Telephone traffic in remote rural areas: The case of Gilat satellite network in Peru

Guy Shachar

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Supervised by: Prof. Aharon Kellerman

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Abstract

A satellite telephone system installed by Gilat has been operational in Peru since 2001, serving thousands of rural communities throughout this vast country. The issue of communications technologies infrastructure and development of rural areas was previously studied. Findings from those studies do not imply for an obvious correlation between provision of telecommunications means and socio-economic development, and rather claim that implementation of such technologies may support such development and should be complemented by additional actions. In this quantitative study, traffic data from the Peru network were obtained and analyzed by various criteria. Findings from the analyses revealed characteristics of the network usage by the villagers. These characteristics include the evolution of telephone usage over time after it was installed in the village, nature of phones usage along the day and the week, characteristics of international calls, and spatial features concerning interactions among rural communities, between rural and urban locations, and differences in traffic characteristics among various areas in Peru. Findings provide evidence to the importance of phones usage for maintaining connections among people in Peru and with Peruvians who live abroad, and emphasize the significance of communications for isolated communities and areas which are far from the capital. Influence of the physical regions of Peru is spotted as well, mainly showing that villagers from tropical areas tend to communicate much more intensely than villagers from rough mountainous areas. Some of the findings are also

supported by impressions from a field trip that was conducted in selected rural sites both in a tropical area as well as a mountainous area. It was also found that some communities, especially extremely poor ones, do not know how to benefit from using the phone, thus implying for the need to enhance the provision of technology by providing value added services promoting the villagers.

The study presents a pioneering methodology for the transformation of raw traffic data into geographical conclusions. Hence, it includes detailed descriptions of the scenarios performed in each of the analyses in order to achieve the desired findings, so such methodologies can be implemented in future studies on other telecommunications networks anywhere in the world.

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List of Abbreviations

ANI -	Automatic Number Identification
ATM -	Automatic Teller Machine
CAS -	Calls Allocation Server
CD -	Compact Disk
CDMA -	Code Division Multiple Access
CDR -	Call Details Record
CLID -	Calling Line Identification
DECT -	Digital European Cordless Telecommunications
EDGE -	Enhanced Data for GSM Evolution
FITEL -	Fondo de Inversión en Telecomunicaciones
FWA -	Fixed Wireless Access
GIS -	Geographical Information System
GOS -	Grade of Service
GPRS -	General Packet Radio Service
GSM -	Global System for Mobile Communications / Groupe Speciale Mobile
GTC -	Grameen Telecom
HF -	High Frequency
HVP -	Hub Voice Processor
ICT -	Information and Communications Technology
IDU -	Indoor Unit
IMT -	International Mobile Telecommunications
INEI -	Instituto Nacional de Estadística e Informática
IP -	Internet Protocol
ISP -	Internet Service Provider
ITU -	International Telecommunications Union
LDI -	Long Distance International
LDN -	Long Distance National
LNB -	Low Noise Blocker
LSRT -	Large Scale Rural Telephony
MMS -	Multimedia Messaging Service
NMS -	Network Management System
ODU -	Outdoor Unit

OECD -	Organization for Economic Co-operation and Development
OSIPTEL -	Organismo Supervisor de Inversión Privada en Telecomunicaciones
PC -	Personal Computer
PCN -	Personal Communications Network
PCS -	Personal Communications Service
PIN -	Personal Identification Number
PSTN -	Public Switched Telephone Network
PTT -	Post Telegraph and Telephone
SCADA -	Supervisory Control and Data Acquisition
SMS -	Short Messages Service
SQL -	Structured Query Language
TCP -	Transmission Control Protocol
TDG -	TeleCommons Development Group
TDMA -	Time Division Multiple Access
UHF -	Ultra High Frequency
UNDP -	United Nations Development Programme
VHF -	Very High Frequency
VP -	Village Payphone
VSAT -	Very Small Aperture Terminal
WLL -	Wireless Local Loop
WTP -	Willingness to Pay

Introduction

For several years I have been dealing with the telecommunications field. In the past few years I have been working in "Gilat Satellite Networks". Among other things, Gilat develops, manufactures and sells satellite operated telephones, which can be installed in remote and undeveloped areas of the world. Thus, many of Gilat customers are telecommunications providers that build and maintain telephony networks in rural areas of developing countries. Many of Gilat's employees, especially marketing and tech support personnel, who return from their business trips to such areas, constantly reveal intriguing stories related to the installation and maintenance of those rural phones – most of them were installed in villages where a telephone was just a dream, and electricity doesn’t even exist after the phone was installed.

After I got acquainted with the rural environment as part of my travels, geography studies and the work in Gilat, I started to get curious about the characteristics of the use of satellite phones, and their influence on the life of the locals. In addition, in Gilat I have access to technical data from the telephony systems, which potentially can provide us with some answers about nature of use of the phones. Since I have the background and access to both the technological aspects and the geographical ones, I decided to take advantage of this rare opportunity, and perform a pioneering research in the field of "geography of telecommunications".

Purpose of the research

In this research I shall examine and highlight several aspects of Gilat's satellite telephony system connecting rural villages in Peru. I will analyze a database of traffic figures of the network. The purpose is to learn from the analysis about the characteristics of the network usage, inspecting data about incoming and outgoing calls. These characteristics include the evolution of telephone usage over time after it was installed in the village, peak usage of the phones along the day and the week, destinations of calls made from villages, origin of calls made to villages, characteristics of international calls, and how the traffic characteristics differ among various areas in Peru. Since such a research has never been conducted before, I intend to show the great potential which hides in the million bits of numbers and figures, for understanding the characteristics of rural communications. Therefore I will also focus on explaining the methodology and analyses of my study, so that such methods may be implemented for studies of other networks in the world. These rather quantitative analyses will be complemented by impressions from a field trip I conducted in several locations of Gilat satellite phones in villages in Peru. Although they are not the main core of the research, the findings from the field trip are important, as they shed light and explain characteristics identified in the quantitative research which I performed.

1. Telephony and rural areas in developing countries

1.1. Telecommunications and rural areas

Even though for us, residents of the western world, the telephone is taken for granted, a significant part of the world population has never conducted a phone call. Many areas in Africa, South America and Asia are not connected to any fixed telecommunications infrastructure (Falch *et al*., 2003). During the mid 1970s, 8.5 million people, about half of Peru population, didn't have any access to a phone (Mayo *et al*., 1992). In 1994, the teledensity for Peru was 2.5 lines per 100 residents – the worst in Latin America (Regional surveys of the world, 2001). Most of the residents who are not connected to any telecommunications infrastructure are spread over a vast area, mainly in small and isolated settlements, which may be even a few kilometers away from a large urban center. In 1993, for instance, there were 6.61 lines per 100 residents in Lima, the capital of Peru, but in other parts of the country (including of course other large cities) only 1.23 lines per 100 residents (Carnejo *et al*., 1998).

1.1.1. Defining "Rural Areas"

There is no single approach to the definition of a "rural area" (Coopers & Lybrand, 1996). It is not always obvious where is the line between a suburban area and a rural one. In this work, I am interested in this term with respect to telecommunications systems. Several organizations dealing with the deployment of telecommunications infrastructures in rural areas referred to this issue.

The *International Telecommunications Union* (ITU) founded in 1999 the "*Focus Group 7*" – a task force that spent a year researching technological developments with a potential to support telecommunication applications for rural and remote areas of developing countries. The group stressed (ITU, 2000, p. 5-6), that rural and remote (or just "rural") areas exhibit one or more of the following characteristics:

- Scarcity or absence of public facilities such as reliable electricity supply, water, access roads and regular transport.
- Scarcity of technical personnel.

- Difficult topographical conditions, such as lakes, rivers, hills, mountains or deserts, which render the construction of wire telecommunication networks very costly.
- Severe climatic conditions that make critical demands on the equipment.
- Low level of economic activity mainly based on agriculture, fishing, handicrafts, etc.
- Low income per capita.
- Underdeveloped social infrastructures (such as health and education).
- Low population density.
- Very high calling rates per telephone line, reflecting the scarcity of telephone service and the fact that large numbers of people rely on a single telephone line, usually a public phone.

These characteristics make it difficult to provide public telecommunications services of acceptable quality by traditional means at affordable prices, while also achieving commercial viability for the service provider.

In 1982, in a report entitled Missing Link (ITU, 1985) the ITU presented another definition. A rural area was defined according to the following demographic criteria:

- Less than 5,000 people live in the area.
- The population density is less than 400 people per square kilometer.
- Over 75 percent of the muscular population deals with agricultural activity.

It is important to note, that each country provides its own interpretation to the term rural area. For example in Colombia the term includes communities of greater than 500 people which have no service. Chile defines rural areas as localities with less than 3000 inhabitants. Argentina defines rural as areas that cannot be accessed through existing exchanges (Coopers & Lybrand, 1996).

1.1.2. Digital Divide

Another term which should be mentioned in this context is the "Digital divide". The OECD (2001, p.5) refers to this term as follows: "The term "digital divide" refers to the gap between individuals, households, businesses and geographic areas at different socio-economic levels with regard both to their opportunities to access information and communication technologies and to their use of the Internet for a wide variety of activities. The digital divide reflects various differences among and within countries. Access to basic telecommunications infrastructures is fundamental to any consideration of the issue, as it precedes and is more widely available than access to and use of the Internet". The *Digital Divide Network* by the *Benton Foundation* (2004) adds that if communities are to remain competitive in attracting, retaining and developing businesses in today's economy, they must develop modern telecommunications facilities and cultivate a well-trained workforce to stay viable. It is important to note, that currently the term is widely used mainly in reference to Internet access. Digital divide figures for Peru 1993 show (Cornejo, 1998), that only 1.6 percent of the poor households had a telephone, whereas on mid-high level households the rate was 21.1 percent.

1.1.3. Access to Telecommunications media

When the issue of connectivity is brought up, usually it refers to access to "Information and Communications Technology", or "ICT". In this work, I will also use the term access to "Telecommunications Means". Considerable amount of material is found in the literature about telecommunications means and their influence on communities in general and rural communities in particular. The intuitive claim is that access of a community to telecommunications means has an influence on the socio-economic development of that community and vise versa – developed societies will also be more "connected".

Mayo *et al* (1992) describe a trial conducted in Peru for providing satellite telephone connectivity to remote villages. During the trial period, between 1982 and 1987, domestic satellite communications technologies were only starting to develop. The trial was conducted in several rural communities in a dense jungle area of Peru, which didn't have any access to telecommunications before. Telephones connected to satellite terminals were installed in a public office in the village. The trial demonstrated that the use of the telephones in those places became so popular, that it was decided to install several additional phones in private homes. I will later show in my findings (section 4.5), that people in the jungle areas in Peru are the heaviest users of rural phones among all Peru residents. This explains the enthusiasm of the jungle people in the trial. Most users were business owners, but residents with lower income were also seen using the phones. All of them emphasized the importance of using the phones. In addition, audio-conferencing halls were setup. This service was granted to the locals for free, and turned out to be highly successful. Conferences were held for a variety of purposes, the most popular of them was education and training. Following the trial, the locals claimed that they can benefit more by contacting experts in the capital city of Lima than consulting local colleagues or supervisors. The influence on social relations was more difficult to examine. Nevertheless, Mayo *et al* emphasize, that the amount of influence of telecommunications systems must be understood in a wider context – of infrastructure improvements in general. They couldn't give a clear answer to the question - in which field is it more important to invest – telecommunications or other alternatives for development?

Malecki (2003) claims that telecommunications is only one piece in the complex puzzle of development in rural areas, a field which is subjective to numerous global processes. The report of *Accenture, the Markle foundation and UNDP* (2001) also touches this point. The report states that telecommunications technologies "create a development dynamic", that is to say, deploying telecommunications infrastructure may create an encouraging environment for development, but this alone is not enough - it has to be backed up by a larger scale activity, involving other economic and social elements.

One of the places I visited while traveling in Peru was a remote mountainous village called Pinagua, where a satellite phone is operational since February 2002 (Figure 1). According to one of the locals, the phone is not used frequently. Only 10 families live in this village, some of them lack the money to pay for calls. When they need life supporting goods they simply go to the nearest town and exchange them for the agricultural products they produce. He added that the satellite phone mainly gets incoming calls from a family member who went to live outside the village. The villagers did not even use the free phone cards they got when the phone was installed. They simply could not think about any reason to use the phone.

Figure 1 - A rural scene in the village of Pinagua, which is equipped with a satellite pay phone

Pinagua is a good example supporting the claims that developing telecommunications infrastructure is not enough to create social-economic development. In such a small village with poor community, the villagers do not even have an idea how they can benefit from this phone.

Hudson (1999) states that telecommunications may support various applications – education, health, social services and more, by private people, small businesses and corporations. But she put the emphasis on "may" – the extent to which telecommunications will indeed promote these aspects depends on policy makers and executors. I witnessed this aspect myself when I visited in Peru. Gilat Peru as an operator, feels the need to "do something with the phones", in addition to the mere provision of the connection, in order to help the local communities learn how to benefit from this instrument. This wish is obvious for a commercial operator such as Gilat, because the more the people talk, the higher the income. So far, Gilat focused on providing the connection, from two main reasons. First, Gilat is mainly an equipment manufacturer, and Gilat Peru was founded in order to install equipment in response to a Peruvian government bid. Second, the network of Gilat is relatively young – on the time of the study, Gilat has just finished installing the majority of the phones, it is still performing installations, and only now it is organizing to a sort of second phase, in which it considers ideas how to increase traffic by promoting the telephones usage.

Bayes (2001) describes in his essay the impact of a unique project executed in Bangladesh for providing telecommunications to rural areas. The pioneering project was financed by the local *Grameen Bank*, and it was intended to provide telephony services to the villagers by leasing cellular phones to operators for using them as public payphones. This project will also be discussed later on. Bayes studied the project impact on the villagers' life and found that services originating from telephones in villages are likely to deliver more benefits to the poor than to the non-poor. With the right policies, telephones may turn into production factors, especially through lowering transaction costs, and may increase merchants' productivity.

After reviewing several essays (ITU, 2000, *Accenture, The Markle Foundation and UNDP*, 2001, Bayes, 2001) I can summarize that telecommunications means in rural areas may contribute to development in the following fields:

- Trade - Enable farmers to market their products directly to markets in field towns and other urban centers without mediators, and to get updated information about product prices in the markets, and to contact carriers.
- Telemedicine – Enable remote access to medical services – i.e. local medical personnel in a remote village or town can consult experts in a large urban center in order to improve the treatment given to the village residents.
- Education and training – Improve instruction and training methods through "distant learning" systems, support teachers, and widen the research capabilities for pupils by providing connections to the Internet.
- Social relations – Tighten connections between relatives and friends.
- Governmental services – Improve access to governmental services by accessing Internet sites or making phone calls.

- Employment – Create more working positions - for people who operate and maintain the telecommunications infrastructure in the various sites, as well as provide end equipment for the system.
- Security and law enforcement.

Bayes (2001), who presented these benefits, further studied the distribution of call purposes and found that among poor as well as non poor people, economic/finance calls took a significant part – about 46% of the calls. About 35% of the calls were for family and personal purposes (Table 1).

Table 1 - Purposes of phone calls made by users in Bangladesh Village Pay Phones project. Source: Bayes (2001)

Purpose of Call	Extremely poor	Moderately poor	All poor	All non-poor
Market prices of commodities	2.4%	4.8%	3.4%	5.5%
Employment opportunities	15.7%	6.4%	11.6%	5.5%
Land transactions	13.2%	22.2%	17.1%	7.1%
Business related	6.0%	20.5%	12.4%	25.3%
Remittance	2.5%	-	1.4%	3.5%
All economic/finance	**39.8%**	**53.9%**	**45.9%**	**46.9%**
Family/personal	**36.1%**	**25.4%**	**31.5%**	**35.3%**
Health-related	18.1%	17.5%	17.8%	10.3%
Other	6.0%	3.2%	4.8%	7.5%

Bayes also found, that the villagers conducted a notable number of international calls, since many residents, especially from poor families, sold their land and moved to live abroad. Bayes concludes that the availability of village pay phones results in substantial socio-cultural benefits in rural areas.

The Village Pay Phones project in Bangladesh was studied by several organizations, among them the *TeleCommons Development Group* (TDG) of Canada for the *Canadian International Development Agency*. They found that (Grameen Phone, 2004) "The Village Phone Program yields significant positive social and economic impacts, including relatively large consumer surplus and immeasurable quality of life benefits. The consumer surplus from a single phone call to Dhaka, a call that replaces the physical trip to the city, ranges from 264 percent to 9.8 percent of the mean monthly household income. The cost of a trip to the city ranges from 2 to 8 times the cost of a single phone call, meaning real savings for poor rural people of between 2.7 to 10 US Dollars for individual calls".

Torero *et al* (2003) studied willingness to pay (WTP) for rural telephone services in Bangladesh and Peru. The main result of their paper suggested that rural telecommunications projects are welfare enhancing, since willingness to pay among households was higher than the prevailing tariff rates. These findings were supported by impressions I got form a visit to the Peruvian village of Caicay. Operator of the Gilat satellite phone installed in this village noted that calls tariffs are reasonable for all village residents, including the poorer ones, and no complains were heard on this matter.

Intelecon researchers (2003) presented findings from five out of six regions of Nigeria, according to which people are willing to pay 10-23 US dollars per month for mobile services. Note, that the annual GDP per capita in Nigeria is 900 US dollars while in Peru 5,100 US dollars (CIA World fact book, 2003).

Previously, I explained researchers' approach according to which in certain cases, deploying telecommunications infrastructure in rural areas may influence the economic status and life of the villagers. Forestier *et al* (2002) deal with this issue and do not reject this approach, but by analyzing test cases from around the world they found that providing telecommunication services extends the gap between rich and poor people in villages, at least on the period following the services inauguration. They claim that the main reason for this is the historic tendency to invest in telecommunications infrastructure for wealthier consumers.

To summarize, many factors influence social and economic development: political stability, physical infrastructure, education level and literacy rate and health services are only a few examples. Telecommunications systems are definitely not a substitute to those factors, and cannot solve development problems. Nevertheless, profound examination of experience gained in various places in the world provides definite conclusions, according to which telecommunications systems have a significant impact on achieving specific goals in social and economical development, as well as contributing to national development strategies in general.

1.1.4. Development projects

Although deploying a telecommunications infrastructure in rural areas requires large financial budgets, governments across the world understand the potential for development and promote projects for providing telecom services to rural areas. In cases where governments have difficulties supporting the heavy costs, financing organizations assist: The world bank, UNDP – United Nations Development Program, philanthropic foundations (such as the Markle foundation), and more.

1.1.4.1. Examples for rural communications projects

1.1.4.1.1. Mobile technologies in Africa

Dymond and Boyd (2003) shed light on the economic aspect of the deployment of rural communications infrastructure. Presenting Africa as an example for network development, they show that mobile technologies caused a revolution in the ability to reach rural areas. If until recent years the common estimation was that 3 billion US dollars are needed to bring fixed telephone network to 2 percent teledensity, mobile operators are now investing most of this amount in Africa annually. People tend to spend more money on telecommunications that estimated before (up to 5-10 percent of the income as opposed to 3 percent), and even the poor people, who previously had no access to communications now "flash" their relatives and friends, making them pay.

1.1.4.1.2. GrameenPhone - Cellular village pay phones in Bangladesh

Village pay phones program began from a social commitment made by the shareholders of GrameenPhone that "good development is good business" (GrameenPhone web site, 2004). The program is implemented by Grameen Telecom (GTC) in cooperation with Grameen bank, the internationally renowned micro-credit lending institution. This program enables Grameen bank's borrowers to retail telephone service in their respective villages. A typical Grameen bank borrower takes a loan of 100 US dollars without collateral from the bank to purchase, say, a cow. The cow would then produce milk that the borrower could sell to her neighbors enabling her to make a living and pay off the loan. The process allows the poorest of the poor to stand up on their feet. In the case of Village Phone, a telephone also acts as an income generating mechanism for a borrower; a telephone serves as another "cow." A woman borrows about 350 US dollars from the Bank and purchases a handset and sell telephone services to the villagers, making a living and thus paying off her loan. It creates a self-employment opportunity in each village and provides access to telephones to all. The borrowers get a phone connected to a GSM cellular network. They become effectively mobile public call offices. This not only provides rural poor with new, exciting income-generating opportunities, but it also helps to enhance the social status of women from poor rural households. Initiated in 1997, the program has continued to grow at a robust pace over the years. The village pay phones in operation provide in 2004 access to telecommunications facilities to more than 60 million people living in rural areas of Bangladesh. More than 68,000 villages in 61 districts have been covered under this program.

1.1.4.1.3. Rural projects in India

India is known lately for embracing new technologies, including in telecom applications for rural areas. There are several examples for places in India where communications solutions serve as a useful tool for social and economical development in rural areas (COAI, 2004).

- **Rural network benefits fisherman in Kerala, India**
  In the state of Kerala, fishermen use GSM phones. These enable them to strike deals once the daily catch is in the boat and much before they reach the shore, thus, enabling them to maximize their earning potential. In addition, they can feel safer while in the sea, as they can communicate immediately for assistance if required.

- **Rural network benefits farmers in Punjab, India**
  A similar benefit is available to Punjabi farmers. One of the GSM service providers operates a service called Agritrack. Its purpose is to help the Punjab farmers get the best price for their produce. Farmers typically sell their crops in the wholesale markets, for which they need to track the daily prices of various crops to time their entry for selling and take advantage of the daily fluctuations in the rates. Agritrack enables them to get real time updated rates using their

phones, without being dependent on any middlemen or brokers to follow rate trends.

- **Commodity trading network**

  A similar solution using VSATs satellite technology can also be found in India. The "E-Choupal" project supports the on-line commodity trading network for rural farmers in India. The system provides Internet access as well as on-line information regarding supply and demand of the commodities, assisting the farmers with the purchase and sales process. Other potential on-line applications include video conferencing, distance education and tele-medicine. "E-Choupal" services were launched in the year 2000 by the International Business Division (IBD) of ITC Limited, and in the year 2004 reached out to more than two million farmers across the country growing a range of crops - soybeans, coffee, wheat, rice, pulses, shrimp - in some 20,000 villages through 3,600 kiosks across six states.

- **Telemedicine**

  Villagers in India lack access to affordable healthcare, since clinics and doctors are usually located in towns and cities. As a result, life expectancy in villages is eight years less than for city dwellers. Jiva Institute, a leading NGO, came up with the TeleDoc initiative. In TeleDoc, village-based healthcare workers record and transmit diagnostic data to a central clinic, using mobile phones that connect over the widely available GSM‘s GPRS network. Custom database applications synchronize with record-management systems at the clinic. Jiva’s expert doctors analyze the data, and then prescribe medication and treatment. Medicines are compounded at a regional office, picked up by field workers, and delivered to patients in their homes for a symbolic price. The system also offers other benefits, such as increased savings of money and time, reduced stress with less travel and health care education.

1.1.5. Urban – Rural communications

One of the communications characteristics I am going to examine in this study deals with urban – rural relations. When referring to the digital divide, Navas-Sabater *et al* (2002) relate the disparities between rich and poor to the disparities between urban and remote isolated areas. In connection with the poverty and isolation issue, Navas-Sabater *et al* point out several gaps. *Market efficiency gap* is described as the difference between the level of service penetration that can be reached under current plans and conditions, and the level one would expect under optimal market conditions. As the poverty and isolation of the communities grow larger, they can be found beyond an *affordability frontier* – these communities may not be reached due to lack of commercial profitability, thus creating the *Access gap*. In this case, some sort of intervention in terms of subsidies should be provided in order to close this gap. Another gap is the *urban-rural teledensity gap*. Statistics about this are not widely available and accurate, but Navas-Sabater *et al* estimate that rural/urban teledensity ratio is 1:20 up to 1:60 in the developing world.

Navas-Sabater *et al* (2002) use Peru to demonstrate the influence of telephone tariffs on people's ability to afford them having a private phone.

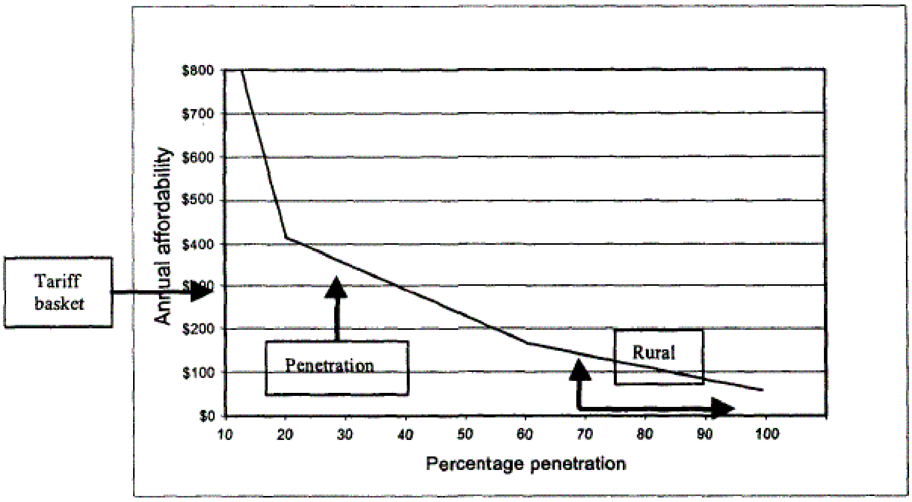

Figure 2 - Peru household affordability. Source: Navas-Sabater *et al* (2002)

Figure 2 assumes that telephone service is normally provided to the richest segment of society first, progressing to lower income groups as penetration grows. In Peru, residential penetration stood at 30 percent in 2002. It seems that it is unlikely to pass

40 percent in the near future because household affordability (the financial ability to maintain a private phone) drops below the tariff basket. In Peru, about 30 percent of the population is rural. If we assume that these also correspond to the lowest 30 percent in the income distribution curve, we can assume that they will generally not be able to afford private lines unless special tariffs are designed for them. They will thus depend on public phones and other public means of access.

Dymond and Boyd (2003) talk about *Asymmetric Interconnection*, as a way to reduce the gaps. Asymmetric tariffs for incoming/outgoing calls may, for example, encourage the more wealthy to call from the cities to the villages, thus enabling operators to provide an economically feasible solution to isolated areas. Another way is through the operation of universal access funds. Dymond and Boyd (2003) make a similar point when they discuss the volume of urban – rural calls and state, that eventually urban to rural call volume exceeds rural to urban call volume, because of the imbalance of affordability and the strong urban/rural family ties.

