seeming chaos; the emergence of various kinds of social order from a combination of self-interested individuals who are not intentionally trying to create order. The evolution of life on Earth, language, the universe and a free market economy have all been proposed as examples of systems, which evolved through spontaneous order. See Friedrich A. Hayek (1947).

The information captured by the sensors' network about the forecast of new informal urban settlements growth and the increasing of informal economies will serve to recast public policies for starting up of businesses, banking, tax systems, labor regulations and thus, ex-ante allowing spontaneous markets to accommodate in an advantageous framework that will allow them to spontaneously generate and increase wealth rather than only use the small wealth created for subsistence.

In developing countries such as Mexico, there are heavy regulations that induce tax evasion and delays and higher costs for public services and thus incapability of the local governments to provide them. With the use of the sensors the objective is to provide local governments with a state of the art technology that will serve as a tool to forecast the next stage of the growth of urban settlements and the efficient regulations needed to allow entrepreneurship expanding in a profitable fashion. Micro enterprises can become effective creators of employment, innovation, income and growth. However, micro enterprises do not for the most part, realize their full potential because they lack access to markets, finance, technology and business skills. Production is becoming increasingly knowledge-based and entrepreneurs therefore need to become innovative and to develop an extensive knowledge of markets and technology. If some major obstacles to economic growth can be overcome thanks to the use of the sensors network technology (such as strategically planned physical infrastructure and adequate institutions such as a flat tax system, easy registry of property rights, streamlined regulations for starting up a business and access to credit for micro-enterprises), then, entrepreneurial activity will be unleashed in a way that will naturally create prosperity. Developing countries have more difficulty in enforcing regulations, which in general are heavier than in developed countries. However, proper legal frameworks as Hernando De Soto argues will recognize the assets of the informal economy and create a system of protecting and giving value to the property of the poor so they can access capital from financial institutions. (De Soto 2000).

APPLICATIONS OF UBIQUITOUS TECHNOLOGIES TO INFORMAL URBAN SETTLEMENTS AND ENTREPRENEURIAL DEVELOPMENT IN INFORMAL ECONOMIES THROUGH COMPUTER SIMULATION

The basic assumption of this study is that massively distributed sensor technologies will be able to predict the growth of informal settlements and create basic models for other studies in developing countries. Once the sensors are sending data to a central system, the information obtained will first capture actual overall characteristics already discussed in the paper. This information will be valuable to determine and model future expansions and predict the necessities to avoid the negative consequences from the past. As an example we can focus on urban utilities, zoning and land use. Once in place and fully functional, the computer application has already modeled future growth, depending on the number of settlers. The model has also predicted the cost of future planning and advice local governments of the results, so that they can be prepared to face new migration.

Let us assume that a large number of migrant settlers have acquired an area next to an existing informal settlement with ubiquitous technologies already in place. Using the number of new settlers estimated by the sensors, land planning and the provision of utilities could be calculated to avoid new structures in the path of natural resources. It will also calculate the areas for specific land use to avoid anarchic urban settlements. This process is indicated in schematic form in figure 9.

The computer system will search through its modeling database. Then it will calculate, design and create a recommendation to local government agencies, environmental and engineering departments the characteristics to provide prepared growth. The goal of sensing technologies is also to capture real time conditions so any density or land use modification will be captured immediately. Of course, this paper is only the first step in developing a full-fledge model of urban informal development and entrepreneurship in informal economies. Such a more developed model would provide a richness of context that cannot exist in a conference demonstration.

EXTENSIONS OF THE TECHNOLOGY TO OTHER SETTINGS: EXAMPLE BRAZIL

The term that refers to extreme poverty populations settled down on irregular urban settlements with informal economies in Brazil is called "favela," which in Portuguese means *slum* (see figure 10). Favelas dated back to the late eighteenth century, where the first settlements were called *bairros africanos* (African neighborhoods), and they were the place where former slaves with no land ownership and no options for work lived. Today, favelas are still a remarkable cultural, social (crime and drugs issues) and economic (informal economies and entrepreneurship) phenomenon. Despite the attempts to improve population in favelas in Brazil's major cities like Rio de Janeiro and São Paulo, the poor population is continuing to grow at a rapid pace as well as the modern favelas that house them.

The explosive growth of favelas has triggered at various times, government removal campaigns. A program in the 1940s called Parque Proletário destroyed the original homes of those dwelling in favelas in Rio and relocated them to temporary housing as they waited for the building of public housing. Eventually little public housing was built and the land that was cleared for it just became reoccupied with new settlements of favela dwellers. Removal programs of the favelas flourished once again in the 1970s under the military dictatorship, disguised as a government-housing program for the poor. What really happened was that more favelas were eliminated and their residents were displaced to urban territory lacking basic infrastructure.

The application of a new technology to predict the growth of population and the requirements of new urban settlements has great potential. As in the case study of Mexico City discussed earlier, many metropolitan areas in emerging economies such as Soweto in South Africa, Manila in the Philippines, Calcutta in India, Cairo in Egypt or Lagos in Nigeria (to name a few), Rio de Janeiro and São Paulo metropolitan areas account for large extensions of urban irregular settlements as well as for a substantial percentage of informal economy.

Akin to the above argument, entrepreneurship can be channeled through the formal economy if this helps entrepreneurs to create and accumulate wealth and have better lives. However, the creation of incentives for allowing entrepreneurs to spontaneously shift from the informal to the formal sectors of the economy require the necessary condition of developing an institutional infrastructure. Not only a better urban organization through the prediction of population growth and economic development is needed but also the appropriate regulations that can stimulate micro and small entrepreneurs to take the leap. Table 1 shows instances of such regulations. First, the Organization for Economic Cooperation and Development (OECD) members' average time to start a business in terms of the number of procedures is 5.7 days whereas in Mexico City is 9, in Monterrey 7, in Brazil 16 and in Latin American and the Caribbean countries together 9.5. Another example is the regulation on the number of days that it takes to obtain a construction permit. The OECD average in this area is 157, for the Latin American and Caribbean countries' average the figure represents 225, in Brazil, 411, in Mexico City, 138, and in Monterrey only 83 days. A final example is the cost with which businesses have to deal to register property rights in Monterrey represents 3.5, in Mexico City 4.8, in Brazil 2.7, in Latin America 5.9 and in the OECD the average is 4.6.

CONCLUSIONS, CAVEATS AND RECOMMENDATIONS

CeNSE and related systems represent an ensemble of promising technologies that have the potential to be of used in a broader of private as well as public endeavors. As we noted earlier, some of these applications include climatology monitoring, health care, and an array of issues related to criminal justice and other applications. Our contribution is to examine an application of distributed sensor networks to urban development, informal urban settlements and the informal entrepreneurial economy in emerging economies. We believe these technologies have the potential to substantially alter the current mediocre or non existence provision of services ranging from banking and finance to an array of public services including sewage, electricity, water supply and other services. Into facilitate the transition from informal subsistence economies to more formal systems of networks where wealth accumulation can take place. The tentative framework developed in this paper can hopefully be expanded into a more fully developed model for improving urban life and urban and economic ecosystems in a wide array of geographical and social settings. Indeed, we hope that, through follow up research, to develop a set of field experiments that would allow us to test this new technology in complex urban settings.

Of course, these technologies are subject to numerous potential caveats, which we have not addressed in this paper. One is the issue of privacy that will surely require additional exploration if our proposed research effort is to proceed. A second, related issue is that of property rights. For example, what kind of access can be obtained to individuals and businesses private property? For that matter what problems of access to public lands may arise? Would be there resistance, organized otherwise to such these efforts to deploy these technologies? A third, somewhat more mundane, involves the need to develop sufficient redundancies in order to mitigate forecasting failure and consequently to minimize the likelihood of improper policy recommendations. There are also certain to be important methodological and related technical issues ranging from sensor failure that may produce forecasting failures, and the need to develop data based management and statistical analyses systems capable of sorting out environmental "noise" from crucial environmental "signals". Regardless of theses concerns, this paper hopefully provides an introductory road map for the exploitation of a technology that may have profound effects on all our lives in the years and decades to come.