1.2. Feasible telecommunications media for rural purposes

Most of the rural areas require the deployment of telecommunications infrastructure in a tough terrain and a large number of subscribers spread over a vast area. Laying and maintaining wired transmission media is not economical and is technically infeasible, thus, prompting the widespread use of wireless systems in rural areas.

The ITU *Focus Group 7* (2000) identified several types of wireless access, illustrating existing and emerging access options for reaching rural communities:

- Radio links
- Cellular Solutions
- Wireless Local Loop (WLL)
- Satellite Solutions

Each of these solutions will be discussed shortly in the following sections.

1.2.1. Radio links

Radio links use simple radio transceivers to support voice and low bit rate data connections between a remote village and a central village or urban settlement. The links usually utilize the VHF and UHF Frequency Bands (100 Mhz to 500 Mhz), which are suitable for communications in rough terrains, and can support connections up to dozens of kilometers long. For extremely remote areas, HF band (3 to 30 Mhz) is used, to support longer distance links. One transceiver is placed in the village, operated by batteries or electricity if possible, and connected to an antenna. The other transceiver is located in a larger populated center, district capital or an urban settlement. The advantages of such systems are the easy deployment of the equipment. The disadvantages are limited services – poor voice quality, no connection to switched network and slow data connection which is not enough for sophisticated applications like Internet connections.

1.2.2. Cellular Solutions

Cellular systems provide communication for mobile subscribers. They are based on an infrastructure of base stations (or relay stations). The base stations contain antennas, control equipment and transmission media. They form as a gateway between the mobile subscribers (using a wireless interface) and the system exchanges (using a wired or wireless link). Each base station can send and receive signals within a specified area, thus "covering" a predefined area, or "cell". The cellular system exchanges are connected to other telephone systems such as the domestic PSTN (Public Switched Telephone System) and International carriers. In order to cover rural areas, especially in rough terrain, numerous base stations and transmission links to connect them should be deployed. Each base station (Figure 3) consumes a considerable amount of power, and if electricity infrastructure doesn’t exist in the area, generators should be added, and supplied with gasoline constantly. Today, cellular infrastructure is easily available and its prices are reasonable. But such a solution is not always feasible - when communities are spread over large areas in rough terrain. This may render the deployment and maintenance of the base stations very costly.

Figure 3 - Cellular base station in a rural mountainous area

Several Cellular technologies are currently in use. GSM is the widespread European standard that became a worldwide standard de-facto. Every country in the world in which cellular services exist today has at least one GSM network. Other common technologies are CDMA (IS-95) and TDMA (IS-136). All those standards are referred to as *second generation* systems. These standards can support voice, data and multimedia services. GPRS and EDGE are *2.5 generation* standards that upgrade GSM systems for higher rates of data bit transmissions using packet switching technologies. The *Third generation* standard IMT-2000 is a unified standard for voice and high rate data and multimedia delivery for mobile subscribers.

The *Grameen Village Phone Program* in Bangladesh is based on a GSM solution. Such a solution is technically feasible in Bangladesh, since it is a flat country with dense population, easy for deployment of cellular systems.

Dymond and Boyd (2003) present evidence from Uganda, Kenya, Nigeria and South Africa, that people value mobile communications even more highly than fixed one. They also claim that with the deployment of mobile systems in various areas accelerates the realization of the potential of the rural market.

Although it seems expensive, mobile can be used "on the cheap" (Dymond and Boyd 2003). For instance – a rural relative may call a more affluent urban relative, and hang up before he gets charged, leaving his caller ID so that the urban relative can call back. Another option is to use the mobile only for incoming calls – being contactable, while conducting outgoing calls via telecenters. SMS is also a good way to save on mobile communications costs, suitable for literate people.

1.2.2.1. Using prepaid calling cards

Dymond and Boyd (2003) also present the benefits of prepaid services, beyond the cost:

- Hassle-free sign-up and no binding long term contracts.
- Easy to use.
- Allows control of expenditure.
- Enables to just receive calls in times of economic difficulty.
- Avoids credit checking and need to have a bank account.
- Ideal for those who have bad debt problems and no steady income.

42 percent of the world mobile subscribers are prepaid customers. In the Bellsouth mobile network in Peru, 72 percent are prepaid customers, while in Africa, excluding South Africa, 90-95 percent of the total mobile customers use prepaid accounts.

1.2.3. Wireless Local Loop (WLL)

Wireless local loop, also known as *Fixed Wireless Access* (FWA) has become an attractive option for network expansion in both developed and developing countries (Intelecon, 2003). WLL is a system that connects subscribers to the public switched telephone network (PSTN) using radio signals as a substitute for copper for all or part of the connection between the subscriber and the switch. WLL systems infrastructure is similar to cellular systems in the sense that base stations are used here as well. Usually, the base station is located in the vicinity of the exchange building, from which fixed wireless links can be deployed to customers in towns and villages. WLL costs are sensitive to base station towers heights, repeater requirements and power availability. There are several known standards that can serve WLL (IEC tutorial): Personal Communications Network (PCN), Personal Communications Service (PCS), Cordless telephones 2nd generation (CT–2) and Cellular Digital European Cordless Telecommunication (DECT) are usually used in urban and suburban areas. In addition, numerous proprietary technologies exist, which give better solutions to rural areas.

1.2.4. Satellite based Solutions

The following section describes the infrastructure of satellite communications systems designated for rural applications. It is based on Gilat Satellite Networks Web site (2004).

1.2.4.1. Communications Satellites

A communications satellite is a specialized wireless receiver/transmitter - essentially a radio-frequency repeater - that is placed in orbit around the earth. Today, there are literally hundreds of commercial satellites in operation around the world. These satellites are used for such diverse purposes as telephony and data communications, television broadcasting, amateur radio communications and military purposes. Most communication satellites in use are geostationary. They orbit the earth directly over the equator, approximately 36,000 km up. At this altitude, one complete trip around the earth (relative to the sun) takes 24 hours. Thus, the satellite remains over the same spot on the surface of the earth (geo) at all times, and stays fixed in the sky (stationary) from any point on the surface from which it can be "seen." A single geostationary satellite can "see" approximately 40 percent of the earth's surface. It is used to say, that satellites "remove obstacles", since the transfer of communication signals is done via dish antennas pointed to the sky (as can be seen in Figure 4). Therefore, even the remotest village on earth can always be connected via a satellite link.

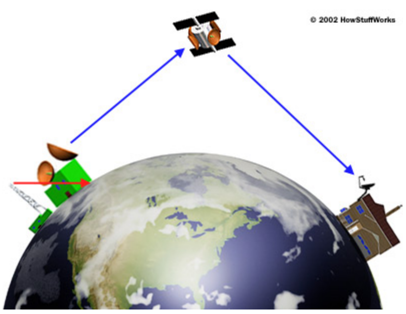

Figure 4 - Transmitting to satellite and receiveing from it

There are various "players" in the satellites industry:

- **Satellites manufacturers**
  Satellites are produced by commercial corporations (such as Boeing and Hughes), or by governments – by space agencies (such as European Space Agency and NASA) or other specialized industries (Like "Mabat" – the space systems plant of the Israeli Aircraft Industry).
- **Satellite launchers**
  Launching a geo stationary satellite is a complicated task that demands the use of a sophisticated launch vehicle. Building and operating such a vehicle, is at the exclusive domain of a limited number of companies (Arianespace for instance) and governments (India, China and Russia for instance).
- **Satellite owners and service providers**
  Satellites are produced and launched for the use of service providers. Once the satellite is in orbit and operational, it starts serving as a telecommunications repeater, and the service providers can start selling *space segment* – bandwidth for telecommunications transmissions over the satellite.

Satellite owners are divided into two types:

- **International or regional corporations**
  Corporations such as *Intelsat* – an international corporation that owns over 30 satellites and provides worldwide satellite communications services, *Eutelsat* – European corporation, and *Arabsat* – Arab states corporation.
- **Governments**
  Most of the large and developed countries in the world operate satellites which they produced themselves or purchased from commercial manufacturing companies. Governments use satellites to deliver communications using their ministry of communications or by selling space segment to service providers. Many governments in Asia (Such as India, Thailand and Indonesia), South America (Such as Brazil) and Africa (Such as South Africa) are using satellites in order to provide communications to remote areas.

1.2.4.2. Satellite communications end equipment

Satellite transmissions require the use of a transceiver and a dish antenna. Numerous companies produce such products that can fit various applications, technologies and network topologies. One of these technologies utilizes VSATs.

1.2.4.3. What is a VSAT?

A *Very Small Aperture Terminal* (VSAT) is a device - known as an earth station - which is used to send and receive satellite transmissions. The "very small" component of the VSAT acronym refers to the size of the VSAT dish antenna (typically about 0.55-1.2 meters in diameter) that is mounted on a roof on a wall, or placed on the ground. This antenna, along with the attached *low-noise blocker* or LNB (which receives satellite signals) and the transmitter (which sends signals) make up the VSAT *outdoor unit* (ODU), one of the two components of a VSAT earth station. The second component of VSAT earth station is the *indoor unit* (IDU). The indoor unit is a small desktop box or PC that contains receiver and transmitter boards and an interface to communicate with the user's existing in-house equipment – a telephone set, a PC, a server, a lottery terminal, an ATM machine, etc. The indoor unit is connected to the outdoor unit with a pair of cables. The VSAT's power consumption is relatively low, enabling it to be powered by batteries charged by solar panels in places where electricity infrastructure does not exist. The price of the VSAT is less than 1,000 US Dollars, so it can easily be manufactured in mass production, in order to facilitate large scale networks of hundreds and thousands of sites. Figure 5 shows a typical VSAT installation in a rural area. All outdoor components are located on a pole: solar panels for providing electricity, dish antenna equipped with outdoor unit, and the battery which is stored in the white box.

Figure 5 - VSAT in a grocery store yard in Oropesa

1.2.4.4. VSAT Network

Telecommunications with VSATs is provided via network topology consisting of three components:

- A central hub.
- A virtually unlimited number of VSAT earth stations in various locations - across a country or continent.
- The satellite.

Traffic originates at the hub, which features a very large antenna (4.5 -11m in diameter). The hub controls the network through a *network management system* (NMS) server, which allows a network operator to monitor and control all components of the network. The NMS operator can view, modify and download individual configuration information to the individual VSATs. The hub also serves as the interconnection point to all the external networks, such as the *Public Switched*

Telephone Network (PSTN), cellular operators, international carriers, *Internet Service Providers* (ISPs), etc. In the hub, the connection to the PSTN is done via a gateway, sometimes called HVP – *Hub Voice Processor*. In large scale systems such as the network in Peru, there are dozens of HVP units that transfer calls to and from the PSTN. Outbound information (from the hub to the VSATs) is sent up to the communications satellite's transponder, which receives it, amplifies it and beams it back to earth for reception by the remote VSATs. The VSATs at the remote locations send information inbound (from the VSATs to the hub) via the same satellite transponder to the hub station. This arrangement, where all network communication passes through the network's hub processor, is called a "star" configuration, with the hub station at the center of the star.

Figure 6 shows the architecture of the *Dialway IP* brand of VSAT network produced by Gilat, and installed in Peru. Telephone sets, fax machines and PCs are connected to the remote units and communicate with the Hub via the satellite links. The hub is interconnected to the PSTN and the Internet Service Providers.

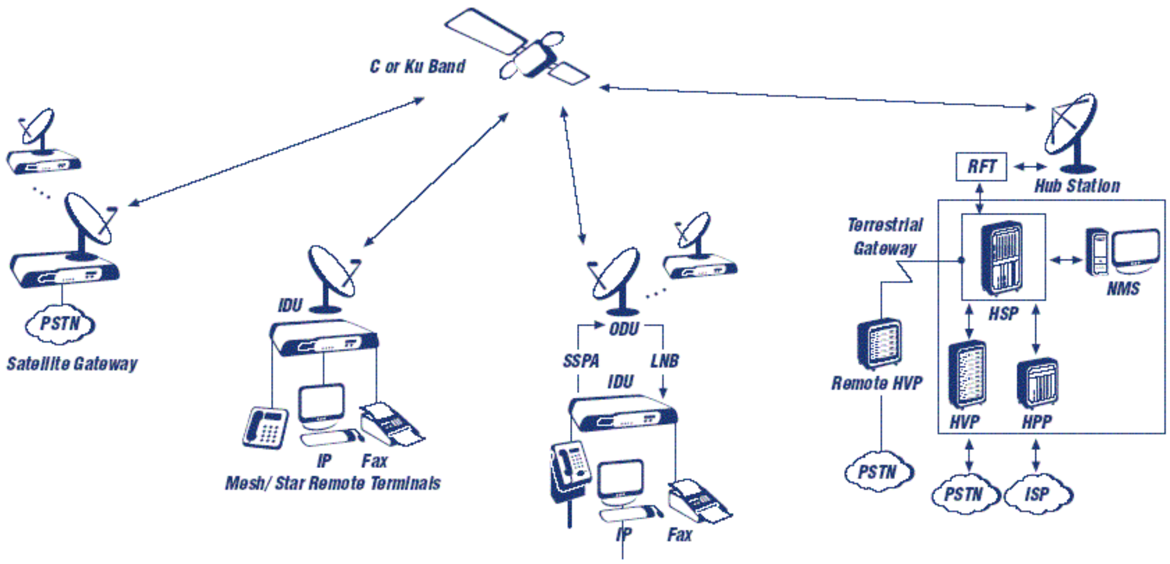

Figure 6 - Architecture of the Dialaway IP VSAT network. Source: Gilat

1.2.4.5. CDRs

The CDR (*Call Details Record*) is the most significant output that the system produces for the operator. The CDRs creation and storage in the VSAT network is done as follows: The Hub of the VSATs network contains a component called CAS – *Calls Allocation Server*. This component is responsible for allocating resources for performing calls in the system – both outgoing and incoming. One of its tasks is to log information related to calls. For any call in the system, whether leading to a successful phone conversation or not, the CAS creates a record with the call details, and transfers it to the NMS. The NMS writes the records into text files which are stored on the NMS server, ready to be processed by any other application.

It is important to note that a record is created for both outgoing and incoming calls.

The main use of the CDRs database is for the calculation and production of the billing information for the customer. Other uses relate to getting information about the system *grade of service* (GOS).

A CDR record in Gilat's dialaway IP system contains over 60 fields. For my research, I will be mainly interested in the following fields:

- Source phone number.
- Source VSAT ID (for a call originating in a VSAT) or Gateway ID (For a call originating in a PSTN subscriber).
- Destination phone number.
- Destination VSAT ID (for a call terminating in a VSAT) or Gateway ID (For a call terminating in a PSTN subscriber).
- Call start time and date.
- Call end time and date.
- Call duration.

1.2.4.6. VSAT Network Users

VSAT networks markets can be divided to two main kinds of customers:

- Enterprises and businesses
- Governmental and public services

Enterprises and businesses that have to deliver mission-critical data between a large number of end points spread over a large distance often choose VSATs as a communications solution. For applications such as the connection of ATM machines to bank computing centers, connecting retail stores cashiers, SCADA and line monitoring, interactive distant lessons and more, terrestrial infrastructure is not adequate. VSAT technology is scalable and easy to deploy, freeing the enterprise from the dependency on a terrestrial service of a service provider. Currently, retail and restaurant chains, financial institutions, hotel groups, convenience stores, national lotteries, news agencies, postal authorities and other national and international enterprises rely on VSAT solutions for their networking needs. Examples for such services are the "E-Choupal" VSATs based network in India mentioned above, Bob Evans and Boston Markets restaurant chains, GTECH lottery, Hollywood Video retail stores, Goodyear, United States Postal Services, Mongolia Airport Authority.

The other kind of entities utilizing VSAT networks are governments (Ministries of communications – PTTs) and communications service providers that need to deploy public communications means in large rural areas. Naturally, such entities can be usually found in less-developed countries and in places where sparse communities are spread over large areas – In Latin America, Africa and Asia. Such VSAT connectivity solutions are often deployed in places where no connection existed before. Mostly, these networks support telephony connections, and some support TCP/IP and Internet connectivity as well.

1.2.4.7. VSATs versus other telecommunications media

To summarize, a major advantage of VSATs is that they can be installed anywhere in the world without the need to deploy complementary terrestrial infrastructure such as cables, transmission towers and relays which are mandatory in other media described. Even connection to the national electricity grid is not needed. Since in most remote and isolated places access should be provided to numerous scattered locations, sometimes situated in rough terrain, the only cost effective communications solution is utilizing VSATs.

1.2.5. Integrated solutions

VSATs can also be integrated with small wireless systems to extend the reach of individual terminals to customers and villages in the local vicinity and thus to serve them more economically than with additional VSATs or with wire-based 'last mile' connections. The LSRT (*Large Scale Rural Telephony*) initiative, for instance, integrates Gilat's VSATs technology with Alvarion WLL technology to provide connectivity in the local village vicinity, while connection to the PSTN is done via the VSAT. This initiative is currently under development.

It is important to note a difference between GSM cellular solutions and satellite solutions, in respect to the value added services provided. GSM is a well developed technology, which supports an increasing number of applications. GSM operators are traditionally seeking for new sources of income from value added services – SMS, MMS, still pictures, video, video conferencing, etc, and the end equipment – the handsets – are easily supporting those features. The satellite communications market is a bit different, in the sense, that networks are usually deployed by the equipment manufacturers. The end equipment is only a terminal supporting a phone or data communications equipment, and it's up to the operator to wisely use this system in terms of applications and value-added services.

1.3. VSATs in villages

When a VSAT network is deployed in order to supply communications to villages, usually the VSAT is installed in a central place in the village. It can be placed as a public phone, or installed in a *telecente*r, which is usually located in the grocery store of the village (which also serves as the village "nerve center"). The phone connected to the VSAT is operated with coins or prepaid cards. If the network also supplies Internet connection, a PC will be installed in the telecenter as well. Figure 7 shows a VSAT public pay phone located inside a grocery store in the village of Padre Cocha, in the Selva – the jungle region of Peru.

Figure 7 -VSAT public phone in a grocery store in the village of Padre Cocha

Figure 8 shows an internet office with PCs connected to a VSAT in the village of Oropesa, in the mountainous region of Peru. Figure 9 shows a VSAT pay phone inside a grocery store located in Quistococha in the Selva region. The outdoor unit of the VSAT is located outside.

Figure 8 - Internet Office in Oropesa

Figure 9 - Public phone and VSAT in Quistococha

The owners of the stores, who are in charge of operating the phones, use them as a source of income as well. They earn a percentage of the fee paid for the prepaid cards they sell. Sometimes they even increase their income by overpricing. For example, in one of the villages I visited in Peru, the owner of the store explained that he often sells a 3 soles card for 4 soles. He also mentioned that tourists from the nearby jungle lodge often come to make international calls. In this case he sometimes sells them a 3 soles card for 3 US dollars (over three times higher…). In other places, owners charge callers by the minute, by measuring their call time with a stopwatch and calculating the fee. Some are setting a tariff for incoming calls as well.

In extremely small villages, such as the village of Pinagua shown in Figure 10, neither a basic grocery store nor any other public venue exists. In such cases, the phone is installed inside the house of one of the villagers. Only 10 families live in Pinagua, in which the houses are made of mud (only 45 mms of annual rain drop in this area allow such construction methods). The village economy is based on agriculture, mostly for self consumption.

Figure 10 - Private house in Pinagua where the public phone is installed

Figure 11 shows a typical house in the jungles region of Peru, with a VSAT installation nearby.

Figure 11 - VSAT near the family house and store in the village of Gen Gen

2. The case study: Telecommunications in Peru

2.1. Regional division of Peru

2.1.1. Physical regions of Peru

Peru is divided into three main regions (Morris, 1987):

Costa - The coastal "staircase" belt.

Sierra - The mountains.

Montana and Selva - The tropical areas.

The location of the three regions is presented in Figure 12.

Figure 12 - Physical regions of Peru

Following is a description of the three regions. Physical aspects are based on Morris (1987), while socio-economic aspects are based on characterization done by the government of Peru in the view of telecom infrastructure provision (Coopers & Lybrand, 1996).

2.1.1.1. Coastal Terrain (Costa)

Physical - This is a narrow belt stretching from about a few kilometers up to 160 kilometers wide. It should not be mistaken for a coastal plain – this is a series of terraces in a form of a "staircase" that leads from the coast up to the steep cliffs of the mountains, 2000 meters above sea level. This area is mostly a desert, with low rainfall but moderate temperatures due to the cooling effect of the Humboldt Current. About 40 rivers that cut through this area create large alluvial floored valleys.

Socio-Economic – In general, it is the most prosperous area, traversed by the pan American highway, supporting trade of goods and services. Fishing is an important activity for rural population centers in this area, as well as agriculture where water is available.

2.1.1.2. Mountain Terrain (Sierra)

Physical - The Sierra is the land of the Andes. Its topography is made of two main elements – a huge dissected tableland and irregular volcanic or fold mountain systems rising above it to peaks above 6000 meters high. Most inhabited places are located in altitudes of 2000 to 4000 meters. The northern area of the Sierra is mild, with rolling hills and heavier rains that allow a good grass cover and living conditions. Further to the south, the environment becomes tougher – higher mountains with dry and colder weather.

Socio-economic – This area hosts the poorest and most remote population centers. Subsistence agriculture is the major activity and external trade is less significant due to limited transport infrastructure.

2.1.1.3. Jungle Terrain (Montana and Selva)

Physical - Mountainous areas on the eastern slopes of the Sierra are dissected by numerous rivers. These areas enjoy about 1000mms of annual rainfall, thus – allowing a rainforest to develop there. Further to the east lie the main plains of the rain forest area – the Selva, in altitudes of 200 meters above sea level. The Selva comprises one half of Peru area.

Socio-economic – The Selva is sparsely populated, but many population centers are settled close to rivers which serve as transport and trade routes. Selva settlements are more prosperous than isolated Sierra areas but less than Costa ones.

The south sierra is regarded as the poorest area in Peru.

52 percent of Peru population lives on the narrow coastal strip, including Lima, 35.7 percent in the Sierra and 12.1 percent in the Selva (Coopers & Lybrand, 1996).

2.1.2. Administrative division of Peru

Administratively Peru is divided into 24 departments ("departamentos") and one constitutional province ("provincia constitucional") of Callao, as can be seen in the map in Figure 13.

Figure 13 – Administrative division of Peru

Some data analyses in this work will compare traffic patterns between different departments, which are located in various physical regions of Peru. For example:

- Loreto, Ucayali and Madre de Dios are located in the Selva.
- Puno and Huancavelica are located in the Sierra.
- Lima and Ica are located in the Costa.

Figure 14 presents a detailed administrative map of Peru, which can be used as a general reference map for the locations mentioned in the study.

Each department is divided into provinces ("provincias"), and each province is consisted of several districts ("distritos"). There are about 1,800 districts in Peru, each of which have a designated capital – usually a larger, more developed populated center, which serves as the social, health, educational and often trade hub for the surrounding villages.

Figure 14 - Detailed Administrative map of Peru. Source: Magellan Geographix

2.1.3. Socio-economic characteristics of Peru

Examining the development index of the various departments of Peru demonstrates the socio-economic gaps between the different geographical areas: most developed departments are in the Costa, the less developed are in the Sierra and the Selva departments are in between. Table 2 is based on socio-economic figures provided by the INEI (*Instituto Nacional de Estadistica e Informatica*) – Peru's national statistics bureau. The original figures were detailed to province level. In order to present the figures in departments level, I calculated weighed average of the provincial figures based on the population size of the provinces.

Table 2 - Socio Economic figures, by Department, sorted according to the development index. Based on INEI figures, 2000.

Department	Population	Development Index	Life Expectancy	Literacy Rate	Household income per capita (Sol/Month)
Lima	7466190	0.746	73.4	96.1	556.8
Callao	773701	0.716	74.4	97.4	457.5
Tacna	277188	0.681	73.5	93.0	420.5
Ica	649332	0.667	72.0	95.7	357.8
Moquegua	147374	0.666	70.1	92.5	412.7
Arequipa	1072958	0.636	69.1	93.5	331.3
Lambayeque	1093051	0.625	71.6	89.4	343.2
Madre De Dios	84383	0.621	69.0	92.8	327.5
Tumbes	193840	0.620	69.7	93.4	311.8
La Libertad	1465970	0.613	70.8	88.4	338.2
Junín	1190488	0.578	67.3	88.0	253.1
Ancash	1067282	0.577	68.9	80.2	307.3
Pasco	247872	0.575	66.9	89.0	233.7
Ucayali	424410	0.565	65.5	90.6	257.4
Loreto	880471	0.564	67.4	91.8	265.3
San Martin	743668	0.553	70.1	89.5	220.6
Piura	1545771	0.550	68.8	86.6	209.2
Cusco	1158142	0.537	65.5	83.2	259.8
Amazonas	406060	0.515	68.5	82.8	195.4
Puno	1199398	0.511	64.1	79.5	179.7
Cajamarca	1411942	0.495	66.6	77.8	198.4
Huánuco	776727	0.494	66.5	77.2	191.9
Ayacucho	527480	0.488	66.2	71.6	167.9
Huancavelica	431088	0.460	64.3	72.4	142.1
Apurimac	426904	0.457	64.3	70.4	137.5

Figure 15 spatially presents the development index figures shown in Table 2.

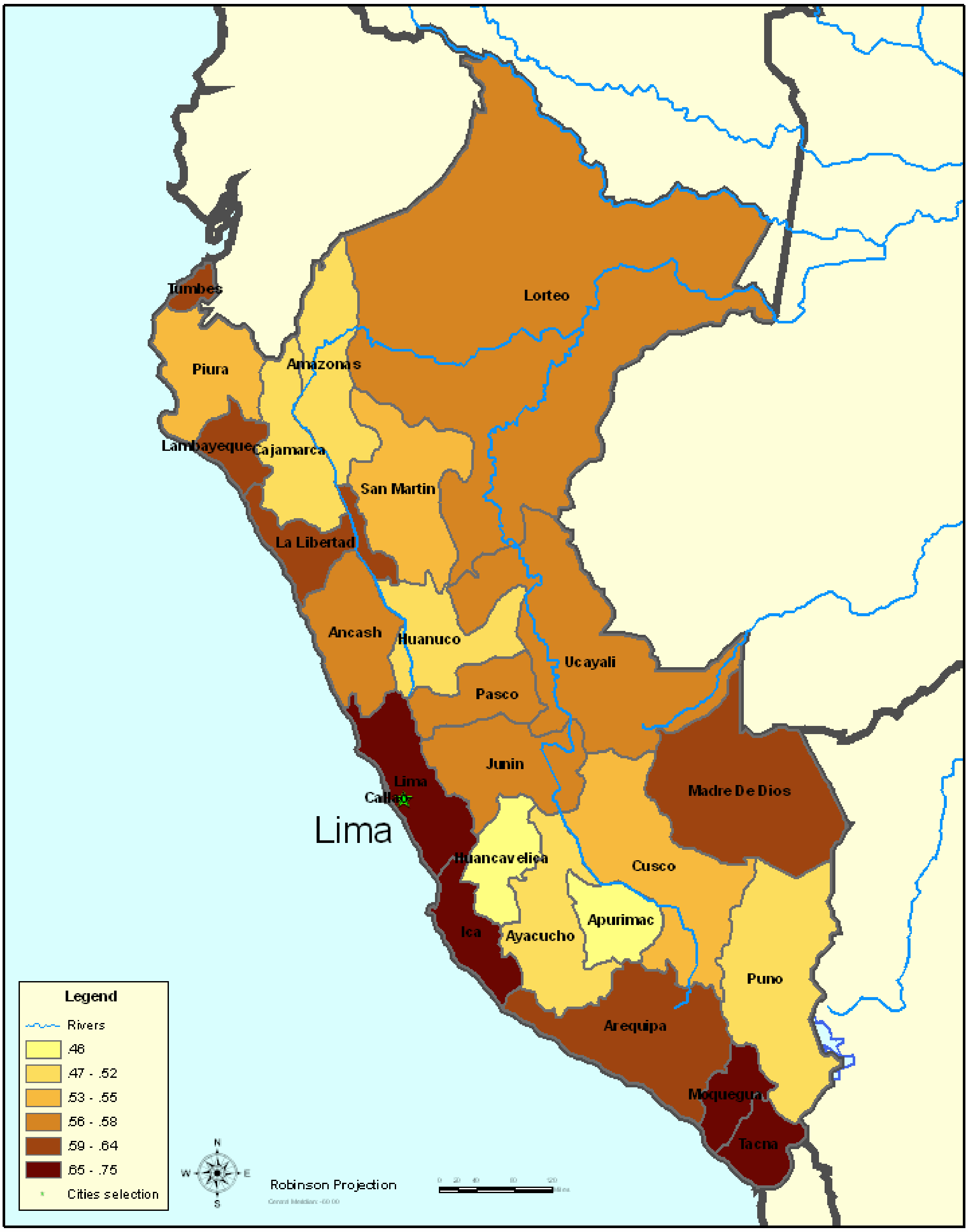

Figure 15 – Development index of the various departments of Peru. Based on INEI figures, 2000

Table 2 and Figure 15 demonstrate the socio-economic gap between the Costa and the Sierra regions: The five departments with the highest development index (shaded dark brown) are on the Costa, while the six departments with the lowest development index (shaded yellow and light orange) are on the Sierra.

2.1.4. Characteristics of Peru's rural areas

Coopers & Lybrand (1996) provide in their policy paper some background on rural populated centers of Peru. There are more than 70,000 populated centers with less than 3,000 inhabitants in each. Many of these are in areas of extreme poverty and inhospitable terrain, isolated from national and regional economies. 56 percent of the populated centers are within one hour traveling distance from their district capital. Most rural populated centers have no medical services or any other public service, and agriculture is their main activity. Primary schools exist in most of them, but no higher education facilities. 79 percent of all businesses in the rural populated centers are small grocery stores (Bodegas). The more prosperous the area, the higher the amount of production sold outside the populated center.

Rural to urban migration in Peru is a continuous phenomenon, as seen in Figure 16 (Rural is colored purple and urban is colored blue):

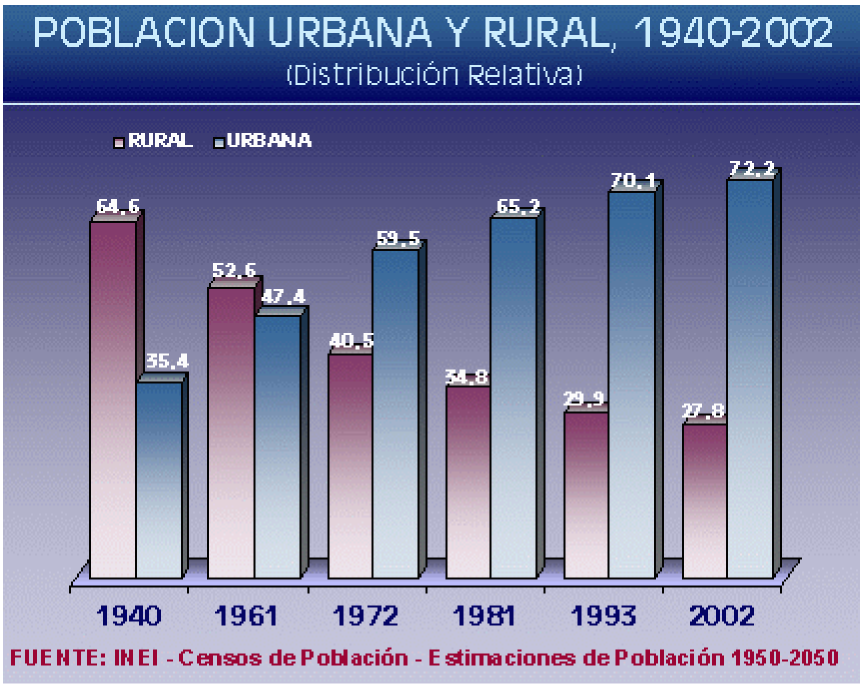

Figure 16 - Rural / Urban population. Estimations 1950-2050 based on population census. Source: INEI Web site

According to Caviedes and Knapp (1995, p. 152), by migrating to cities, rural South Americans hope to improve their living standard and fulfill personal aspirations that cannot be realized in a rural setting, but such goals are achieved by only a few, while many other rural migrants ending up in the big city slums.

In addition to domestic migration, a notable number of Peruvians migrate abroad. According to the *Multilateral Investment Fund* estimations, the number of Peruvians living abroad reached 2.5 million in 2003 (Inter-American Development Bank, 2004).

Table 3 shows the number of people in-migrating and out-migrating from Peru's departments. Data is based on 1993 census.

Table 3 - In and Out migration – departents, 1993 census. Source: INEI Web site

Department	Out-migrants	In-migrants	Migration intensity
Amazonas	81930	78248	-1.047
Áncash	367137	120033	-3.059
Apurímac	197360	23909	-8.255
Arequipa	186368	246464	1.322
Ayacucho	315624	36239	-8.710
Cajamarca	482434	76998	-6.266
Cusco	221918	89790	-2.472
Huancavelica	220370	20130	-10.947
Huánuco	158463	75270	-2.105
Ica	156698	121116	-1.294
Junín	329314	168611	-1.953
La Libertad	257845	194739	-1.324
Lambayeque	185909	182365	-1.019
Lima and Callao	316959	2392014	7.547
Loreto	123156	57046	-2.159
Madre de Dios	9287	29355	3.161
Moquegua	35758	48915	1.368
Pasco	113185	36976	-3.061
Piura	275760	75238	-3.665
Puno	297487	36024	-8.258
San Martín	103643	175363	1.692
Tacna	28827	94553	3.280
Tumbes	29652	45528	1.535
Ucayali	39461	109621	2.778

Note, that the department of Lima contains not only Lima metropolitan area but a much larger area, in which rural communities live as well.

Figure 17 is a spatial presentation of Table 3 data. Departments with positive migration are colored in shades of green while departments with negative migration are colored with shades of red. It can be clearly seen that most people in-migrate to Lima metropolitan area, and a notable out-migration exists in several Sierra departments.

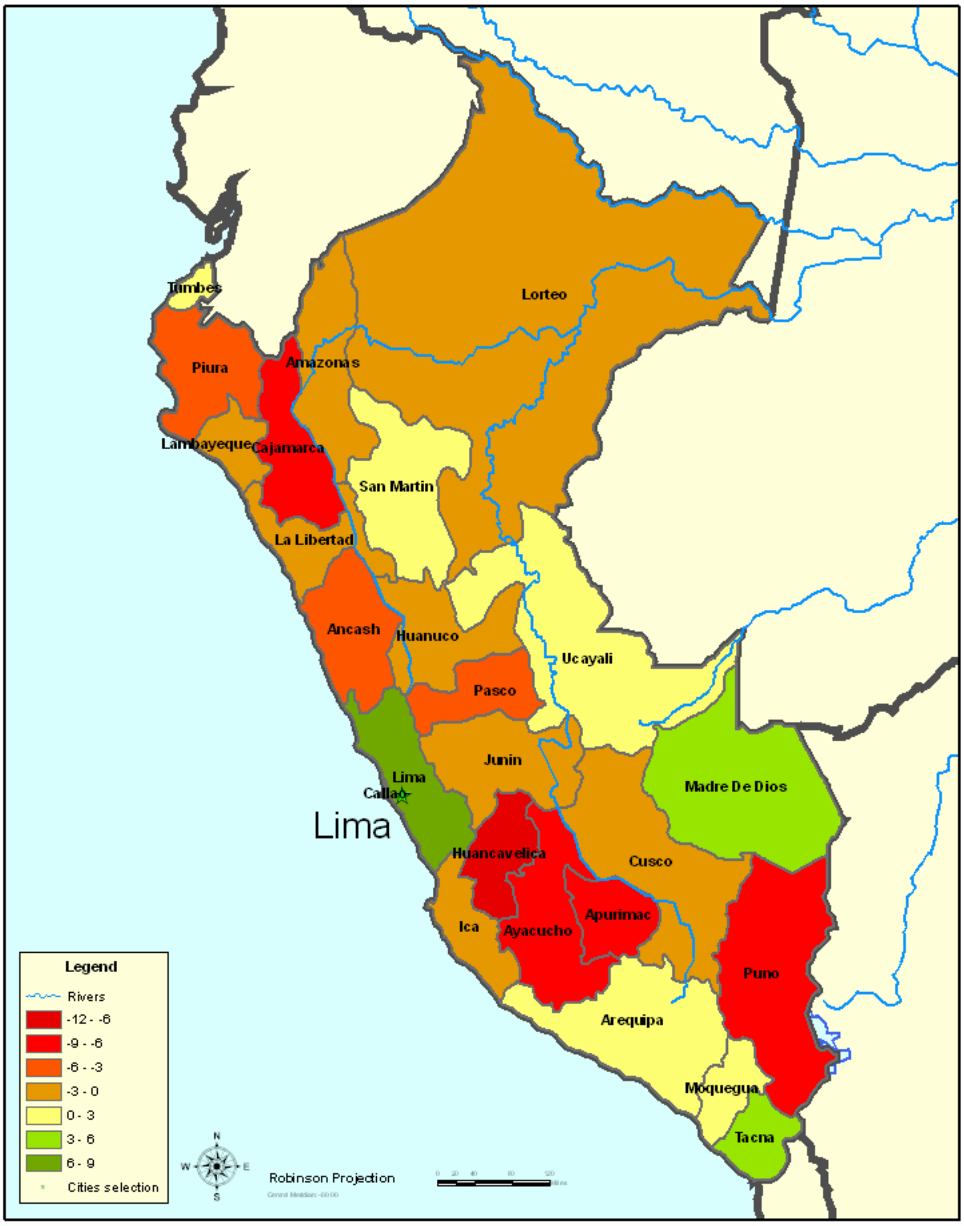

Figure 17 - Migration intensity. Based on INEI figures from 1993 census

2.2. The telecommunications market in Peru

2.2.1. History and bodies involved

The telecommunications infrastructure in Peru has been poor for many years. In 1992, 60 percent of the entire phone lines served subscribers in Lima and its vicinity. In the mid 1990s, only 44 percent of the call trials got a dial tone. A network of microwave links connected the main cities in Peru from North to South, including coastal and mountainous areas, and a fiber optics network was added in 1995. Mobile services were introduced in the beginning of the 1990s. Nowadays, the telecommunications market in Peru is competitive, following its privatization in 1994. In that year, the telecom companies ENTel (which provided telecommunications services all over Peru) and CPT (which provided local services in Lima) were united under the newly formed company "Telefonica del Peru". When it was formed, the company had 772,000 subscribers. 54 percent of them were connected to digital exchanges. As part of the privatization process, several other organizations were formed:

OSIPTEL - *Organismo Supervisor de Inversion Privada en Telecomunicaciones* - a roof organization, responsible for regulation and supervision of the private entities that take part in the Peruvian telecom market.

FITEL - *Fondo de Inversión en Telecomunicaciones* – an organization tended to finance telecommunication projects in rural areas. FITEL is a universal service/access fund, aiming to award subsidies to operators, usually in a competitive manner, to make the regional or rural licenses more attractive for the operators. This is a common way to support the provision of services in challenging areas. FITEL's source of income is a 1 percent tax collected from the gross revenues of all telecom operators in Peru.

2.2.2. Telephone services in Peru

2.2.2.1. Types of calls in Peru

Three types of calls are available in Peru:

Local calls – Calls made within the same department. This means that a call inside the city of Iquitos in Loreto is a local call, as well as a call between a remote village in Loreto to Iquitos.

Long Distance calls – Calls made between departments. This means that a call from a village in Huancavelica to the city of Lima is a long distance call, and a call from a village in Huancavelica to the nearest urban center which is Ayacucho in the department of Ayacucho is a long distance call as well.

International calls – Call to/from other countries.

2.2.2.2. Fixed telephony figures

Table 4 presents figures regarding fixed telephone lines installed and in service in Peru since the market privatization.

Table 4 - Fixed lines figures. Source: OSIPTEL

	Installed Lines	Lines in Service	% of lines in Service	Teledensity - lines per 100 inhabitants
1994	874,436	759,191	86.80%	3.21
1995	1,359,743	1,088,176	80.00%	4.53
1996	1,765,019	1,332,356	75.50%	5.45
1997	1,919,307	1,537,341	80.10%	6.18
1998	2,012,141	1,553,874	77.20%	6.14
1999	2,000,689	1,609,884	80.50%	6.26
2000	2,021,689	1,617,582	80.00%	6.19
2002	2,045,435	1,656,624	81.00%	6.15
2003	2,249,508	1,839,165	81.80%	6.72
June 2004	2,328,658	1,943,460	83.50%	7.06

2.2.2.3. The Cellular market of Peru

The cellular as well as the data services markets of Peru were the main contributors to the growth in the telecommunications market of Peru in 1998-2002 (OSIPTEL). As can be seen in Table 5, in 1993, there were about 37,000 mobile subscribers in Peru, while in June 2004 there were 3,414,590 of them. The number of mobile subscribers exceeded the number of fixed lines in the year 2001. The mobile teledensity in June 2004, 12.39 percent, also exceeds the fixed lines teledensity which was only 7.06 percent at that time (Table 4).

Table 5 - Mobile subscribers and teledensity. Source: OSIPTEL

Year	Mobile Subscribers	Mobile Teledensity
1993	36,881	0.16
1994	52,000	0.22
1995	75,397	0.31
1996	201,895	0.83
1997	435,706	1.75
1998	736,294	2.91
1999	1,045,710	4.06
2000	1,339,667	5.12
2001	1,793,284	6.76
2002	2,306,943	8.56
2003	2,930,343	10.71
March 2004	3,142,889	11.45
June 2004	3,414,590	12.39

Four operators provide cellular services: Telefonica, Bellsouth, Nextel and TIM. Telefonica is the main operator out of Lima – in the provinces. Table 6 shows the amount of subscribers in Lima and the provinces, and the type of payment used.

Table 6 - Types of mobile subscribers and their location. Source: OSIPTEL

	Lima	Provinces	Total	% in Provinces
	Jun-04	Jun-04	Jun-04	Jun-04
Prepaid	1,828,677	855,098	2,683,775	**31.86**
By Contract	564,312	166,503	730,815	**22.78**
Total	**2,392,989**	**1,021,601**	**3,414,590**	**29.92**
% Prepaid	**76.42**	**83.70**	**78.60**	

The number of subscribers in the provinces is about 29 percent of the Peruvian mobile subscribers. This figure matches the figure that 72 percent of the cellular base stations are located in Lima (Boyd, 2004). Taking into account Navas-Sabater *et al* (2002) estimation that 80 percent of subscribers outside the main urban center are located in minor urban centers, and the fact that the cellular coverage in Peru is mainly limited to the urban centers, I can conclude that the amount of rural people who own/use mobile phones in Peru can be neglected.

It is also interesting to note that 78 percent of the mobile subscribers are prepaid subscribers. This percentage of prepaid users is slightly higher in the provinces, but also in Lima, where the population's socio economic status is higher, this number reaches 76 percent. High percentage of prepaid subscribers is typical to developing countries. For comparison, in the Partner-Orange GSM network in Israel, the prepaid subscribers were only 30 percent of the subscribers base, as of December 2003 (Partner Communications, 2004).

2.2.2.4. Public payphones in Peru

Since Gilat installs satellite public payphones, and my work will analyze traffic figures of rural public payphones network, it is important to view several figures regarding payphones spread in Peru. In Table 7 we can clearly see the increase in the number of public pay phones following the market privatization. The public phone lines teledensity is quite low, but it is important to remember that as opposed to fixed line that serves a single household or business, a public phone servers numerous users.

Table 7 - Public Payphones – number and teledensity. Source: OSIPTEL

Year	Public phone lines	Teledensity - lines per 100 inhabitants
1993	8,032	0.035
1994	13,711	0.058
1995	24,426	0.102
1996	34,181	0.14
1997	40,129	0.161
1998	49,399	0.195
1999	63,276	0.246
2000	85,672	0.328
2001	94,596	0.356
2002	109,518	0.406
2003	123,002	0.45
June 2004	133,439	0.484

Table 8 shows Gilat's share in the provision of communications via public pay phones.

Table 8 - Public Payphones - by company. Source: OSIPTEL

	Telefónica	BellSouth	Gilat to Home	Telmex	Americatel	Gamacom	Rural Telecom	TOTAL
1993	8,032							**8,032**
1994	13,199	512						**13,711**
1995	22,580	1,846						**24,426**
1996	32,311	1,870						**34,181**
1997	38,290	1,839						**40,129**
1998	47,040	2,359						**49,399**
1999	60,789	2,487	**232**					**63,508**
2000	81,253	2,594	**240**					**84,087**
2001	92,360	2,123	**1,553**					**96,036**
2002	107,280	1,927	**4,467**	160				**113,834**
2003	115,502	7,046	**5,780**	294	1		793	**129,416**
June 2004	119,302	7,153	**5,709**	267	1	141	866	**133,439**

2.2.2.5. Figures per departments

Table 9 presents figures of selected criteria by departments.

Table 9 - Departmental figures. Figures were collected from various OSIPTEL sources.

Department	Number of fast Internet connections June 2004	Number of mobile subscribers June 2004	Number of public phones - Telefónica June 2004	Number of Fixed lines in service June 2004
Amazonas	179	3,491	509	4,910
Ancash	2,250	60,588	4,170	46,584
Apurimac	307	5,250	751	5,867
Arequipa	3,066	172,883	7,517	92,655
Ayacucho	554	14,282	1,348	11,803
Cajamarca	1,194	45,748	2,033	22,927
Cusco	1,862	58,726	4,369	39,936
Huancavelica	159	1,294	408	2,471
Huánuco	653	15,411	1,213	11,922
Ica	1,711	61,290	2,538	42,436
Junín	1,719	58,661	5,234	46,935
La Libertad	4,059	158,314	7,029	98,337
Lambayeque	2,680	91,086	4,483	60,046
Lima & Callao	85,205	2,392,989	62,555	1,273,488
Loreto	10	25,908	1,798	26,320
Madre de Dios	0	2,124	253	2,710
Moquegua	507	15,156	907	9,385
Pasco	232	4,163	481	4,184
Piura	2,741	93,585	4,198	59,800
Puno	875	41,488	2,049	20,730
San Martín	37	9,368	1,496	17,549
Tacna	869	51,679	2,039	19,455
Tumbes	227	14,981	485	8,449
Ucayali	585	16,125	1,439	14,561
Total	**111,681**	**3,414,590**	**119,302**	**1,943,460**

It is interesting to note, that when dividing those figures with the number of inhabitants in each department, to calculate departmental teledensity, a notable difference exists between the departments. The teledensity in more developed departments is higher than in the less developed ones. This teledensity gap between the rich and the poor departments is relevant to all means of communications: fixed lines, public pay phones, mobile lines and fast internet connections. Mobile lines and internet connections have the most extreme teledensity gap, demonstrating the "digital divide" which is especially significant in the provision of modern communications media.

2.2.2.6. Long distance and international traffic figures

Table 10 lists the volume of domestic as well as international long distance minutes conducted in Peru telephony systems. Note the increase in International minutes, especially incoming international minutes. Competition in the international long distance market of Peru has started in 1999 following the monopoly deregulation (Vidal, 2003). One of the immediate results of deregulation was a decrease in prices: At the end of the first year of deregulation, prices dropped up to 84 percent, causing the dramatic increase in international minutes. The number of incoming international calls is higher than the number of outgoing international calls, due to affordability reasons. Most Peruvians cannot afford calling abroad or conducting lengthy calls. On the other two and a half million Peruvians live and work abroad, and many of them send remittances to their relatives back in the homeland, and naturally call them as well. According to Gilat Peru, that sort of phone calls holds a significant share in the volume of incoming international calls to Peru.

Table 10 - Long distance minutes. Source: OSIPTEL

Traffic Type	1999	2000	2001	2002	2003
Domestic Long Distance	826,362	859,962	878,287	889,159	988,332
Outgoing International	107,616	107,916	109,788	144,690	188,099
Incoming International	293,835	458,592	792,685	1,079,700	1,561,629
Relation between Incoming and Outgoing international minutes	2.73	4.25	7.22	7.46	8.30

2.2.3. FITEL contracts and Gilat

The government of Peru has given high priority to the integration of rural areas into the overall Peruvian economy, and considered telecommunications to be a vital means for accomplishing this objective. The government set the principles for rural communications, gave guidelines to the FITEL fund, and its supervision by OSIPTEL. National Statistics and Informatics Institute (INEI) provided the data according to which population centers were selected for the various FITEL development projects, according to government guidelines regarding "Preferential social interest areas" – such as border areas, areas with terrorist activity, areas with potential of drug trafficking, areas prone to natural disasters, and areas of particular impoverishment.

OSIPTEL defined two stages for the deployment of rural communications services using FITEL fund (San Román, September 2002), each stage is comprised of one or more projects.

Stage 1 (FITEL I-II-III) – Coverage of rural population centers with less than 3,000 inhabitants – total of 5,000 locations (3.9 million rural inhabitants), and the provision of Internet access for 500 rural district capitals.

Figure 18 shows FITEL stage 1 projects – FITEL I to III, each project with the planned number of VSATs to be deployed and the installation areas.

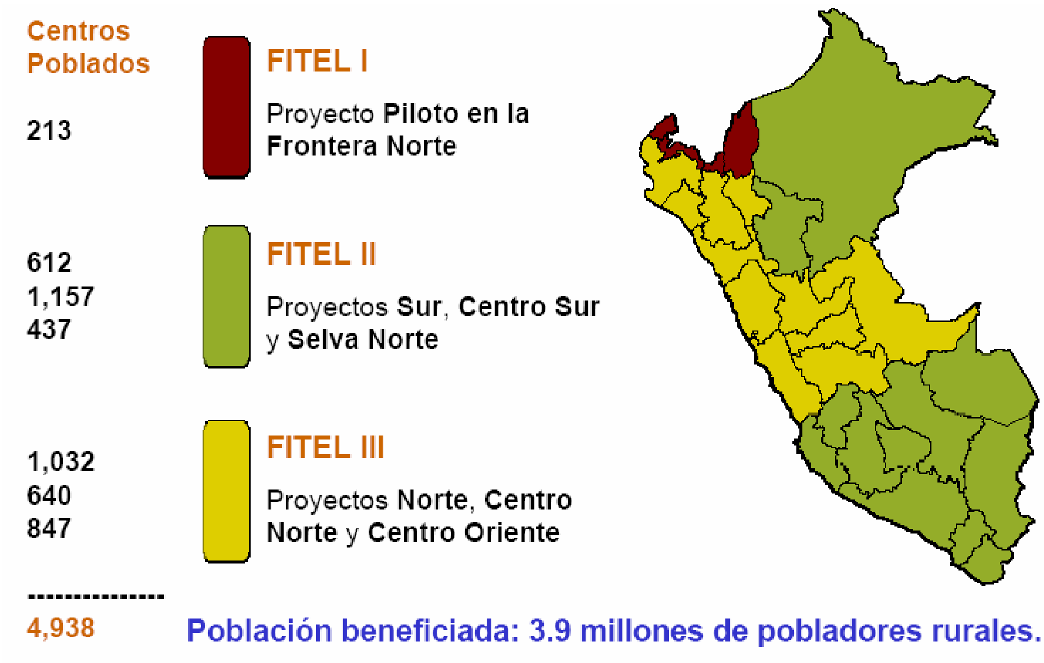

Figure 18 - FITEL stage 1 contracts I - II - III. Source: OSIPTEL

Stage 2 (FITEL IV) – Increasing public payphone teledensity in provinces and locations with insufficient service (approximately 1,600 locations with population of 1,000 – 5,000 inhabitants, 1.8 million inhabitants).

Figure 19 shows FITEL stage 2 project – FITEL IV, with the planned number of VSATs to be deployed and the installation areas.