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FIGURES AND TABLES

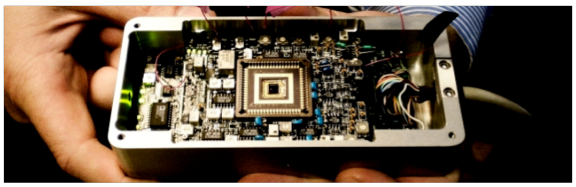

Figure 1. HP Labs senior researcher Peter Hartwell holds a prototype of a sensor network node incorporating the new MEMS accelerometer from HP. The first to be deployed as part of HP Labs’ Central Nervous System for Earth (CeNSE), it is about 1,000 times more sensitive than today’s mass-produced devices. Photo: Margie Wylie.

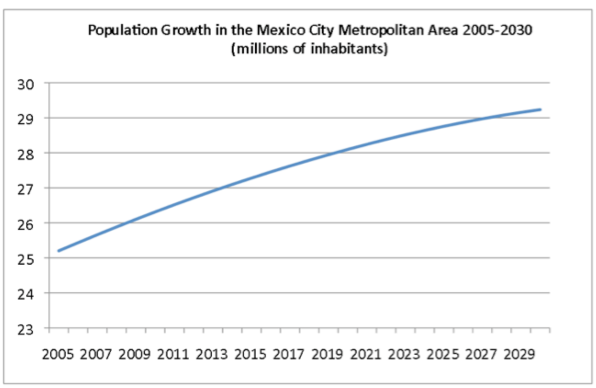

Figure 2. Population Growth in the Mexico City Metropolitan Area. Source: Mexican National Institute of Statistics, Geography and Information.

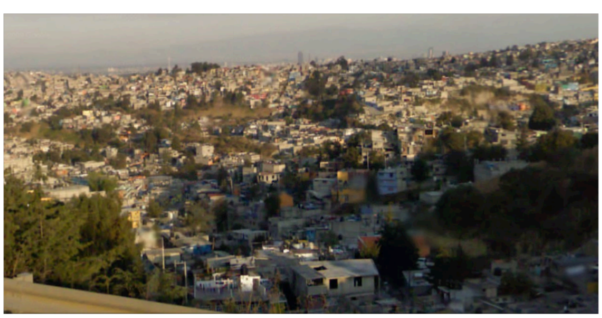

Figure 3. Picture of a typical informal urban settlement in Mexico City. Source: Google Earth.

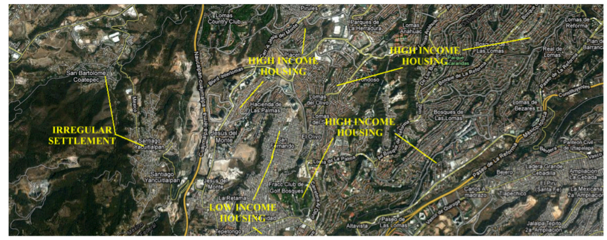

Figure 4. Typical informal urban settlements in Mexico City. Source: Google maps.

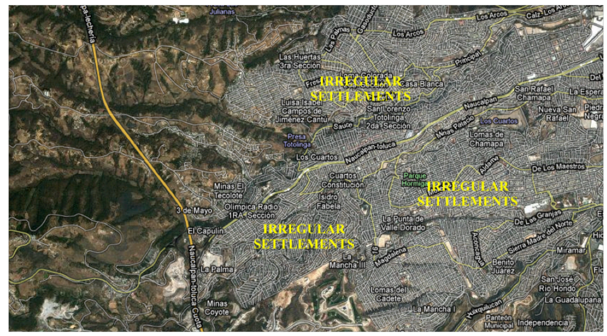

Figure 5. Typical informal urban settlements in Mexico City. Source: Google maps.