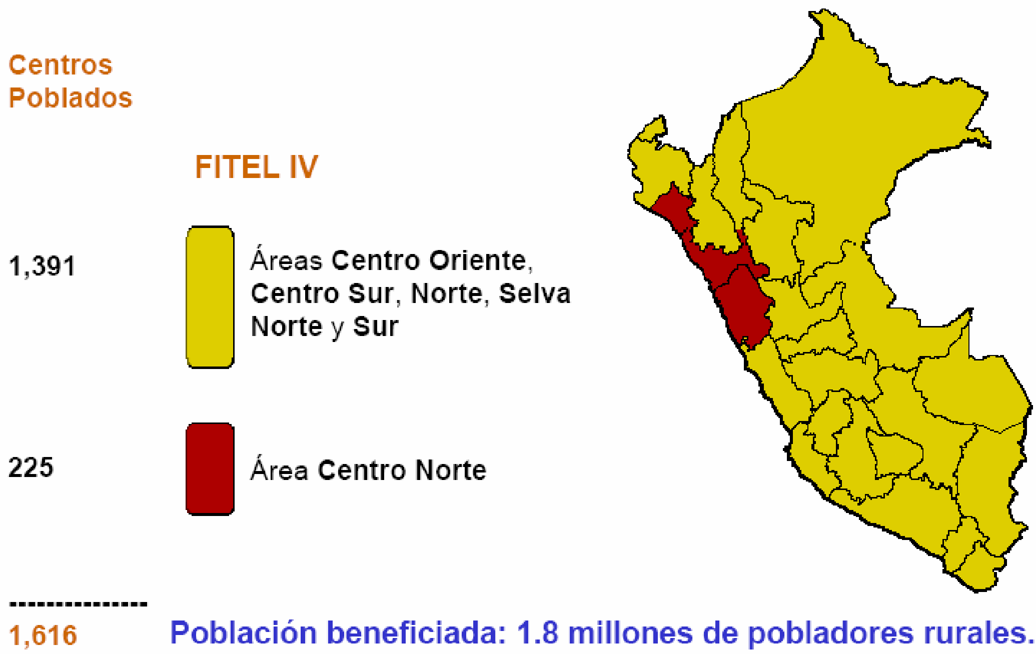

Figure 19 - FITEL stage 2 contract - IV. Source: OSIPTEL

2.2.3.1. Gilat's FITEL network in Peru

Gilat to Home Peru, a subsidiary of Gilat Satellite Networks, won most of FITEL bids, for the building, operating and maintaining of rural communications sites. Gilat to Home Peru headquarters and operations center is located in Lima. Gilat provides its services using a VSAT network, with a hub located at the headquarters in Lima. The network utilizes "Dialaway IP" brand VSATs, which can support telephony conncetion as well as IP connection for Internet access. In places where electricity is not available, the VSAT is powered by a battery charged by solar panels. Installations and maintenance is done by Gilat's local subcontractors throughout Peru. Table 11 lists the numbers of VSATs installed by Gilat as part of FITEL projects. Gilat installed VSATs in 21 out of the 24 departments of Peru, most of them in the poor Sierra departments.

Table 11 - Number of VSATs installed by Gilat by FITEL projects, departments and areas.

Department	Area	FITEL I	FITEL II	FITEL III	FITEL IV	TOTAL
Amazonas	Norte	64	3	208	62	337
Ancash	Centro Norte	0	0	0	0	0
Apurimac	Centro Sur	0	205	0	73	278
Arequipa	Sur	0	148	0	46	194
Ayacucho	Centro Sur	0	261	0	87	348
Cajamarca	Norte	58	9	603	126	796
Cusco	Centro Sur	0	387	0	116	503
Huancavelica	Centro Sur	0	224	0	60	284
Huánuco	Centro Oriente	0	3	314	72	389
Ica	Centro Sur	0	50	0	27	77
Junín	Centro Oriente	0	10	203	122	335
La Libertad	Centro Norte	0	0	0	0	0
Lambayeque	Centro Norte	0	0	0	0	0
Lima & Callao	Centro Oriente	0	11	159	76	246
Loreto	Selva Norte	0	222	0	47	269
Madre de Dios	Centro Sur	0	29	0	11	40
Moquegua	Sur	0	62	0	12	74
Pasco	Centro Oriente	0	0	95	54	149
Piura	Norte	63	2	221	118	404
Puno	Sur	0	351	0	151	502
San Martín	Selva Norte	0	192	0	93	285
Tacna	Sur	0	38	0	6	44
Tumbes		28	0	0	19	47
Ucayali	Centro Oriente	0	6	76	13	95
Total		213	2213	1879	1391	5696

Figure 20 is intended to give a general idea about the location of VSATs all over Peru. Each red dot presents one VSAT, according to the VSAT list and locations from the Gilat NMS database.

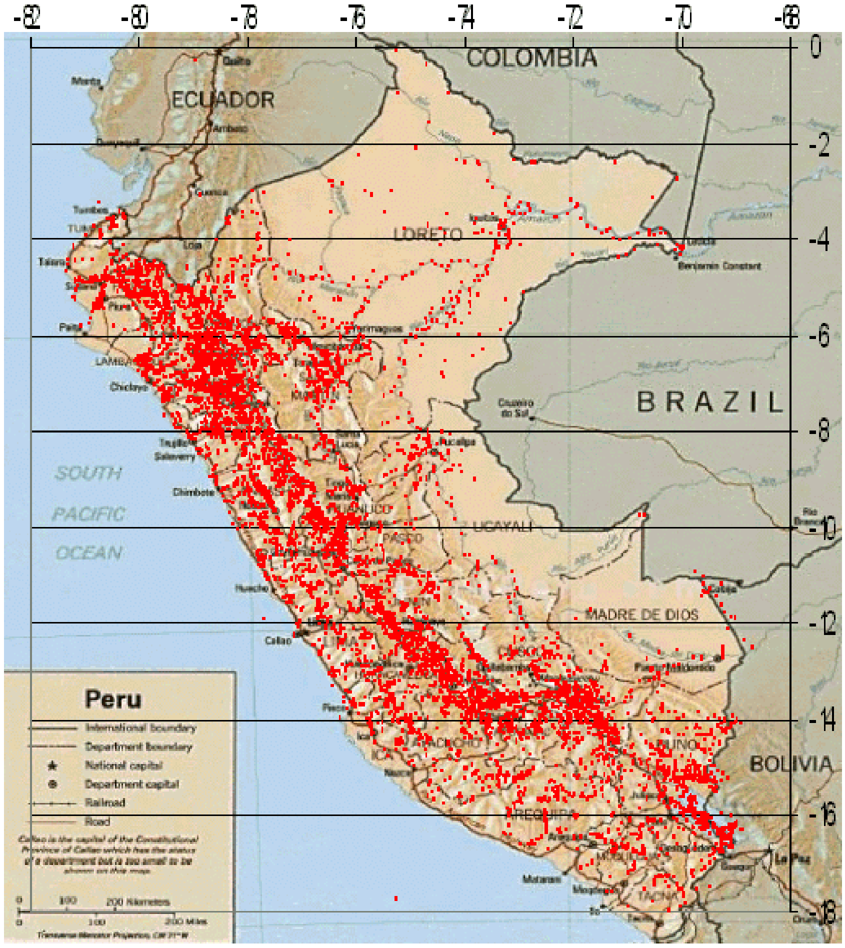

Figure 20 - Gilat to Home Peru VSATs locations in Peru. Source: NMS Database

It can be clearly seen from the figure, that most installed VSATs are concentrated in the Sierra region. The government of Peru aimed on improving telecommunications infrastructure especially in this region, which is the poorest in Peru. Less VSATs were installed in the Costa region and only a relatively small portion was installed in the Selva, mainly because of the scarce population in this region. Note that the red VSAT dots in the Selva departments – Loreto, Ucayali and Madre de Dios almost create the form of the rivers along which they are installed, since most villages are located by the rivers which serve as waterways and sources of life in the jungle. In addition, a notable number of VSATs was installed on the borders, as the government wished to strengthen its control over the frontiers area.

Figure 21 shows OSIPTEL representation of rural populated places equipped with a telephone before implementing FITEL projects (in green, on the left) and after implementing FITEL projects (in red, on the right). The figure illustrates the increase in phones especially in the Sierra region.

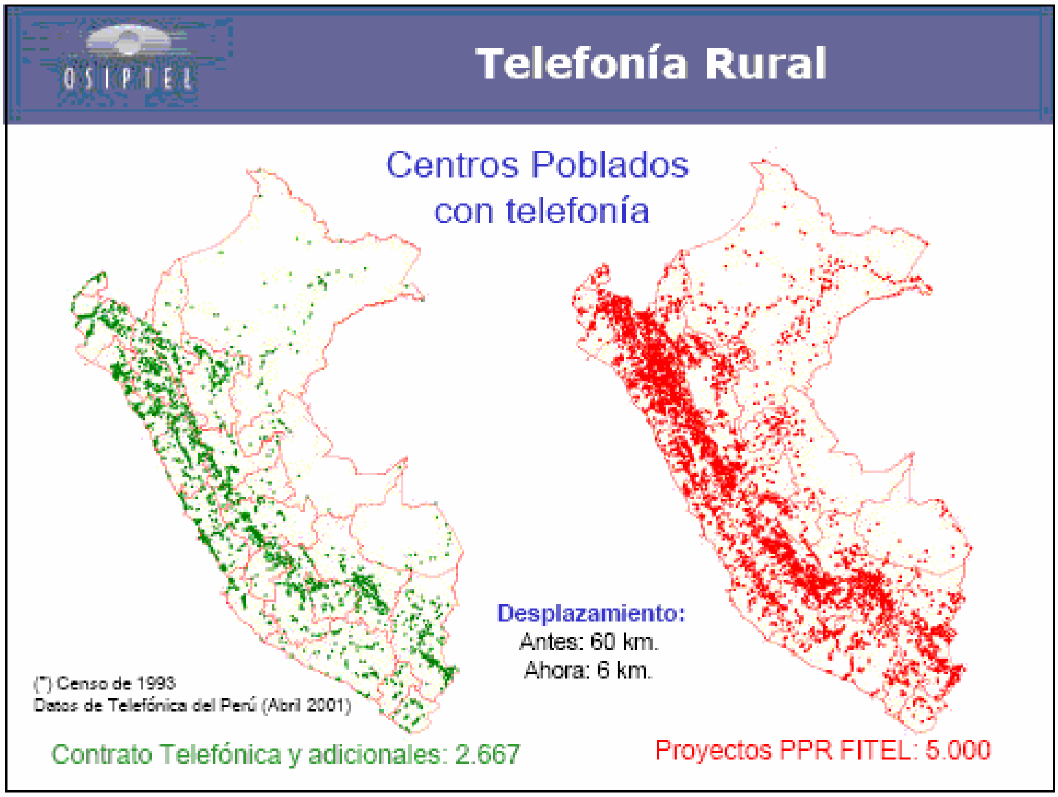

Figure 21 - Rural populated places with telephones. Source: OSIPTEL

Table 12 describes FITEL achievements in the provision of telecommunication services to the rural areas, mainly the reduction of the average distance to a phone from 56 Km to 5.7 Km.

Table 12 - FITEL program summary statistical data. Source: OSIPTEL / FITEL

	FITEL I	FITEL II	FITEL III	FITEL IV	Total / Average
Approximate number of sites	213	2,170	2,520	1,614	6,517
Population (Millions)	0.14	1.6	2.1	2.9	6.74
Population / Site	689	758	827	1,822	1,024
Average Distance (prior)	90 Km	54 Km	24 Km	-	56 Km
Average Distance (post)	5 Km	8 Km	4 Km	-	5.7 Km

2.2.3.2. Using village phones

As described above, using prepaid communications is ideal for the rural community, which doesn’t always have the financial means, and needs to communicate scarcely.

The network of Gilat Peru utilizes a prepaid scheme. Villagers buy a prepaid card branded "Mifono", identified by a secret PIN number. Each card is initialized with a certain value.

When a caller wishes to conduct a call, he performs the following steps:

- Picking up the handset.
- Dialing 99# - access code to the prepaid system.
- Dialing the PIN number.
- Listening to an automated message stating the card balance. If the card still has credit, dialing destination phone number.
- Conducting the call.
- Hanging up.

3. Research design

3.1. Research questions

Due to the pioneering character of this research, I could hardly find reference material directly dealing with the subject of the research. With no much background to hold on, I decided to pose research questions rather than try to build assumptions which are not well established. While analyzing the data, I was in continuous contact with Gilat Peru personnel regarding my findings. They assisted with important insights about the system, and inspired me to perform calculations and analyses on aspects that I did not consider at the first place. Therefore, the research questions that I present as follows are based on questions posed while preparing the research proposal as well as questions inspired by the findings and inputs from Gilat Peru.

The research questions were as follows:

- How do traffic characteristics of the telephone usage evolve over time after the telephone was installed in the village (Length of calls, duration of calls)?
- What are the peak hours of the telephone usage?
- What is the influence of the day of the week on traffic patterns?
- What are the destinations of calls made from villages?
- What are the origins of calls made to villages?
- What are the characteristics of international calls to and from the villages?
- How do traffic characteristics differ among various areas in Peru?

3.2. Research area

In light of the variety of research questions and traffic aspects, the study is consisted of several separate analyses, each focused on a specific research question or traffic aspect. Due to that reason, in addition to data availability constraints, each analysis is done on a different research area. The areas I selected for each of the analyses differ among them in scale and location. Some take into account the whole network, some are done on a department scale, and some are focused on a group of selected

VSATs. Further definitions of research areas will be presented in the analyses and findings chapter.

3.3. Time framework

Analyses are based on details of calls made between December 2002 and August 2004. Additional information about exact time framework for each of the analyses will be described further on in this chapter and in the relevant analyses sections.

Field trip in Peru was conducted between May 25th and June 13th, 2004.

3.4. Methodologies

The main purpose of this study is to perform a quantitative research based on the analysis of traffic database of the network which is comprised of Call Details Records (CDRs) (For explanation about CDRs refer to the technological background chapter at page 24). The Gilat Peru telephony network creates over 240,000 CDR lines per day. Stored as textual files, CDRs of one day consume over 125 Megabytes of disk space. Gilat Peru stores all CDR files in a database as well as on CDs for backup.

For this study, I analyzed the CDRs by two methodologies:

1. Performing direct queries and manipulations on selected CDRs.
2. Performing calculations on aggregated CDR data imported from Gilat Peru reports system.

It is important to note, that each one of the research questions and aspects I examined required a specific different analysis scenario. Therefore, in this section I will describe the general steps of analysis I performed for each of the methodologies, while detailed description of each analysis scenario will be described in the relevant section in the analysis and findings chapter.

3.4.1. Performing direct queries and manipulations on selected CDRs

In this methodology, I obtained raw CDR files from Gilat Peru and imported them into an SQL Server database. The structure of the records in the database table resembles the structure of the call details record created by the NMS. Due to the huge amount of data to be processed, I defined two datasets, and selected the time periods to be imported. In total, I imported to the database 26,403,121 CDRs, representing the traffic of the 108 selected days (Detailed in Table 13). I then used "SQL Query Analyzer" to perform queries on the database.

Table 13 - CDR datasets imported to the database

CDR Dataset	Months	Days
1	December 2002 – February 2003	22-31/12/2002 1-15/1/2003 17-19/1/2003 22-31/1/2003 1-16/2/2003 Total: 54 days
2	November 2003 – May 2004	1-12/11/2003 1-12/1/2004 1-17/3/2004 1-13/5/2004 Total: 54 days

The reason for the separation into two datasets is the extensive numbering change in Peru telephone numbers that took place in the beginning of March 2003. The numbering plan changes dealt mainly with the area codes. Prior to the change, there were only eight area codes in Peru. Area code "1" was assigned to Lima, and the other seven – to the other departments. Thus, several departments had the same area code. As can be seen in Table 14, following the change, each department is now assigned with a unique area code. Since some of my analyses are based on analyzing area codes of numbers, in order to determine the area of originating and terminating calls, working on dataset 2 is more convenient, because it holds calls details after the numbering plan change, thus, can give a more accurate pinpointing to the area.

Table 14 - Area codes of Peru before and after the numbering change. Source: Peru MTC

DEPARTMENT	Old Area Code	New Area Code	Number of digits
Lima	1	1	7
Ica	34	56	6
Cajamarca	44	76	6
Amazonas	44	41	6
La Libertad	44	44	6
Ancash	44	43	6
Arequipa	54	54	6
Puno	54	51	6
Moquegua	54	53	6
Tacna	54	52	6
Huánuco	64	62	6
Pasco	64	63	6
Huancavelica	64	67	6
Ayacucho	64	66	6
Junín	64	64	6
Ucayali	64	61	6
Tumbes	74	72	6
Piura	74	73	6
Lambayeque	74	74	6
Apurímac	84	83	6
Cusco	84	84	6
Madre de Dios	84	82	6
San Martín	94	42	6
Loreto	94	65	6

3.4.1.1. Characteristics of phone numbers

In order to understand the complications in analyzing the CDR database, especially in respect to phone numbers, it is important to understand the characteristics of phone numbers as they appear in the CDRs.

3.4.1.1.1. Destination phone numbers

Destination phone numbers in the CDRs do not pose any difficulty in analysis because they reflect the actual number dialed by the caller, which represents a true physical line (whether a fixed line, mobile subscriber or public pay phone).

Destination phone numbers - VSATs outgoing dials

The domestic long distance dialing prefix in Peru is "0", and the international dialing prefix is "00". The format of the destination phone numbers in the CDR is as follows:

Domestic calls to Lima: 0-1-[7 digits number]

Domestic calls to other departments: 0-[2 digits area code]-[6 digits number]

Therefore, a valid domestic destination phone number in the CDR has 9 digits.

For International calls, the length may vary, so the format of the number in this case will be: 0-0-[at least 9 digits]

Destination phone numbers – incoming dials to VSATs

Destination phone numbers of VSATs in the CDRs may take two formats: [area code]-[number] as well as 0-[area code]-[number].

This complicates the analysis, and will be discussed further in the relevant section that describes specific queries.

3.4.1.1.2. Source phone numbers

Source phone numbers are more difficult to analyze, because not always a true physical line is represented by the source number. It is important to distinguish between two terms:

CLID – *Calling Line Identification*, which is an actual directory number of a calling party.

ANI – *Automatic Number Identification*, which is the number passed by the calling party's exchange to the network.

The number seen in the CDR is the ANI received by Gilat from PSTN operators, and may not represent a real line.

Source phone numbers – incoming dials to VSATs

When the call is originated in a fixed line or a mobile subscriber, the ANI will be the true CLID, and the number will take the format [area code]-[number].

But in other cases, the source phone number in the CDR shows a "fake ANI":

1. International incoming calls – Carriers that route incoming international calls use a "mask ANI". Telefonica del Peru uses the mask: 2-19YY-XXX where 19YY is the identification code of the long distance carrier. Telmex Peru (Former AT&T) uses the masks: 5623380155 and 5623387595. Searching for these formats in the CDRs may help finding information about incoming international calls to VSATs.
2. Calls originating in public payphones – all calls originating from public payphones appear under one or a few "mask ANIs" per area code. For instance, 13987100 is used as a mask for public phones in Lima. The mask ANIs for public payphones always take a number prefix which is part of the payphones prefixes numbering plan. Since I have the detailed numbering plan of Peru, I can distinguish the payphones originating calls to find information about calls from public phones.
3. Calls originating in various prepaid services – these take various mask ANIs.

Source phone numbers – VSATs outgoing dials

Source phone numbers of VSATs in the CDRs take the format: [area code]-[number].

3.4.1.2. Numbering plan

Most telephone exchanges in the world, including in Peru, are installed in a specific place, providing services to subscribers in the neighboring areas. Each telephone exchange can support a limited amount of phone lines, and thus assigned with a set of numbers for those lines, as part of the country's national numbering plan. Each exchange is given a prefix number, and a series of numbers for the lines supported by this exchange. Thus, the structure of a national telephone number takes the form:

[area code] [exchange prefix] [number of line in exchange]

For example: the number 39228292 in Israel can be divided as follows:
3- Israel Center Area Code
922-Prefix of an exchange in the city of Petah-Tikva
8292-Number of subscriber line in that exchange

For mobile subscribers, the number assignment does not always take the same form. In Israel, for example, a unique area code is given to each of the cellular operators. In Peru, there are no unique area codes for cellular operators, but unique prefixes within each of the area codes.

3.4.1.3. Using the "Maestro De Numeración"

The "Maestro De Numeración" is an Excel sheet containing the full list of all telephone exchanges and services in Peru. This sheet was provided by Gilat Peru. For each Area code, prefix and line range, the maestro specifies the location of the exchange, the service type provided, and the operator.

Table 15 - Sample from the "Maestro de Numeracion" file. Source: Telefonica del Peru

Department	Location	Area Code	Prefix	Start	End	Service Type	Operator
LIMA	CHACARILLA	1	298	0790	0889	TELEFONIA PUBLICA	TELEFONICA DEL PERU
SAN MARTIN	RIOJA	42	55	8000	9023	TELEFONIA FIJA	TELEFONICA DEL PERU

Table 15 shows an example of two entries in the maestro:
First row – set of numbers (1-2980790 to 1-2980889) in Chacarilla in the department of Lima, used for public phones operated by Telefonica del Peru.
Second row – set of numbers (42-558000 to 42-559023) in Rioja in the department of San Martin, used for fixed telephone lines operated by Telefonica del Peru.

Since CDRs contain information about calling and called phone numbers, the maestro can provide valuable information for analysis of those numbers, in terms of location and service type.

3.4.1.4. Identifying calls to/from VSATs and to/from PSTN

The ID field in the CDR is also useful for queries and analysis. The ID specifies the end-units of the calls in the Gilat VSAT network. The VSATs with their unique ID are the end-units on the payphone side, and the HVPs (*Hub Voice Processor*) are the hub components which serve as gateways to the PSTN (There are about 50 HVPs in the Dialaway IP network in Peru). VSAT IDs are always larger than 1000, while HVP IDs are always lower than 1000. Therefore, depending on the types of calls, the ID formats in the CDR will take the format:

Type of Call	Source ID is	Destination ID is
VSAT to VSAT	> 1000 (VSAT)	> 1000 (VSAT)
VSAT to PSTN	> 1000 (VSAT)	< 1000 (HVP)
PSTN to VSAT	< 1000 (HVP)	> 1000 (VSAT)

Using conditions on the IDs, I can distinguish between types of calls while conducting the queries on the CDRs.

3.4.2. Calculations on aggregated CDR data

CDRs are also fed into a reports system operated by Gilat Peru. The reports system contains CDR information from March 2003 till today. It provides basic analysis and aggregation tools that enable to view traffic figures of a single VSAT, group of VSATs or the whole network, for a specified time period. A group of VSATs can be selected for administrative department and/or project (FITEL I, II, III, IV). After the user selects the criteria, the system produces a report which includes the following data for the specified criteria:

1. Total number of call minutes.
2. Total number of calls.
3. Average duration of calls.
4. Number of local call minutes.
5. Number of local calls.
6. Average duration of local calls.
7. Number of long distance (LDN) call minutes.
8. Number of long distance (LDN) calls.
9. Average duration of long distance (LDN) calls.

10. Number of international (LDI) call minutes.
11. Number of international (LDI) calls.
12. Average duration of international (LDI) calls.

Such data set is provided for both outgoing and incoming calls.

These sets of variables will be referred later in this study as "Reports system basic set of figures".

Since the criteria according to which VSATs can be selected by this tool are quite limited, I used this tool as a means to get raw data. I then imported the data to Excel worksheets for further analysis, in order to get the desired calculation.

Further description of the analysis will be provided in chapter 4 - "Analysis and findings", concerning each analysis I performed.

3.5. Auxiliary figures

In addition to the CDRs, I obtained additional data which were crucial to complete the analysis:

Type of Data	Source	Specific figures
List of all VSATs	NMS (Network Management System) Database	VSAT ID, VSAT name, Location, coordinates of the location – Longitude and Latitude, department of location and project name.
List of VSAT installations	Gilat Peru operations center	VSAT ID, location: site name, district, province, department, telephone numbers assigned to the VSAT, installation date, project (FITEL I,II,III,IV).

3.6. Geographical location

In order to place sites and select sites spatially I used several tools and data sources. VSATs list and list of installations provided by Gilat Peru and taken from the NMS database provided with basic information about location of installed VSATs. In addition, I used another tool of Gilat Peru – An online GIS (Geographical Information System) tool. This tool holds a database of all the VSATs in the system, and can present their details and status on a map of Peru. I used this tool for assistance in sampling VSATs.

Further information about the location of places in Peru was taken from an online database of locations around the world, available in the following web site: http://www.traveljournals.net/explore/peru

4. Analysis and findings

4.1. Change in the amount of calls and calls duration over time after installation

This analysis focuses on the development of traffic patterns during the first months following the VSAT installation. A sample of VSATs is used to calculate and present the change in the number of calls and the duration of calls in this time framework.

4.1.1. Steps of Analysis

Methodology used: calculations based on reports system output.

1. Sample of VSATs:

   Analysis was based on a sample of 19 VSATs. These VSATs were randomly chosen from 4 different departments, spread all over the departments' areas. The limit on the selection was to find VSATs that were installed in the same one month time frame: between February 16th and March 19th 2003. Table 16 shows the locations of the VSATs, their departmental association and their installation date.

Table 16 - Selected VSATs for analysis of change of calls and call duration over time after installation

Location	Department	Installation Date
VILLAMAR (VILLA MAR)	HUANUCO	16/02/2003
YOMBLON	AMAZONAS	17/02/2003
SAN MIGUEL DE VELAPATA	AMAZONAS	19/02/2003
TRES DE MAYO RODEO	HUANUCO	19/02/2003
YURAJHUANCA	PASCO	19/02/2003
PINRA	HUANUCO	19/02/2003
LA HUECA	PASCO	21/02/2003
LANTURACHI	PASCO	21/02/2003
CHILCHOS	AMAZONAS	22/02/2003
VILLA AMERICA	PASCO	24/02/2003
SANTA ROSA DE CHUCHURRAS	PASCO	24/02/2003
HUANCAPALLAC	HUANUCO	28/02/2003
SAN MIGUEL DE LA REYNA (SAN MIGUEL)	AMAZONAS	01/03/2003
MALCAS	CAJAMARCA	04/03/2003
EL HUAYO	CAJAMARCA	04/03/2003
ROBLEPAMPA	AMAZONAS	06/03/2003
CHUQUIBAMBA	CAJAMARCA	07/03/2003
SANTA ROSA	CAJAMARCA	14/03/2003
HUAGAL	CAJAMARCA	19/03/2003

2. Data for each one of the 19 VSATs was collected separately using Gilat reports utility. The query in the reports system defined basic set of figures for each VSAT, aggregated to a period of one month. Such a query was repeated for each of the 19 VSATs 13 times – for the months March 2003 to March 2004.
3. The figures were transferred to Excel sheets for further analysis. A separate analysis was performed for each of the 13 months (March 2003 to March 2004), calculating average of all figures taken from the 19 VSATs.
4. Graphs were created in Excel form the calculated data.

4.1.2. Findings

4.1.2.1. Number of calls

Figure 22 represents the average number of outgoing calls per VSAT per month, divided into long distance calls and local calls.

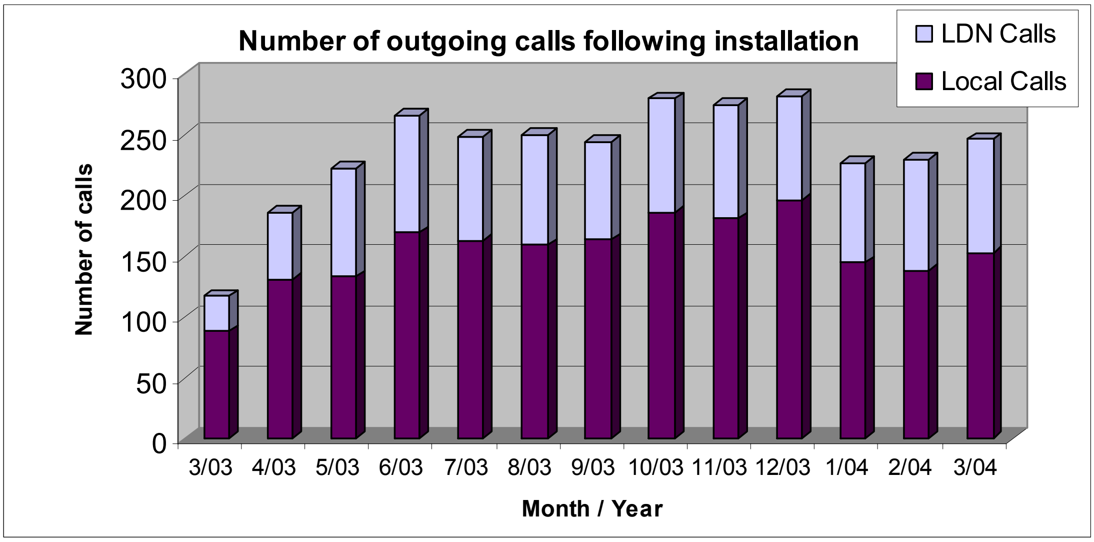

Figure 22 – Number of outgoing calls following installation

Observations from this figure are as follows:

1. We can clearly see an increase in the number of local as well as long distance calls in the first 4 months of the telephone operation.
2. The number of outgoing local calls is significantly higher than long distance calls during the whole period.
3. After June 2003 a sort of "wavy" behavior can be spotted in the number of calls: three months of decrease in the number of outgoing calls, followed by three months of increase, followed again by three months of decrease.

Figure 23 represents the average number of incoming calls per VSAT per month, divided to Long distance calls and local calls.

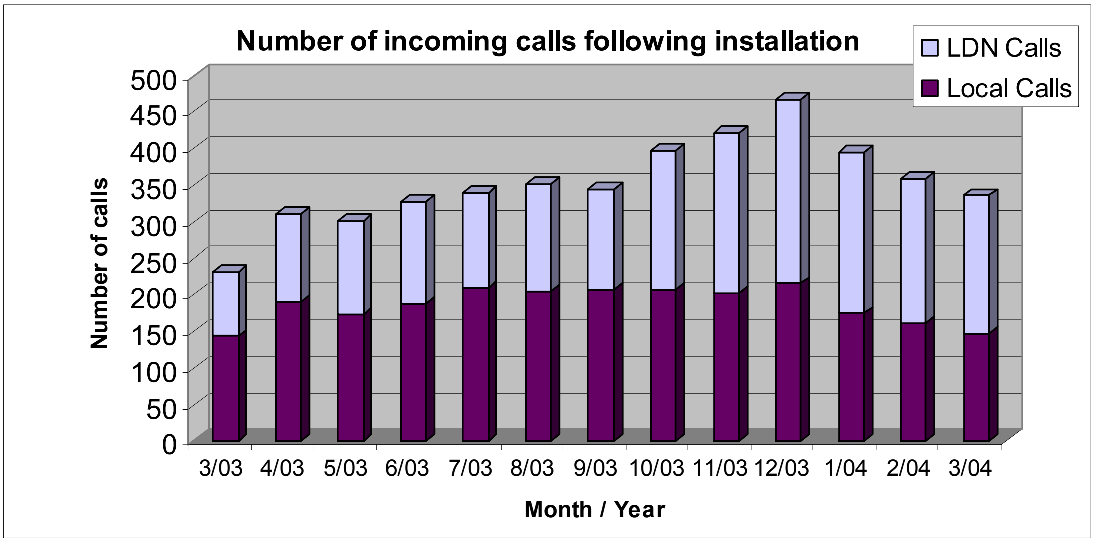

Figure 23 - Number of incoming calls following installation

Observations from this figure are as follows:

1. The increase in the number of incoming calls takes much longer, and lasts about 10 months, as opposed to only 3 months of growth in the outgoing calls. The explanation can be based on the time needed for people to know about the new phone. During the first months people in the village initiate outgoing calls and tell their friends, families and businesses about the new phone. 3-4 months are adequate for them to develop their habits of using the phone. It takes longer until people outside this village, especially in far cities and other departments hear these news and develop the communications habits with the village, such as fixed schedules for calling.
2. The main contributor to the increase in the number of incoming calls is long distance calls. This point is also related to how distance plays a role in spreading the news about the installed phone: The closest big city (from which local calls are made) gets to know about the phone much faster than cities in other departments (from which long distance calls are made).
3. In January 2004, a notable decrease in the incoming calls starts. This trend, together with the "wavy" behavior seen in Figure 22 may be explained by seasonal variations.

4.1.2.2. Duration of calls

Figure 24 shows the average duration of outgoing calls following installation.

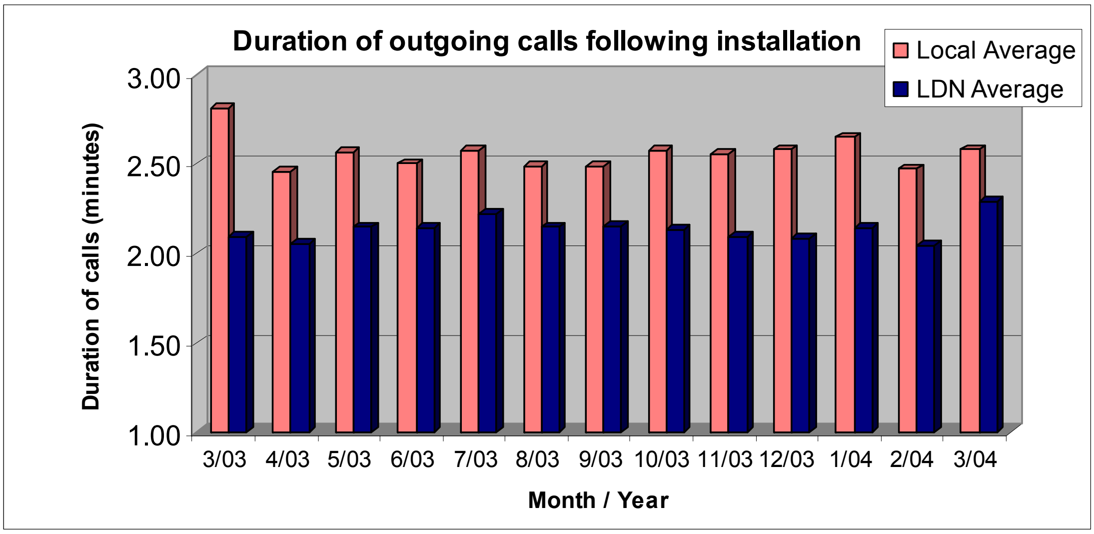

Figure 24 - Average call duration of outgoing calls following installation

Observations from this figure are as follows:

1. Duration of local outgoing calls in the first month following installation is clearly higher than in the following months. This can be explained by local people's enthusiasm of using the new device.
2. Duration of local calls is higher than long distance calls. This makes sense since the price of long distance calls is higher than local calls.
3. Generally there are no significant characteristics changes in call duration along the period.

Figure 25 shows the average duration of incoming calls in the period after the installation.

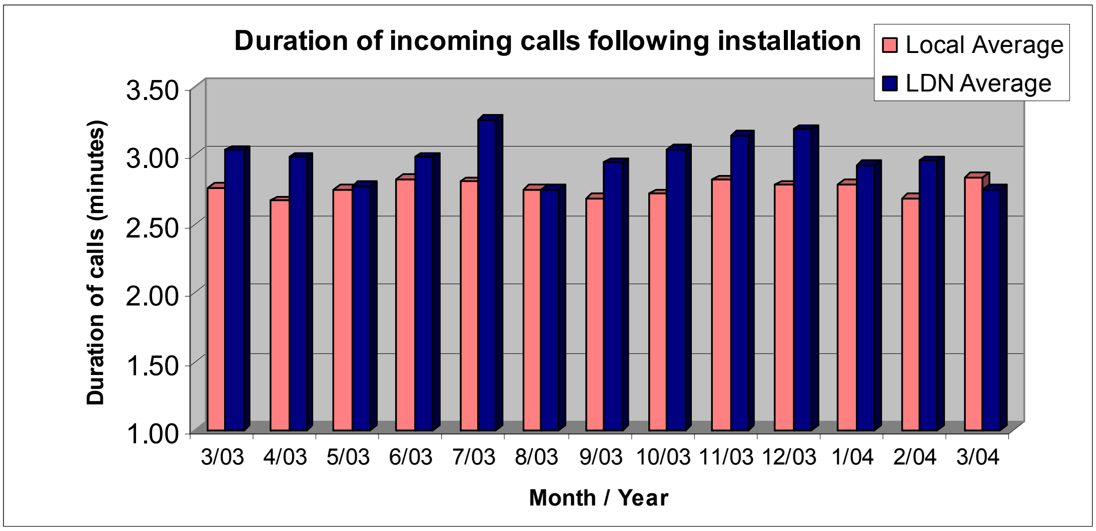

Figure 25 - Average call duration of incoming calls following installation

Observations from this figure are as follows:

1. Generally there is no significant characteristic to call duration along the period.
2. The duration of incoming calls is generally higher than the duration of outgoing calls. This relates to the nature of callers to the VSATs sites: whether family, friends or business, they can afford conducting longer calls than people who live in the remote areas.
3. The duration of incoming long distance calls is significantly higher than the duration of long distance outgoing calls. This can also be explained by the nature of callers: People who call from villages and towns might not be able to afford making long calls, while people calling them can afford this.

4.2. Characteristics of traffic patterns and calls along the week

This analysis will seek answers to the questions how traffic patterns differ along the week, and whether traffic patterns on weekdays are different from patterns seen on weekends.

4.2.1. Steps of analysis

Methodology used: Calculations based on reports system output.

- Queries in the reports system were aggregated to a period of month. In such queries, the basic set of figures is detailed to a resolution of day.
- The month chosen was June 2004 (In analyses in sections 4.2.2.4 and 4.2.2.5, April 2004 was selected as well). Note that in June 2004, Sundays occurred on the dates: 6, 13, 20, 27. June 20 was Father's Day, a Christian holiday which is widely celebrated by Peruvians.
- Aggregation was set to network level (Except for section 4.2.2.3 were it was limited to specific departments).
- Data was transferred to Excel for figures organization and graph compilations.

4.2.2. Findings

4.2.2.1. All calls

The weekly pattern of calls seen in Figure 26 and Figure 27 show a significant growth in the number of calls, both incoming and outgoing, on Sundays.

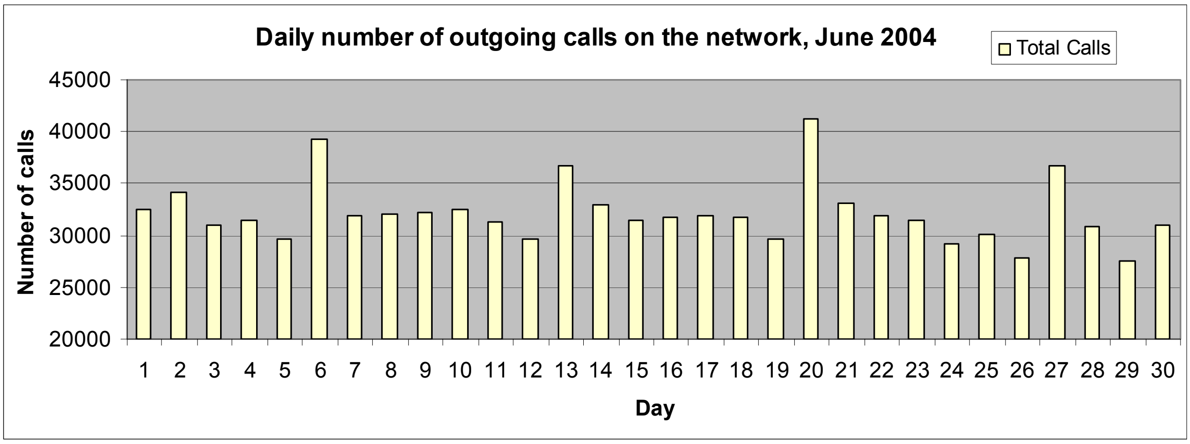

Figure 26 – Daily number of outgoing calls on the network, June 2004

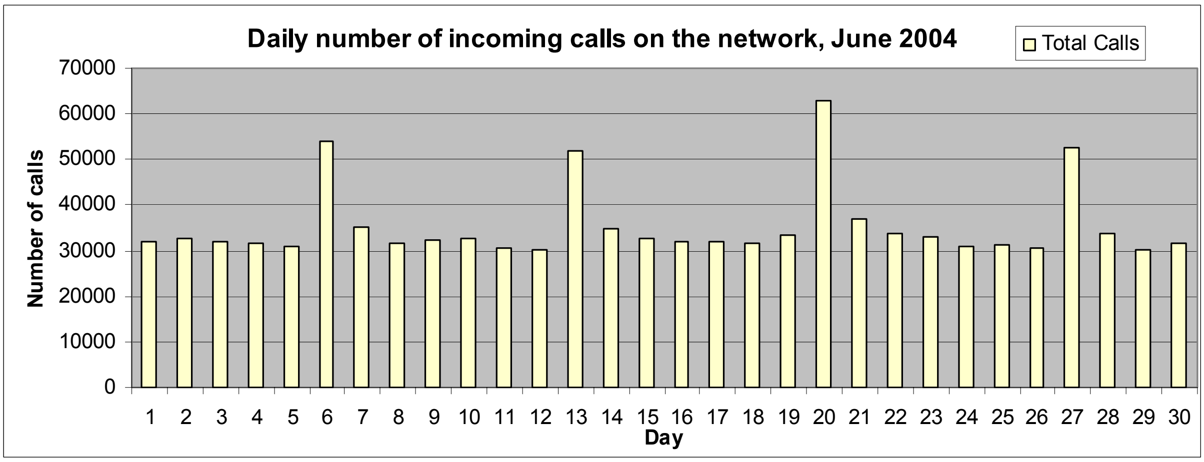

Figure 27 – Daily number of incoming calls on the network, June 2004

Since calls on Sundays are social, these findings emphasize the importance of the social aspect in the use of the telephones. Another example for the social aspect is call patterns during holidays: the increase in June 20 (Father's Day) is especially dramatic, since people tend to conduct more phone calls in festivals and holidays.

In order to better understand the pattern of calls along the week, I analyzed these patterns by call types. The findings are illustrated in the following sections.

4.2.2.2. Local and long distance calls

Figure 28 and Figure 29 focus on daily number of local and long distance calls along the month.

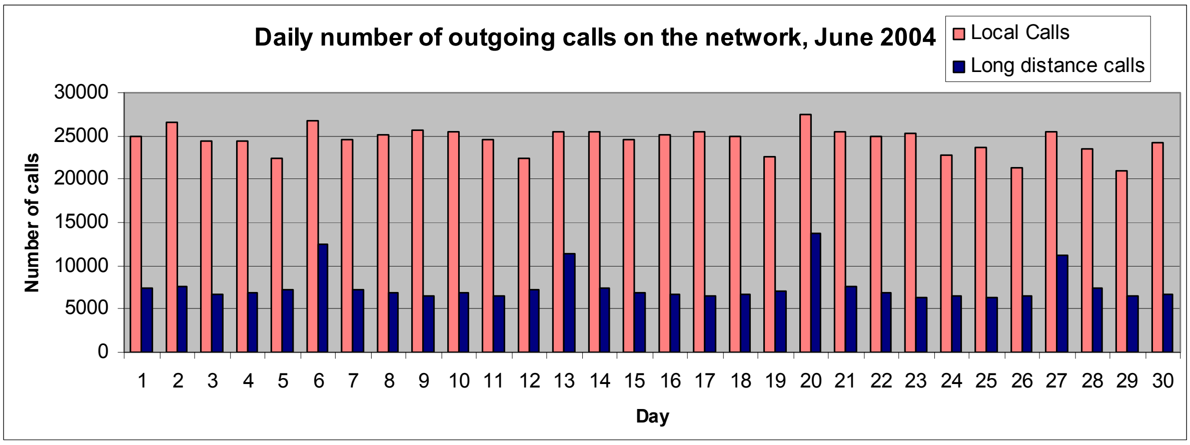

Figure 28 – Daily number of outgoing local and long distance calls on the network, June 2004

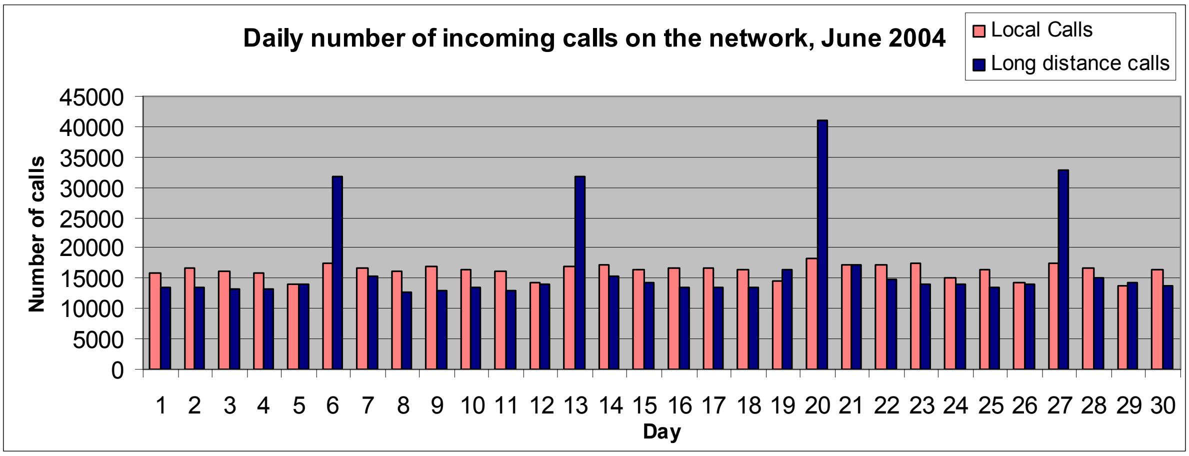

Figure 29 – Daily number of incoming local and long distance calls on the network, June 2004

The trends observed form the findings:

1. Long distance calls - there is a minor decrease during the week, an increase on Saturdays and a significant increase on Sundays.
2. The number of Long distance calls is a significant contributor to the rise in the total number of calls on Sundays. Due to the activity on Sundays, the variation in the amount of long distance calls along the week is high.

3. Local calls - during the week, a slight increase in the amount of local calls is observed towards the middle of the week, followed by a notable decrease towards Saturdays and a minor rise on Sundays.
4. In general, the variations in the number of local calls are not high.

In summary, the high increase in long distance activity on weekends is closely related to the nature of these calls. The calls are social, to friends and family members who left the villages and towns to live in other departments. The high number of calls on June 20, Father's Day, further illustrates the social issue.

4.2.2.3. Local calls – department cases

According to the findings in the previous section, the patterns of local and long distance calls are different: while a notable peak in the number of long distance calls appears on Sundays, number of local calls does not rise dramatically on Sundays but rather has a slight increase in the middle of the week (Figure 28 and Figure 29). Therefore, I decided to further examine the patterns of local calls along the week by analyzing several department cases.

4.2.2.3.1. Huancavelica

Figure 30 and Figure 31 present daily number of local calls in the department of Huancavelica.

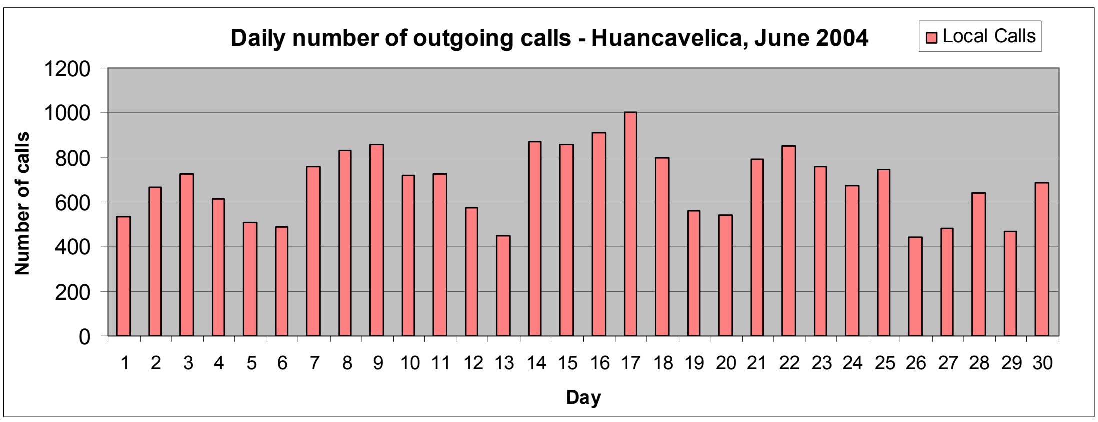

Figure 30 – Daily number of outgoing local calls – Huancavelica, June 2004

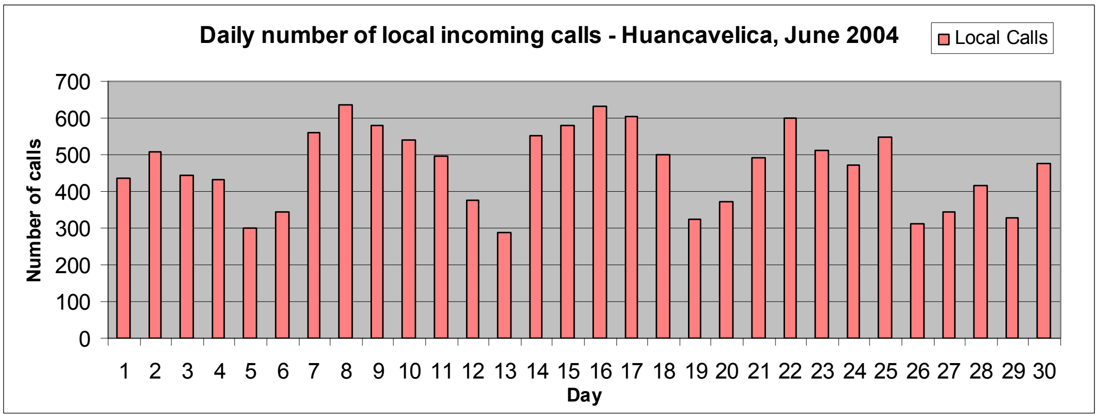

Figure 31 – Daily number of incoming local calls – Huancavelica, June 2004

The pattern seen here is a rather extreme version of the average network pattern seen in Figure 28 and Figure 29. The patterns observed are:

1. Clear variance in number of calls during the week.
2. The increase in the number of calls towards the middle of the week (Tuesday/Wednesday) is significant both in outgoing and incoming calls.
3. The decrease towards the weekend is very sharp.

4.2.2.3.2. Puno

Figure 32 and Figure 33 present daily number of local calls in the department of Puno. The pattern seen here is not obvious as the network average or the pattern of Huancavelica.

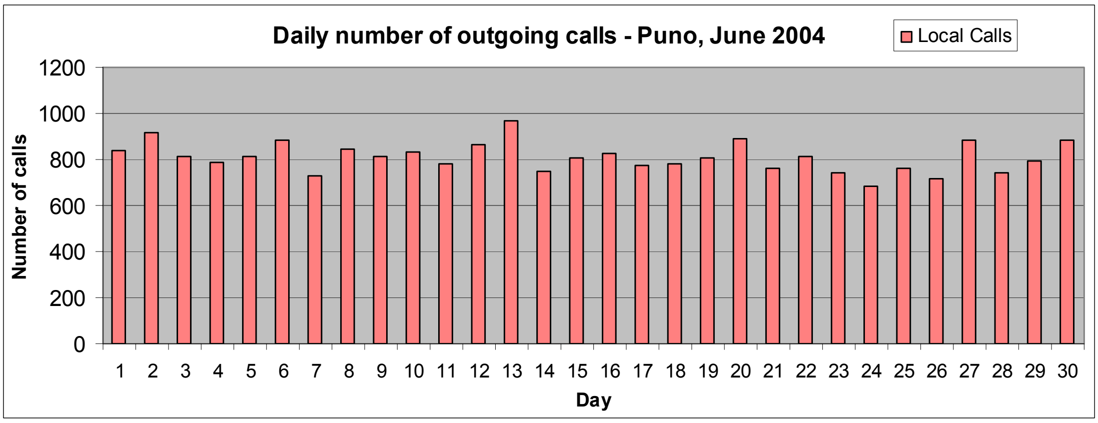

Figure 32 – Daily number of outgoing local calls – Puno, June 2004

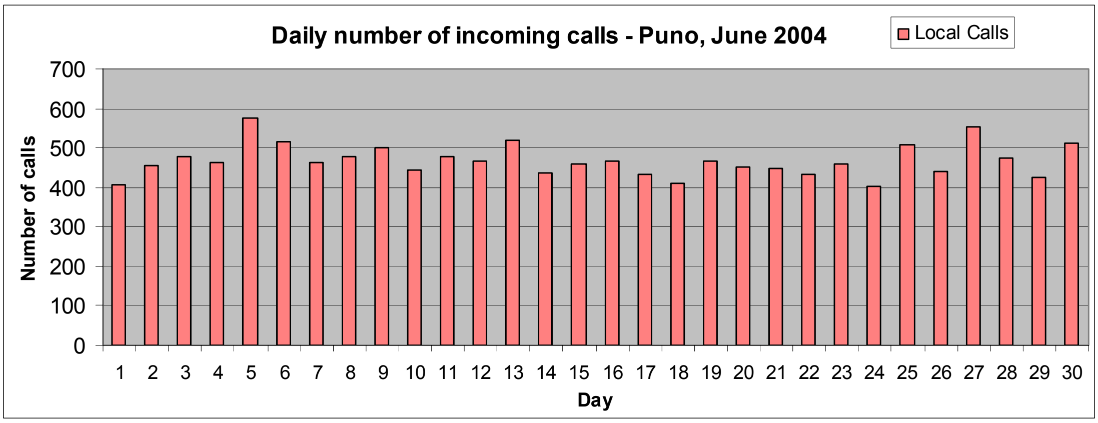

Figure 33 – Daily number of incoming local calls – Puno, June 2004

In summary, the following trends are noticed:

1. Clear increase in the number of local calls in the middle of the week in Huancavelica and the network average.
2. The absence of "Sunday peak".