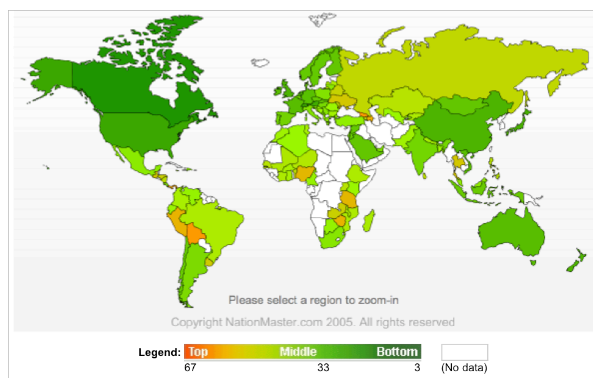

Figure 6. Informal Economy by Country.
Source: nationmaster.com

Figure 7. Example of Informal Economy in Mexico City Metropolitan Area.

Figure 8. Aerial Views of Informal Economies Trade Areas. Source: Google Earth.

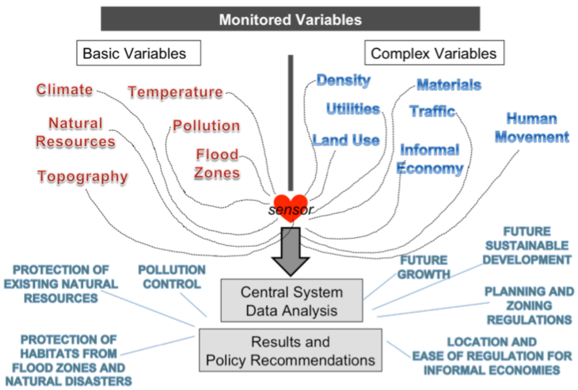

Figure 9. Schematic form of sensor measurement of variables and capabilities for public policymaking.

Figure 10. A Favela in Rio de Janeiro. Source: Wikipedia.

Table 1. "Regulations and Institutional Infrastructure".

Starting a business: The challenges of launching a business are shown below. Included are: the number of steps entrepreneurs can expect to go through to launch, the time it takes on average, and the cost and minimum capital required as a percentage of gross national income (GNI) per capita.

Indicator	Mexico City	Monterrey	Brazil	Latin America and Caribbean	OECD Average
Procedures (number)	9	7	16	9.5	5.7
Time (days)	28	19	120	61.7	13.0
Cost (% of income per capita)	12.5	15.7	6.9	36.6	4.7
Min. capital (% of income per capita)	11	11	0.0	2.9	15.5

Dealing with Construction Permits: Shown below are the procedures, time, and costs to build a warehouse, including obtaining necessary licenses and permits, completing required notifications and inspections, and obtaining utility connections.

Indicator	Mexico City	Monterrey	Brazil	Latin America and Caribbean	OECD Average
Procedures (number)	12	13	18	16.7	15.1
Time (days)	138	83	411	225.0	157.0
Cost (% of income per capita)	131.0	33.6	50.6	210.8	56.1

Registering Property: The ease with which businesses can secure rights to property is shown below. Included are the number of steps, time, and cost involved in registering property.

Indicator	Mexico City	Monterrey	Brazil	Latin America and Caribbean	OECD Average
Procedures (number)	5	6	14	6.8	4.7
Time (days)	74	28	42	70.4	25.0
Cost (% of property value	4.8	3.5	2.7	5.9	4.6

Enforcing Contracts: The ease or difficulty of enforcing commercial contracts is measured below. This is determined by following the evolution of a payment dispute and tracking the time, cost, and number of procedures involved from the moment a plaintiff files the lawsuit until actual payment.

Indicator	Mexico City	Monterrey	Brazil	Latin America and Caribbean	OECD Average
Procedures (number)	38	38	45	39.7	30.6
Time (days)	415	256	616	707.0	462.4
Cost (% of claim)	32	33.4	16.5	31.3	19.2

Source: Doing Business, World Bank, 2009.