These trends may imply that the nature of local calls is mainly business related. This explains the higher local calls activity in the middle of the week, and the lack of increase in the number of calls during Sundays. Such pattern is obvious in local calls and not in long distance calls because small local communities are more likely to conduct their business relations with nearby villages, towns or bigger cities in the same department.

In most of the villages I visited in Peru I saw evidence supporting this claim. In the small village of Pinagua the villagers sell and buy products in the closest village of Oropesa. The village of Caicay, which serves as a district capital, conducts most of its business connections with Cusco, the department capital. The village of Gen Gen in Loreto conducts connections with nearby villages and with Iquitos, the department capital. Most business relations in those cases were related to the selling and buying of agricultural products and trading other life supporting goods.

4.2.2.4. International outgoing Calls

The pattern of international outgoing calls is not as distinct as the local and long distance calls, therefore data from two months will be analyzed. Findings are presented in Figure 34 and Figure 35.

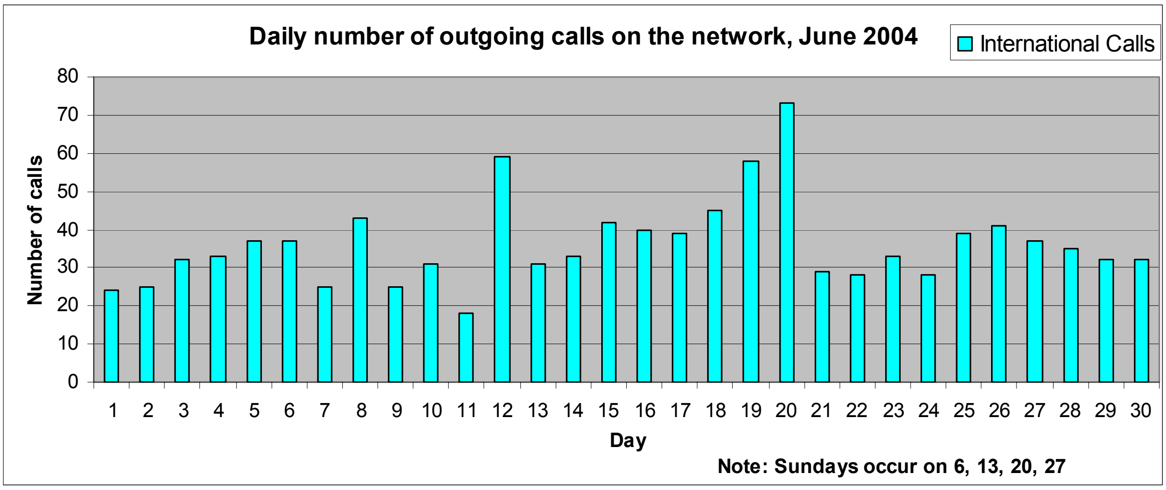

Figure 34 – Daily number of outgoing International calls on the network, June 2004

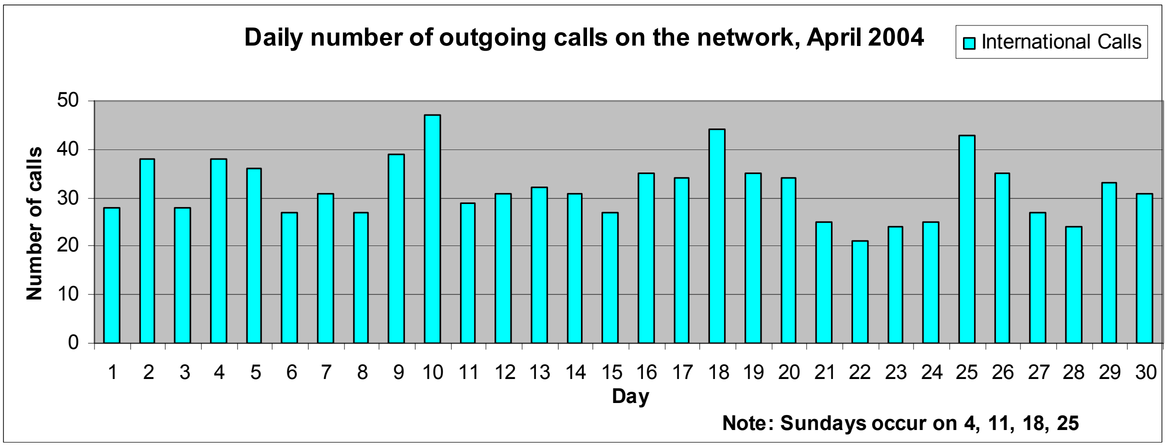

Figure 35 – Daily number of outgoing international calls on the network, April 2004

Observations from these figures are as follows:

1. The peak day for international outgoing calls is sometimes Saturday and sometimes Sunday.
2. The patterns of outgoing international calls are not distinct. That's because of the relatively low number of outgoing international calls. Most villagers do not call abroad due to the high price and the complexity of calling. The sporadic

nature of calls as demonstrated in the graphs can imply that most of the calls are conducted by travelers and businessmen traveling in the area and do not reflect the true nature of the network use by local people.

4.2.2.5. International incoming Calls

Figure 36 and Figure 37 show the pattern of incoming international calls.

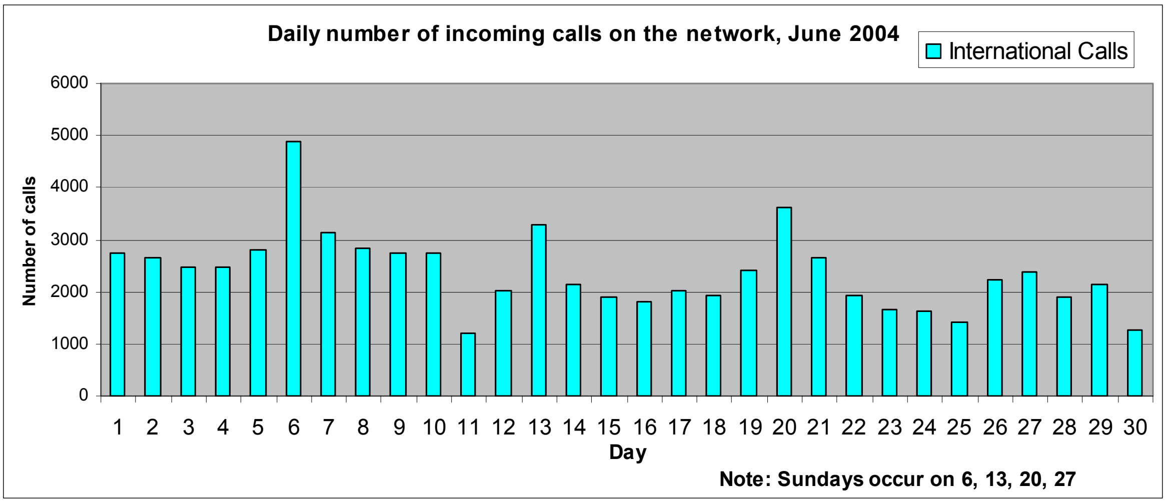

Figure 36 – Daily number of incoming international calls on the network, June 2004

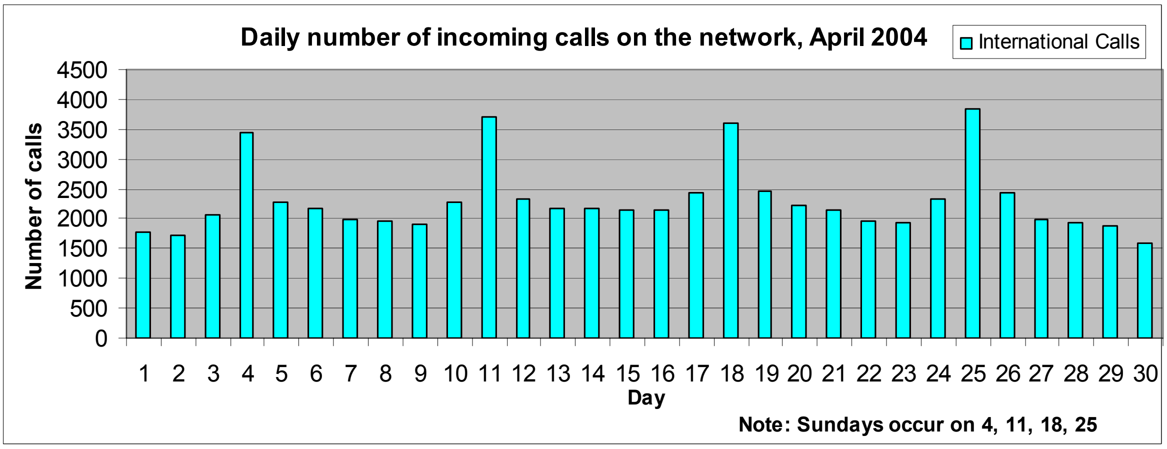

Figure 37 – Daily number of incoming international calls on the network, April 2004

These figures are more similar to the nature of long distance calls, with a decrease during the weekdays, and increase on Saturday and a significant increase on Sunday. This can be explained by an orderly habit of users to schedule a fixed time for receiving calls from abroad. Since international calls are expensive for most people in villages and towns, they set an hour for people from abroad to call them. Naturally it is easier to schedule such times on Sundays. This can imply that incoming calls from abroad are also mainly social.

These patterns support OSIPTEL figures shown in section 2.2.2.6, demonstrating the significant difference between the amount of outgoing and incoming international calls, since people abroad have more economic power to afford calling into the villages in Peru.

4.2.2.6. Duration of calls

Figure 38 and Figure 39 show the average duration of calls along the month.

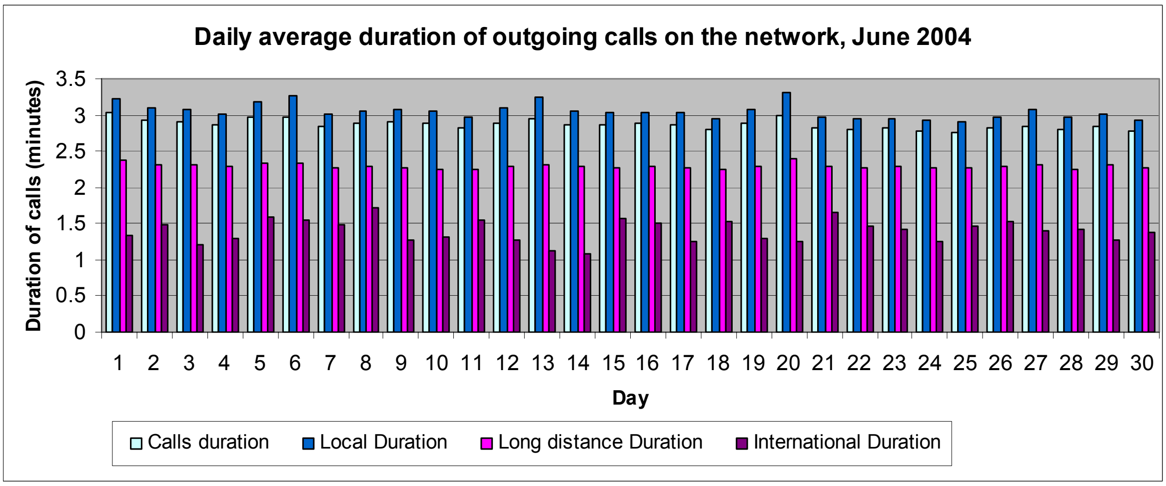

Figure 38 – Daily average duration of outgoing calls on the network, June 2004

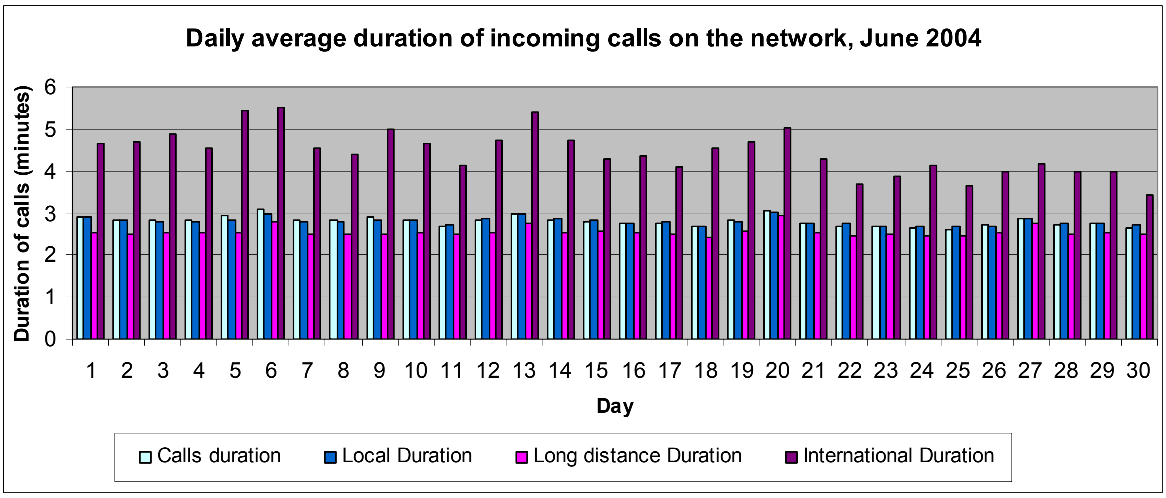

Figure 39 - Daily average duration of incoming calls on the network, June 2004

Main findings from these figures are:

1. A slight increase in duration of all types of calls can be spotted on Sundays. A significant increase in duration of incoming international calls is spotted on Sundays as well. The reason is that on Sundays people are more relaxed and have the time to conduct longer calls. The significant increase in international calls duration will be discussed shortly.
2. When examining outgoing calls, there is a notable difference in duration of the various types of calls. Local calls are the longest, followed by long distance calls, and international calls are the shortest. This may be explained by the various calls tariffs, which are meaningful to the relatively poor rural communities. Since local calls are the cheapest ones, they are longer, while international calls, which are the most expensive ones are the shortest.
3. When examining incoming calls, duration of local and long distance calls is similar, but international calls are significantly longer. These findings provide another support to the statement that incoming international calls are originated by users who can afford paying them, such as Peruvians who went to work abroad.

4.3. Characteristics of traffic patterns and calls during a single day

This analysis will focus on patterns of traffic during the day, calculating hourly average number of calls and hourly average calls duration.

4.3.1. Steps of analysis

Methodology used: calculations based on reports system output.

Naturally, figures per single day are not reliable, since traffic may vary between days. Therefore, an average had to be calculated from figures of several selected days. In addition, a brief examination of the data demonstrated that the nature of calls is different between weekdays and Sundays. Therefore, separate analysis was done for weekdays and Sundays.

Table 17 presents the selected days, which were chosen randomly.

Table 17 – Traffic patterns during a single day - Selected days for calculation

Weekdays	Sundays
3.12.2003	7.12.2003
7.1.2004	25.12.2003
11.2.2004	18.1.2004
25.3.2004	22.2.2004
21.4.2004	14.3.2004
12.5.2004	25.4.2004
10.6.2004	16.5.2004
23.6.2004	27.6.2004
8.7.2004	11.7.2004
21.7.2004	25.7.2004

After selecting the dates for calculation, the following steps were conducted:

1. Query on the reports system was done for network level and limited for a specific day, thus providing detailed figures to a resolution of every hour during the selected day.

2. The query was repeated 20 times, for each of the selected days, thus providing basic set of figures in a resolution of hours.
3. The basic sets of figures were transferred to Excel for calculations of averages. One average calculation was done for the 10 weekdays and another one was done for the 10 Sundays.
4. Graphs were created from selected relevant figures.

4.3.2. Findings

4.3.2.1. General characteristics

One distinct pattern that can be observed during the day is the two peaks in the traffic: The morning peak and the evening peak. During the night the amount of calls drops to almost zero due to the technological aspect of the system – the VSATs are normally staying in "Hibernate" mode between 8 pm and 8 am (But can still generate calls during this time). The two peak pattern is interesting because of the nature of the phones usage: since most people go out of the village or town to work during the day, calls are conducted early in the morning – before work, and in the evening – after work and before the VSATs go to Hibernate mode. It's important to note that the tariffs of calls are fixed during the whole day.

4.3.2.2. Number of outgoing calls

Figure 40 and Figure 41 present the hourly number of outgoing calls during Sundays and weekdays respectively.

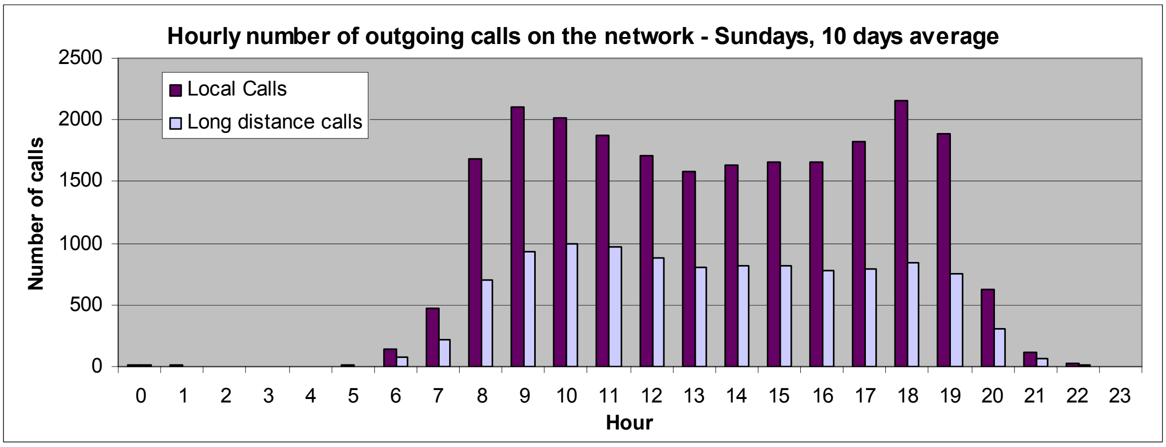

Figure 40 – Hourly number of outgoing calls on the network – Sundays

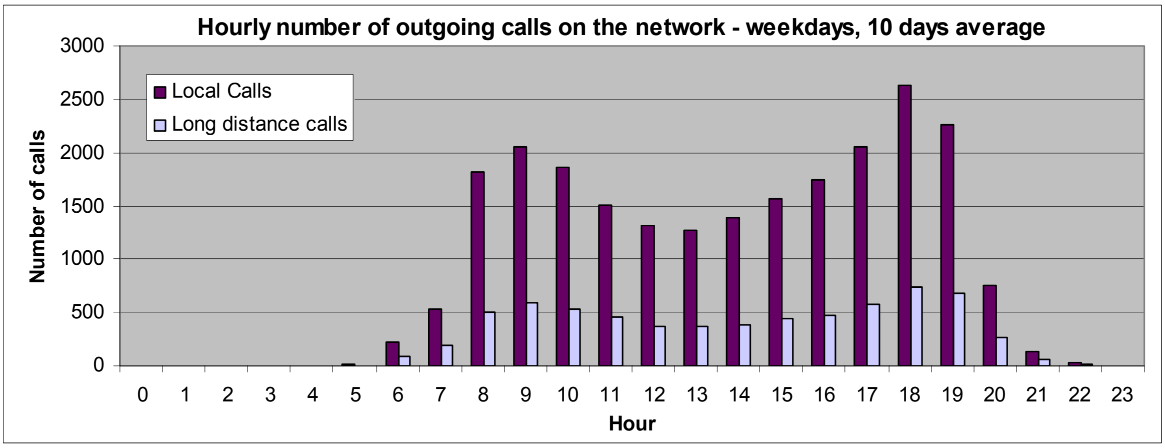

Figure 41 – Hourly number of outgoing calls on the network - weekdays

The patterns seen in the figures are as follows:

1. Local calls: during weekdays the peaks are much more distinct than during Sundays. This is explained by the location of people during Sundays – they do not go out to work, and mostly hang around the village or town center where the phone is located, spending some social time and available to make calls during mid day as well.
2. The pattern of long distance calls along the day is different. On weekdays, the two peaks can be clearly seen, but on Sundays, there is a significant peak in the morning, and almost stable number of calls throughout the day with a

slight rise in the evening. The explanation might be the anxiety of people to make the long distance calls. Since it's Sunday, most likely that these calls are made to relatives and friends throughout Peru. The significant rise in the number of calls on Sundays compared with weekdays (almost twice as much) which is also demonstrated here is another example for the role of social usage of the network.

4.3.2.3. Number of incoming calls

Figure 42 and Figure 43 present the hourly number of incoming calls during Sundays and weekdays respectively. The pattern of incoming calls also bears the two peaks of the morning and evening. It is distinct during weekdays and less distinct on Sundays, due to the reasons explained above.

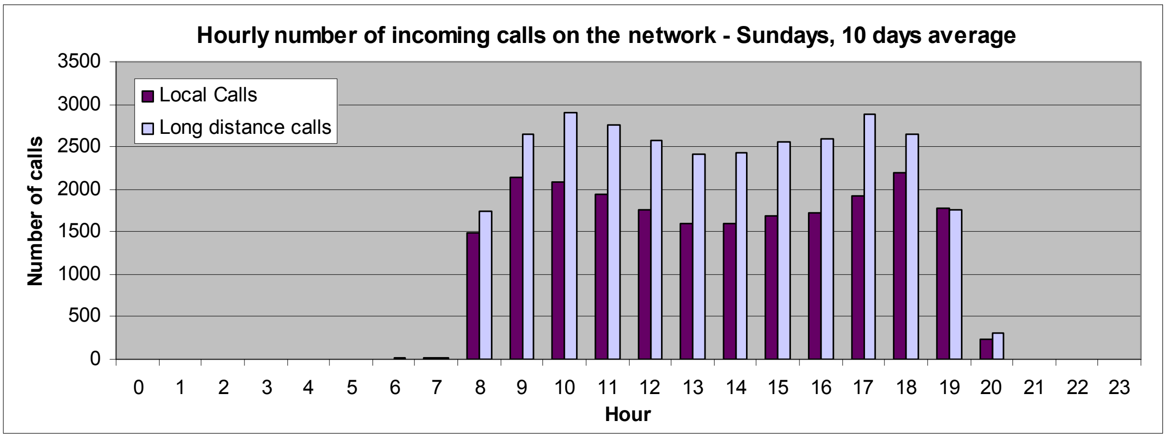

Figure 42 – Hourly number of incoming calls on the network – Sundays

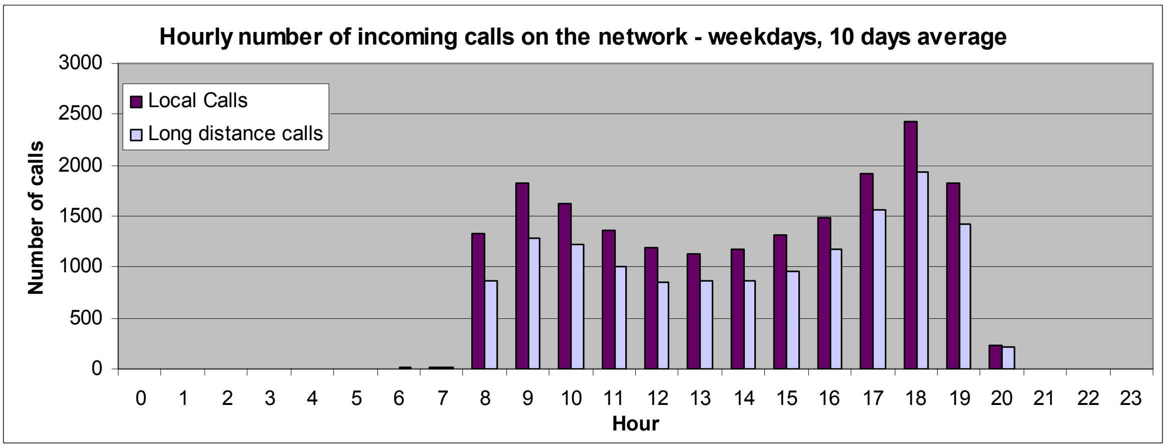

Figure 43 – Hourly number of incoming calls on the network - weekdays

4.3.2.4. Duration of outgoing calls

Figure 44 and Figure 45 present hourly average duration of outgoing calls.

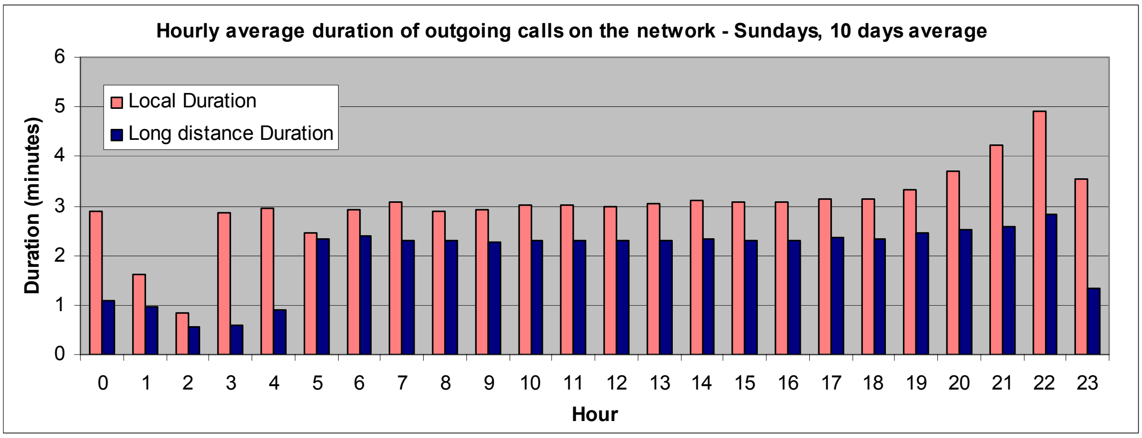

Figure 44 – Houry average duration of outgoing calls - Sundays

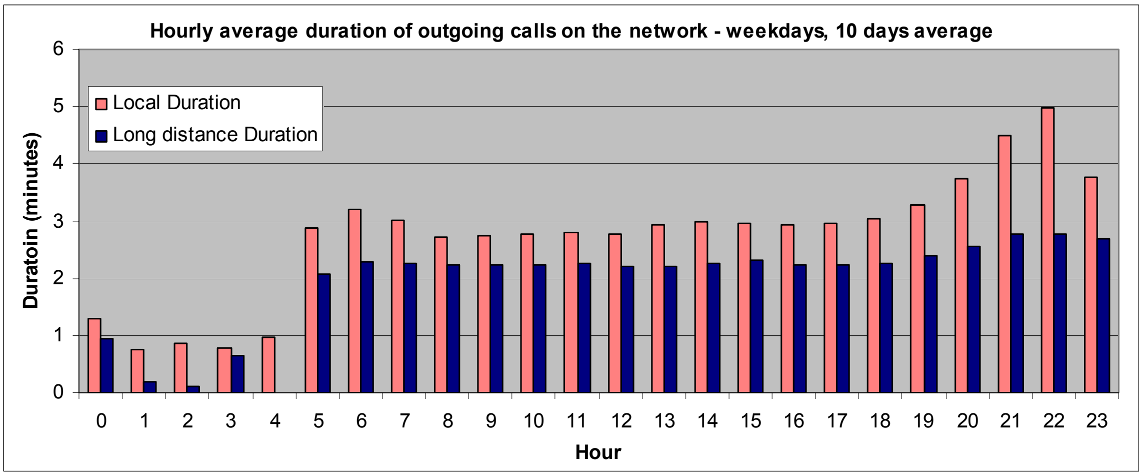

Figure 45 - Houry average duration of outgoing calls - weekdays

The distinct pattern here is that outgoing calls are longer in the evening. From 6 PM a distinct rise in call duration is observed, mainly in local calls. The explanation might be that people are more relaxed in the evening and have the time to make longer calls.

4.3.2.5. Duration of incoming calls

Figure 46 and Figure 47 present average duration of incoming calls. The pattern of increase in call duration in the evening seen in outgoing calls is less obvious in this case.

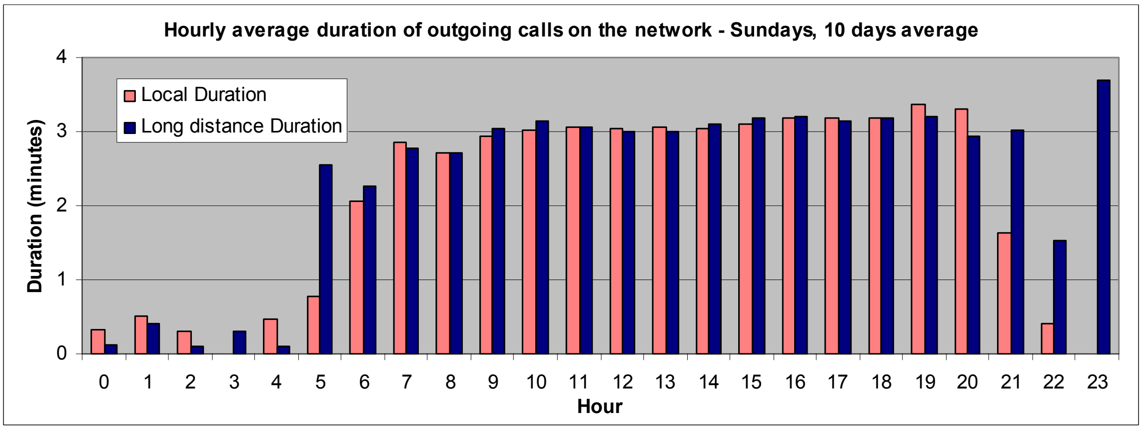

Figure 46 - Houry average duration of incoming calls - Sundays

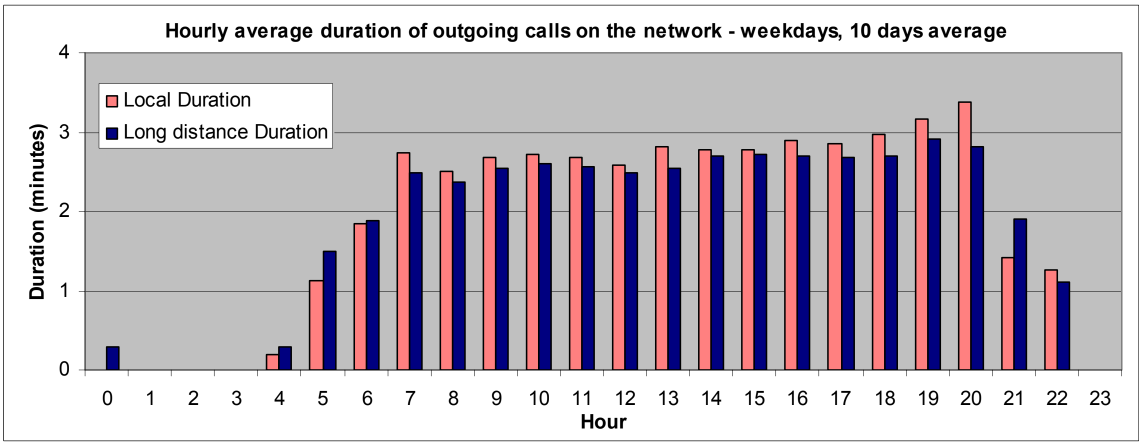

Figure 47 - Houry average duration of incoming calls - weekdays

4.4. Characteristics of traffic patterns and calls – departments and projects wise

This analysis examines characteristics of traffic patterns from a spatial point of view, comparing several criteria among the various departments. Characteristics covered are call types distribution and duration of calls.

4.4.1. Steps of analysis

Methodology used: Calculations based on reports system output.

1. Queries from reports system were conducted by departments and FITEL projects (F1: FITEL1 , F2: FITEL2 , F3: FITEL3, F4: FITEL4).
2. Period of data was January 1^{st} to July 17^{th} 2004.
3. Output of the query was a basic set of figures ordered by departments and projects and aggregated to the selected period.
4. Figures were transferred to Excel for further organization and graphs were created displaying the data in percentage format.

4.4.2. Findings

4.4.2.1. Call types distribution - outgoing calls

Figure 48 presents the distribution of outgoing call types by departments and projects.

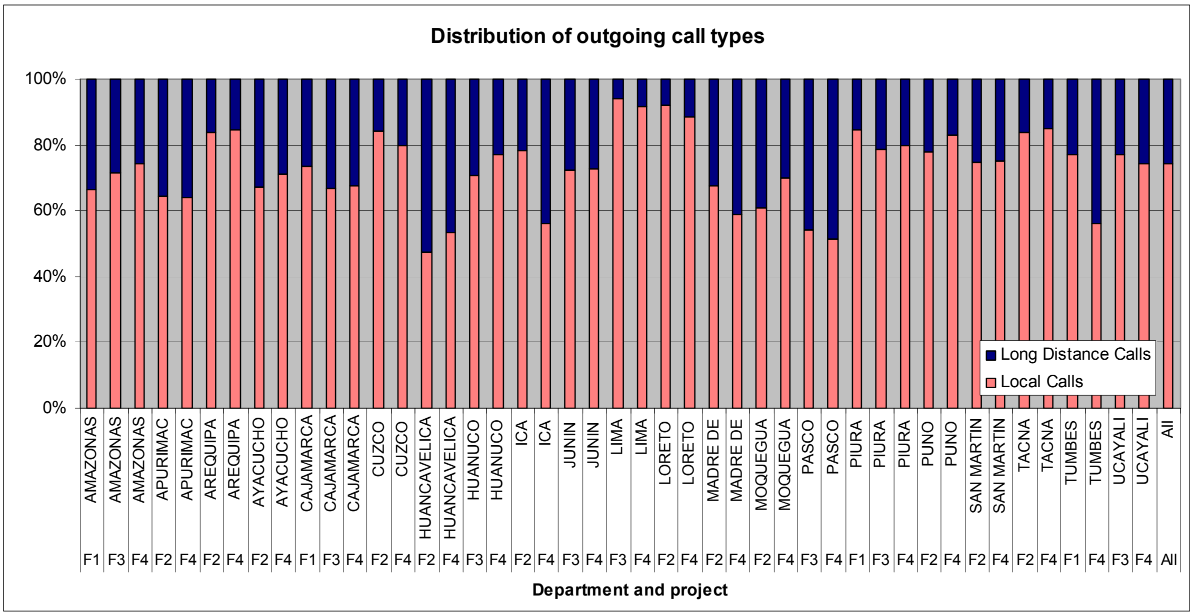

Figure 48 - Distribution of outgoing call types according to department and project

Observations from the calculated data and this figure are as follows:

1. Average distribution is: Local– 74.3 % Long Distance – 25.6 % International – 0.1 %
2. The following departments are "local call oriented":
   a. Lima
   b. Loreto
3. The following departments are "long distance call oriented":
   a. Huancavelica
   b. Pasco

Variations of call types distribution among the different departments may be explained in several ways:

1. Lima – it is not surprising to discover that most calls in the department of Lima are local. If it is for business/work matters, the urban center that people call is

the city of Lima. If it is friends or family members, most likely that they went to live in the city of Lima which is the closest urban center, and the capital, so these types of calls are also local.

2. Loreto – The reason for the dominance of local calls in Loreto might be its remoteness and isolation. Loreto is not connected by roads to the rest of Peru. Its only urban center is Iquitos. If it is for business matters, there's no much reason for people to call anywhere but Iquitos. If it's social calls, probably people do not migrate much out of Loreto. If they do, they go to Iquitos, the capital of Loreto.
3. Huancavelica / Pasco - Economic situation of residents in various departments – it would be expected that poorer people would tend to conduct local calls rather than long distance calls which are more expensive. But Huancavelica is one of the least developed areas in Peru, and yet – it is "long distance oriented". In addition, when we later examine the distribution of incoming calls we discover a similar pattern, although the nature of callers is different. It seems that the explanation for this issue is more complex and may reside in another issue: The proximity of villages in Huancavelica and Pasco to large urban centers which are located within a neighboring department.
4. The distribution of local/long distance calls is much dependent on the location of the urban center that people call. If the urban center is in the same department, local calls will be dominant. But if the urban center is located in another department, there will be a greater dominance to long distance calls.

4.4.2.2. Call types distribution - incoming calls

Figure 49 presents the distribution of incoming call types by departments and projects.

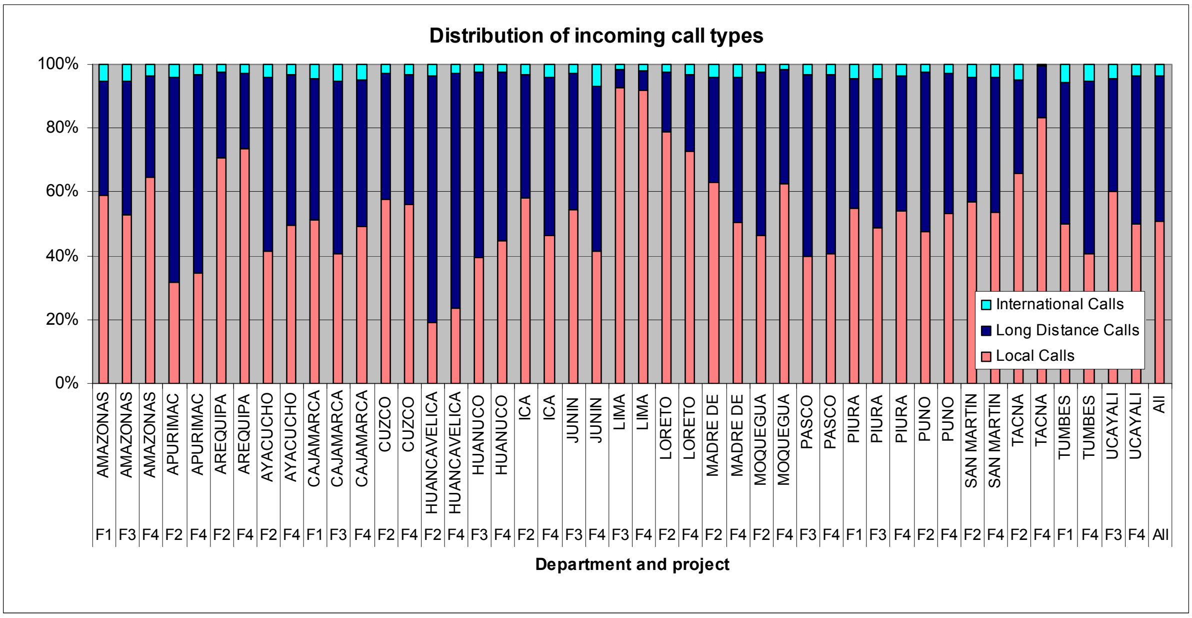

Figure 49 - Distribution of incoming call types according to department and project

Observations from the calculated data and this figure are as follows:

1. Average distribution is: Local– 50.8 % Long Distance – 45.4 % International – 3.8 %
2. The following departments are "local call oriented":
    a. Lima
    b. Loreto
    c. Arequipa
3. The following departments are "long distance call oriented":
    a. Huancavelica
    b. Apurimac
    c. Pasco

Variations in incoming calls may be explained in the following ways:

1. Huancavelica and Apurimac are the least developed departments in Peru. This may explain migration of people out of these departments to other areas of Peru, thus contributing to high amount of incoming long distance calls.

2. Pasco – Since the percentage of long distance calls is relatively high in Pasco for both outgoing and incoming calls, the reason here might also be the connection to large urban centers which are outside the Pasco area code – such as Huanuco and Lima.

4.4.2.3. Call duration

Figure 50 and Figure 51 illustrate the average duration of calls according to department and project.

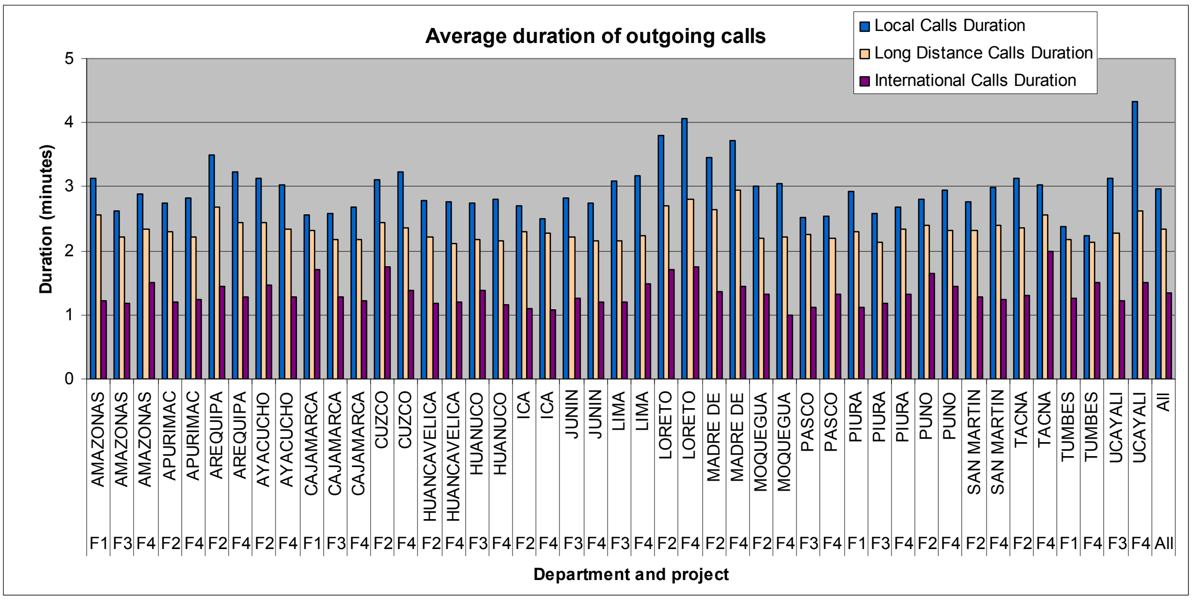

Figure 50 - Duration of outgoing calls

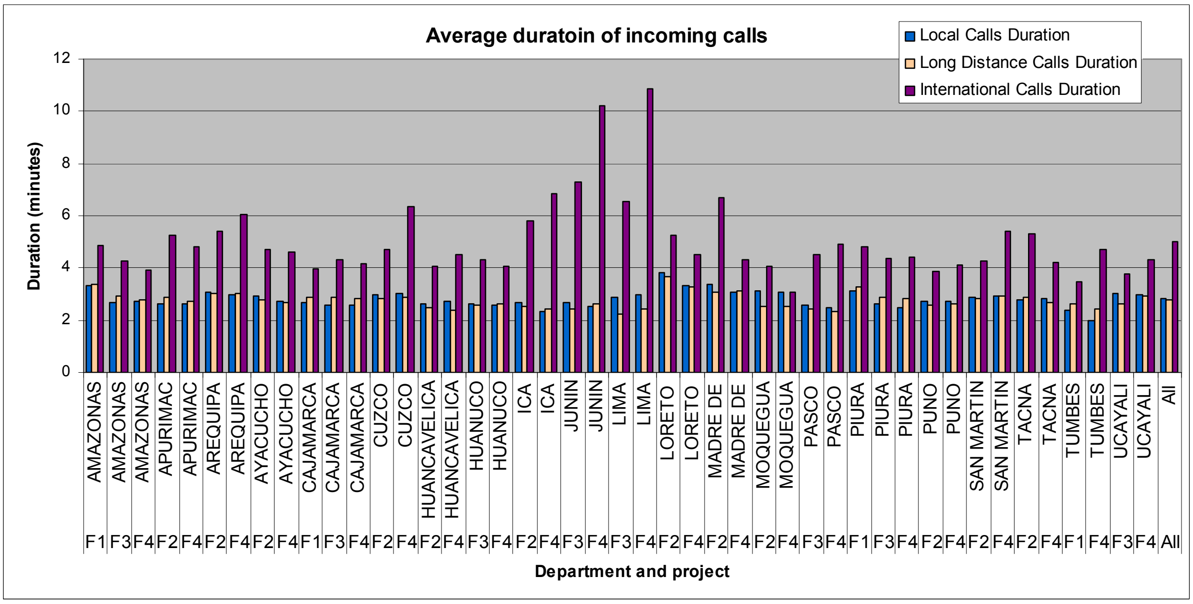

Figure 51 - Duration of incoming calls

Observations from these figures are as follows:

1. Longest outgoing calls are held from Loreto, Madre De Dios, Ucayali, Cusco and Arequipa. This refers to all types of calls. Interesting to note, that Loreto, Madre De Dios and Ucayali are the Selva departments. Hot and humid climate causes people to stay outside most of the time, and communicate longer.
2. In incoming calls, the dominant phenomenon is the variance of duration of international calls among the departments. Incoming international calls to Junín, Lima and Ica are longer than to other departments.
3. Patterns shown in section 4.2.2.6 are observed here as well: in outgoing calls, the longest calls are local, then long distance, and then international calls, while in incoming calls, the longest calls are international, while local and long distance calls are much shorter, approximately in the same length.

4.5. Volume of daily VSATs traffic - by departments and projects

One of the interesting comparisons between departments is to check the average amount of daily VSAT traffic, and to find out whether the different physical regions of Peru influence these characteristics.

4.5.1. Steps of analysis

Methodology used: calculations based on reports system output.

1. Query was done in the reports system for figures about the total number of incoming and outgoing minutes per department per day.
2. The departmental figures were divided by the number of active VSATs in each department.
3. Data was selected for the period of January 1st to August 13th 2004.

Note: The VSATs in all of the departments were installed between the years 2001 and 2003. The analysis is based on data for the year 2004, which means that most of the VSATs have already been active for at least 2 years. Therefore it is assumed that the traffic patterns analyzed for this period will reliably represent the traffic differences between the departments.

4.5.2. Findings

4.5.2.1. Departmental view

Figure 52 presents the daily average minutes of VSATs in each of the departments, separated to outgoing and incoming calls. Figure 53 lists the total average volume of daily VSAT minutes in descending order, by departments. Figure 54 presents those figures spatially.

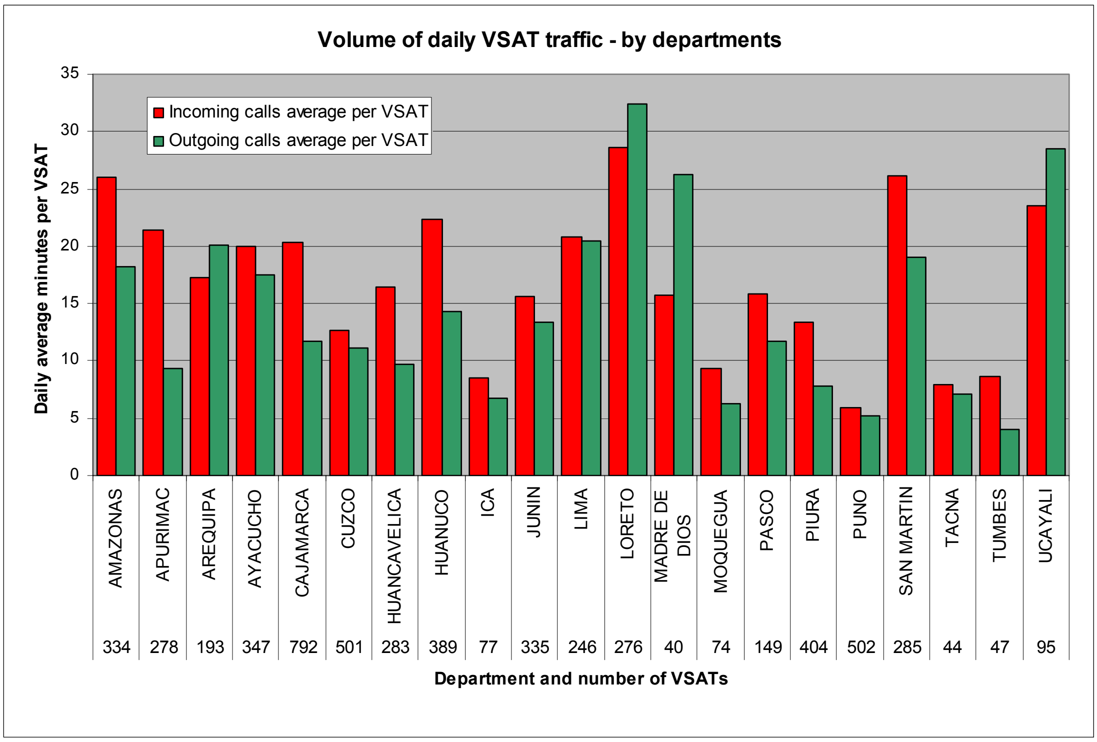

Figure 52 – Daily average minutes per VSAT - by departments

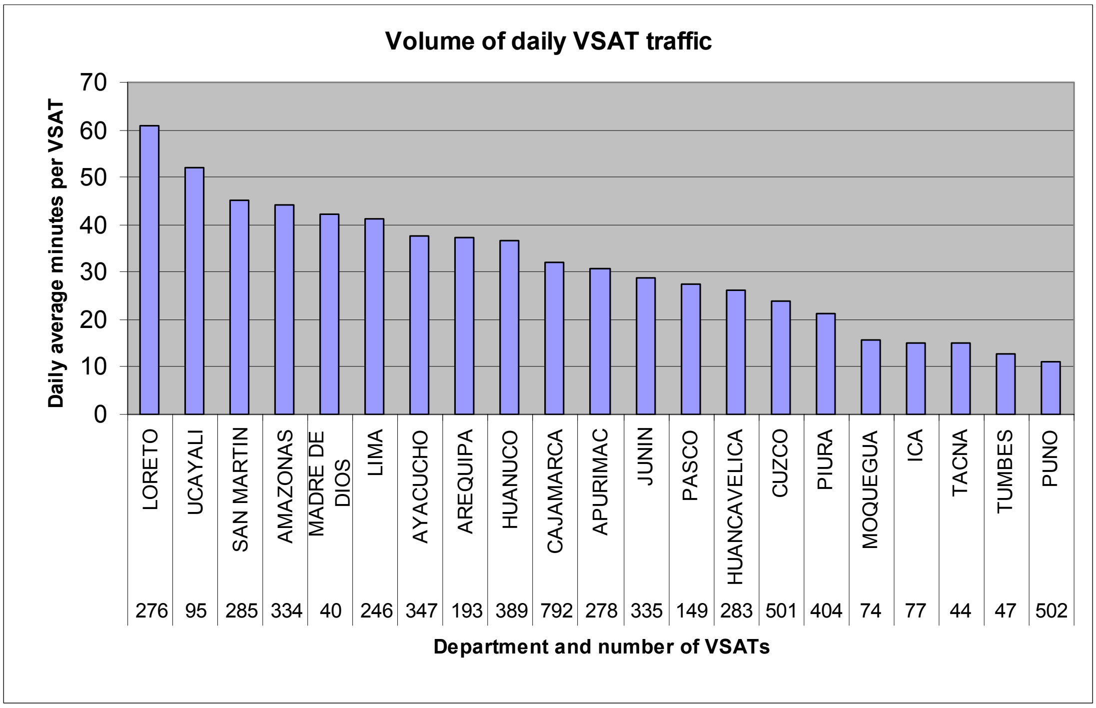

Figure 53 – Daily average minutes per VSAT – by departments – total minutes

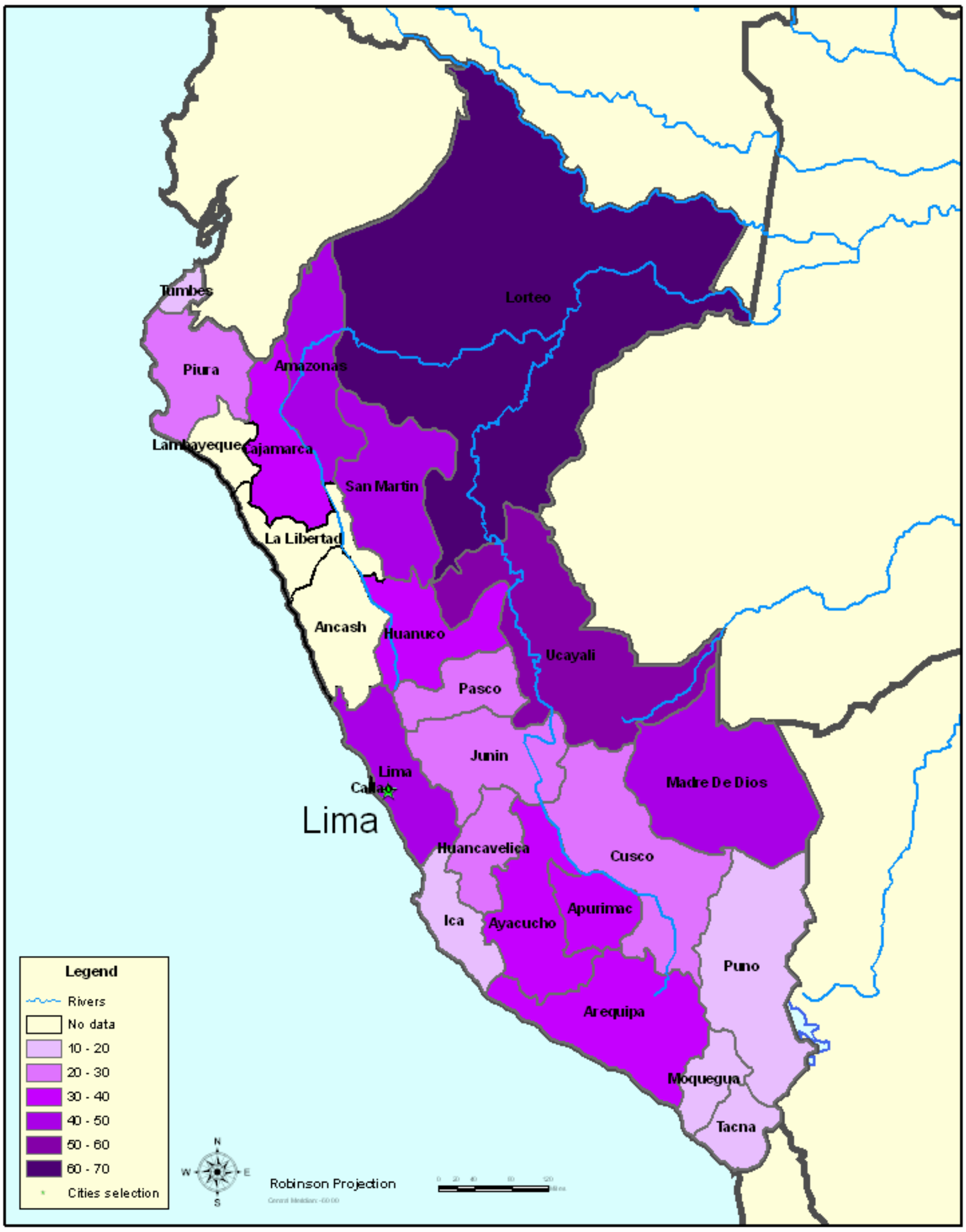

Figure 54 – Daily average minutes per VSAT – spatial presentation

The observations from those figures are:

1. There are several distinct patterns concerning the three Selva departments - Loreto, Ucayali and Madre de Dios:
    a. They generate the highest number of outgoing VSAT minutes.
    b. The amount of outgoing minutes is clearly higher than incoming minutes, as opposed to most other departments (Arequipa is the only non-Selva department in which the same pattern occurs).
2. When examining incoming minutes the leaders are more difficult to spot. But there are several departments that "join" the Selva departments as the leaders

in the volume of incoming minutes – Amazonas and San Martin – "Montana" departments. In Madre De Dios the volume of incoming minutes is significantly lower than the outgoing minutes.

3. The Selva and Montana departments (Loreto, Ucayali, San Martin, Amazonas, Madre de Dios) are the leaders in amount of total minutes.
4. The lowest amount of outgoing minutes is found in Tumbes, Puno, Moquegua and Ica.
5. The lowest amount of incoming minutes is found in Puno, Tacna, Ica and Tumbes.
6. Puno, Tumbes, Tacna, Ica, Moquegua and Piura have the lowest amount of total minutes. Apart from Puno, these departments are located on the far northern part of Peru by the ocean, and on the far southern part of Peru by the ocean.

The high volume of VSAT minutes that is found on the Selva and Montana departments is closely related to the physical characteristics of these areas and the nature of people living there. Being hot and humid, people spend much time in their open balconies and outside in the village, encouraged to talk more – on the phone as well. Figure 55 shows the village of Gen Gen (pronounced "Hen Hen"), which is an example of a Selva village. This 30 families village is accessible via waterways, and is located one hour by speed boat from Iquitos, the capital of the department of Loreto. As seen in Figure 56, the VSAT is located inside the balcony of the village store, and the owner, like most people in this region, is minimally dressed.

Figure 55 - General view of village of Gen Gen from the river

Figure 56 - Public pay phone in Gen Gen grocery store

The physical characteristics of Puno can also explain the other edge of the graph – it is a mountainous high altitude area with rough climate – cold and bitter, which encourages people to remain closed in their homes, therefore to talk less. Figure 57 shows a general view of a typical Sierra village – the remote village of Pinagua in the department of Cusco.

Figure 57 - General view of Pingua with the Gilat VSAT

4.5.2.2. Department and project comparison

Figure 58 shows the daily minutes per VSAT detailed to department and project level.

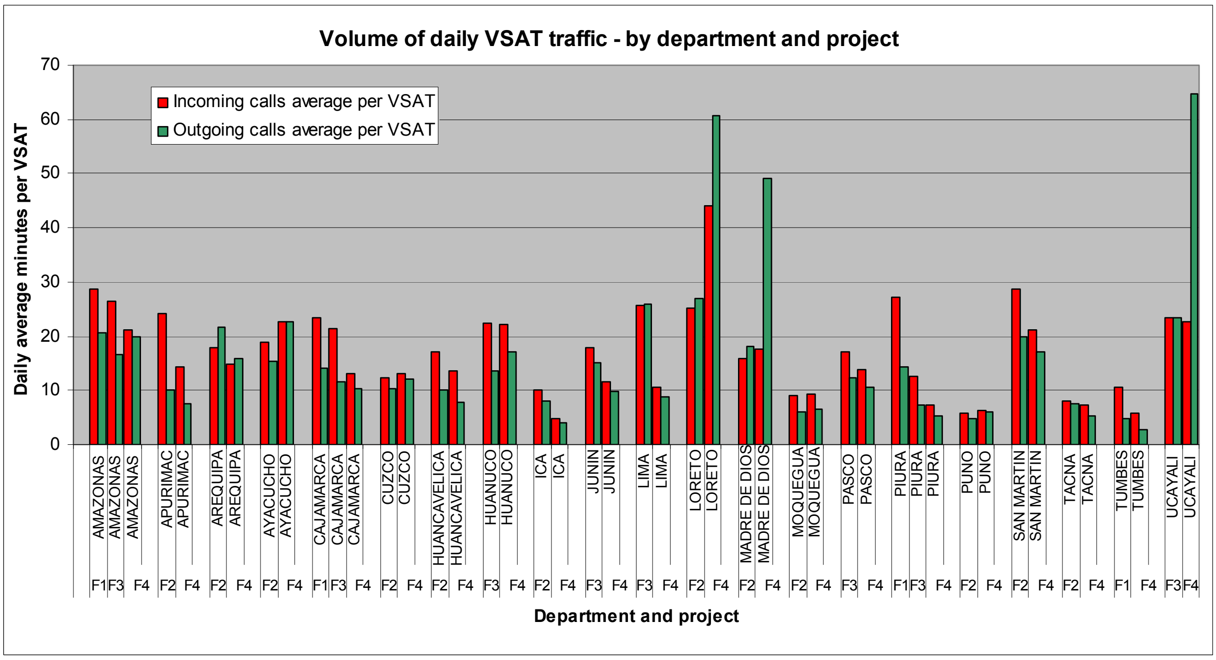

Figure 58 – Daily average minutes per VSAT – by departments and projects

When comparing the amount of minutes between sites installed in FITEL4 project and the other FITEL projects, the Selva departments reveal another interesting finding. In most departments, FITEL 1, 2 and 3 VSATs generate more outgoing and incoming minutes than FITEL 4 VSATs. But in the Selva departments it is the opposite – FITEL 4 VSATs have more daily minutes, especially outgoing minutes.

Explaining the general pattern - FITEL1,2,3 VSATs have more minutes than FITEL4 VSATs is not simple: on the one hand, in most cases, FITEL 1,2,3 VSATs were installed before FITEL 4 VSATs. Following with previous findings, according to which the VSAT traffic increases with time - the "older" VSATs have more traffic. But on the other hand FITEL 4 VSATs are installed in district capitals – which are bigger villages that likely to generate more traffic. The reason that can support the findings after all, in addition to the first reason mentioned is the fact, that FITEL 4 VSATs are installed in places where another communication device exists – a Telefonica phone. This reduces the number of calls made through Gilat VSATs, and may be the main explanation. One of the villages I visited in Peru was Padre Cocha, a relatively large village located in the vicinity of Iquitos, the capital of Loreto. A FITEL 4 VSAT is installed in this village, alongside a previously installed pay phone operated by Telefonica. The owner of the store in which the VSAT is installed specifically noted that some people prefer using the Telefonica phone, whether due to the use of coins instead of Gilat's prepaid cards, or the proximity of the Telefonica phone to their residence.

4.6. Comparison between more central and remote VSATs

Another interesting question is how traffic patterns differ between VSATs which are close to urban centers and VSATs which are located in remote areas, far away from urban centers.

4.6.1. Steps of analysis

Methodology used: calculations based on reports system output.

1. Since I learned that traffic patterns differ between departments and geographical locations, I repeated the analysis in two different regions: The Selva and The Sierra. For each region I chose two groups of sample VSATs:
   - The first group – VSATs which are close to an urban center (Within a maximum radius of 40 kilometers from the urban center) – "Near".
   - The second group - VSATs which are remotely located, within a distance as far as possible from urban locations in the specified area – "Far".

   Selecting the sample VSATs was done by using the GIS Server utility of Gilat Peru, which visually marks the locations of VSATs on the map of Peru. Detailed lists of the VSATs selected for each of the test-cases can be found in appendix 1.

   First, I performed one test-case per each region. But while performing the research I noticed that the patterns are much different between the Selva test-case and the Sierra test-case. Therefore I repeated the calculation for each region with an additional test-case. In total, four test-cases were analyzed, each one of them contains two groups of VSATs.
2. Using the reports system, I collected 8 sets of basic figures for each of the selected VSATs. Each set of basic figures was selected for a specified period of month, from January to August 2004 (total 8 months). The reason why I chose to collect separate data for 8 months is to verify that the traffic characteristics are similar along several months.
3. For each of the 4 test-cases, I ordered the results in several sheets:

- Outgoing traffic for VSATs which are close to an urban center ("Near")
- Incoming traffic for VSATs which are close to an urban center ("Near")
- Outgoing traffic for VSATs which are far from an urban center ("Far")
- Incoming traffic for VSATs which are far from an urban center ("Far")

4. For each sheet I calculated the average of the traffic values for all the VSATs per each month.
5. As was mentioned, those steps were repeated for the two Selva test-cases and the two Sierra test-cases.

4.6.2. The Selva region

This test-case included two sets of comparisons – in the departments of Loreto and Ucayali. Both departments are characterized by notable number of scattered villages which are connected to the department capital mainly by waterways. Loreto, the largest Selva department, is quite isolated from the rest of Peru. Iquitos, its capital, is connected to the southern areas of Peru only by waterways and air traffic. The roads network extends only a few dozens kilometers away from the city and most of the traffic between the city and rural areas in Loreto is conducted via waterways.

Test-case 1 - Loreto

20 "Far" sample VSATs in Loreto, installed between June and November 2001 as part of FITEL II project.

9 "Near" VSATs around the city of Iquitos (capital of Loreto), installed between May and June 2001 as part of FITEL II project.

Figure 59 shows the locations of the selected VSATs for this test-case.

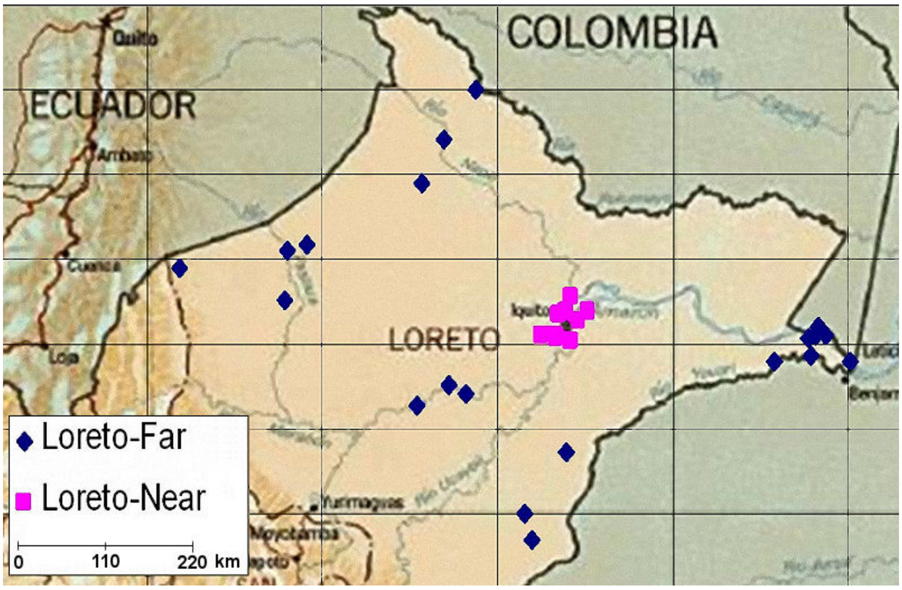

Figure 59 - Locations of test-case 1 selected VSATs in Loreto

Test-case 2 - Ucayali

15 "Far" sample VSATs in Ucayali, installed between November and December 2002 as part of FITEL III project.

15 "Near" VSATs around the city of Pucallpa (capital of Ucayali) installed on November 2002 as part of FITEL III project.

Figure 60 shows the locations of the selected VSATs for this test-case.

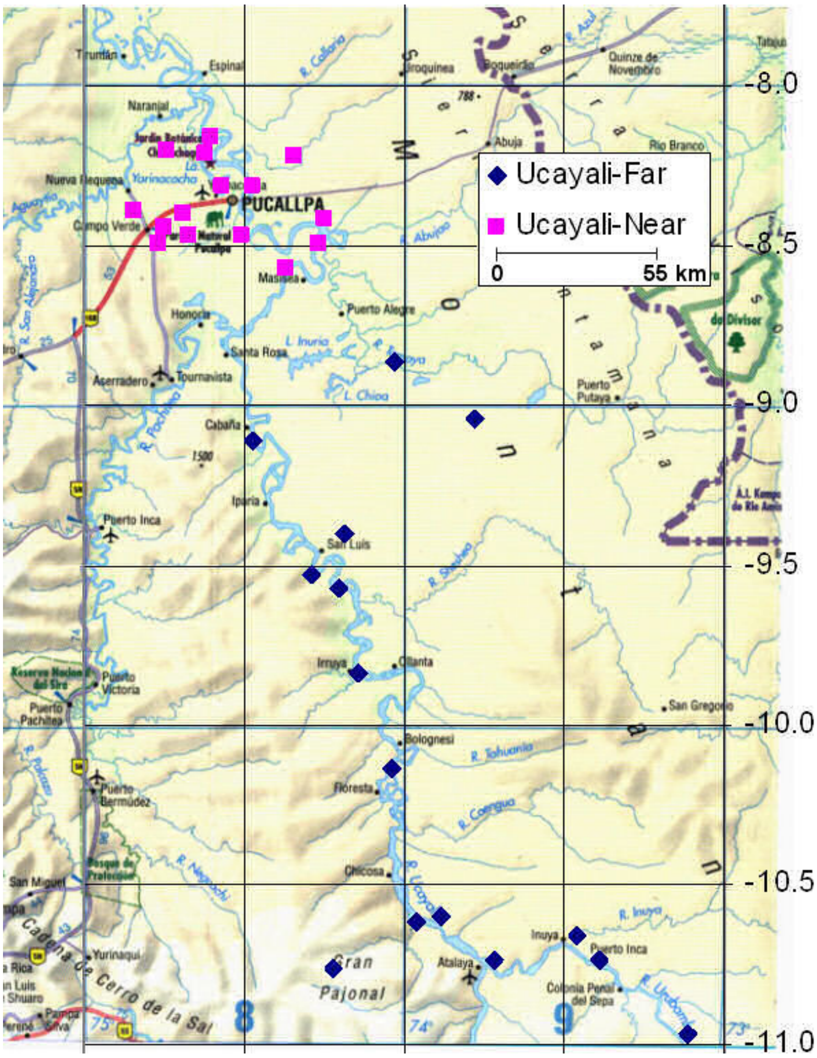

Figure 60 - Location of test-case 2 selected VSATs in Ucayali

(Note: August query for sets 1,2 contains figures up to August 14th).

4.6.2.1. Findings - the Selva – number of calls

Figure 61 and Figure 62 illustrate the total number of outgoing calls in each of the two Selva test-cases. Figure 63 and Figure 64 present the total number of incoming calls in each of these test-cases.

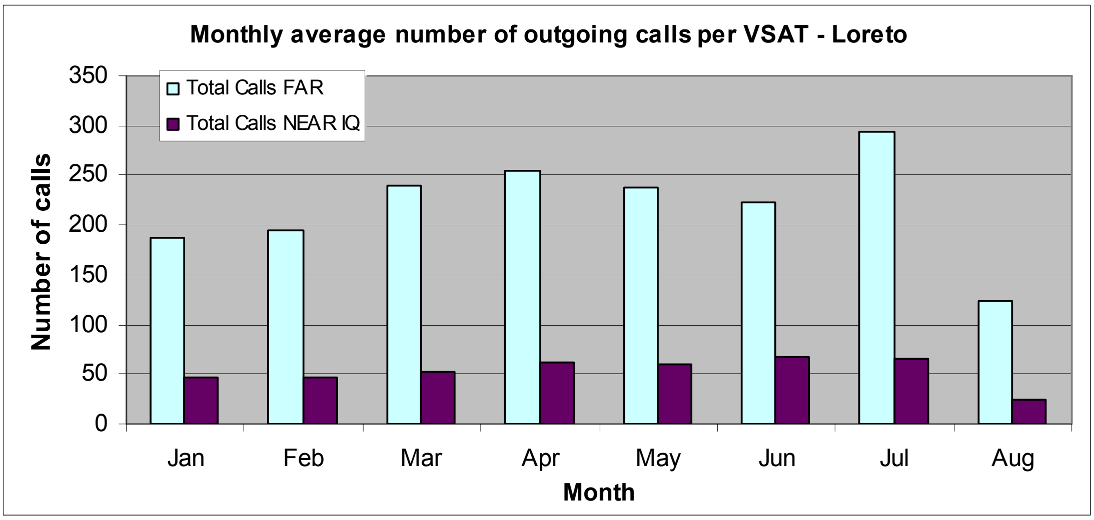

Figure 61 – Monthly average number of outgoing calls per selected VSATs – test-case 1 – Loreto

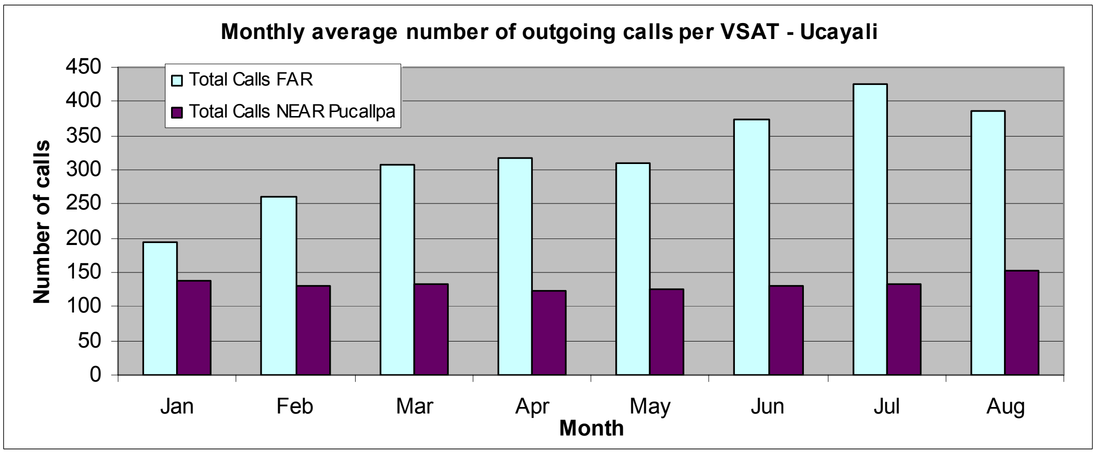

Figure 62 – Monthly average number of outgoing calls per selected VSATs – test-case 2 - Ucayali

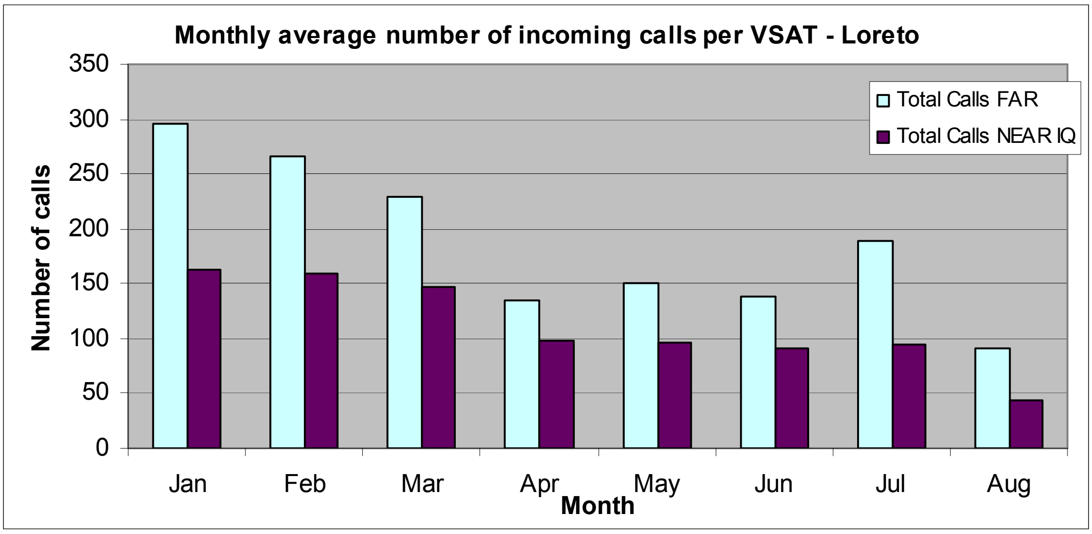

Figure 63 – Monthly average number of incoming calls per selected VSATs - test-case 1 - Loreto

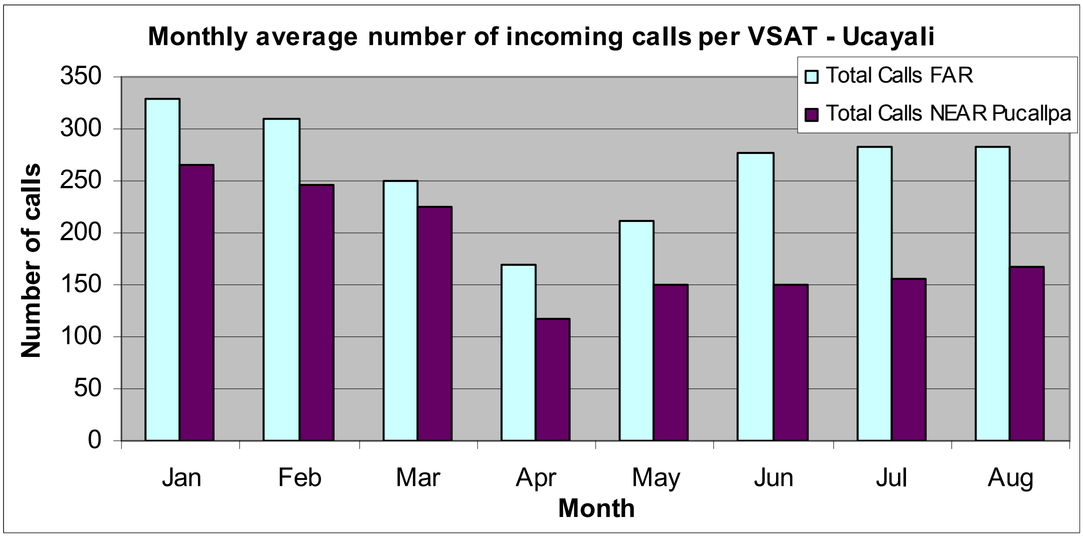

Figure 64 – Monthly average number of incoming calls per selected VSATs - test-case 2 - Ucayali

The patterns seen in Loreto and Ucayali are similar: the number of calls is significantly higher in the "Far" VSATs compared with the VSATs near Iquitos and Pucallpa for both outgoing and incoming calls. These findings may imply for the strong communal connection between remote villages. Since they are scattered far from urban center they maintain closer commercial and social relations among themselves, which are reflected in the number of calls. Villages which are located near an urban center naturally maintain their main connections with this center. This notion is supported by findings from the field trip I made to villages around the city of

Iquitos. For instance, the village of Padre Cocha is located in a distance of half an hour boat ride from Iquitos. People I met in the village explained that usually when they need something they simply go to the city to arrange it.

4.6.2.2. Findings - the Selva – call types distribution

To better understand the difference in traffic volume between the "Far" and "Near" VSATs, I calculated the number of calls by distribution of call types. Figure 65 and Figure 66 illustrate the number of outgoing calls in each of the two Selva test-cases. Figure 67 and Figure 68 present the number of incoming calls in each of these test-cases.

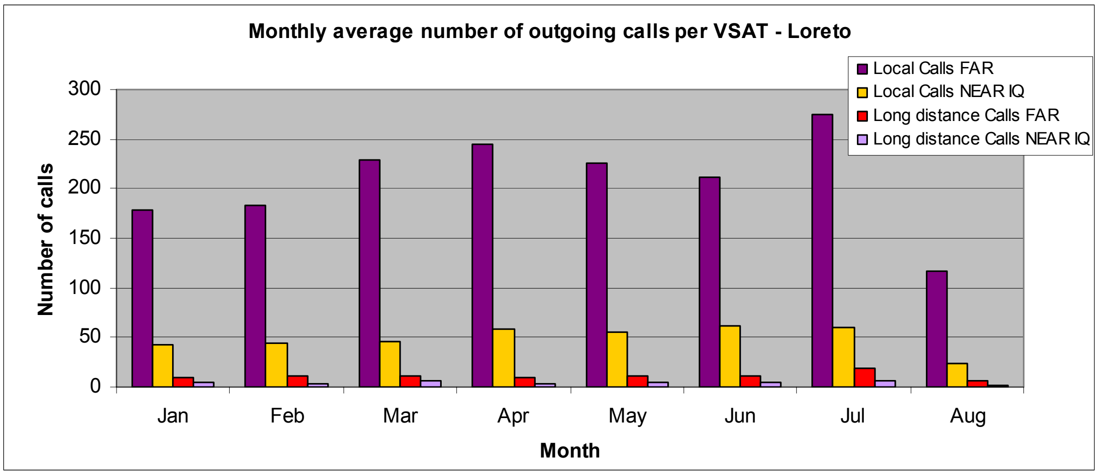

Figure 65 – Monthly average number of outgoing calls – by call type distribution - test-case 1 - Loreto

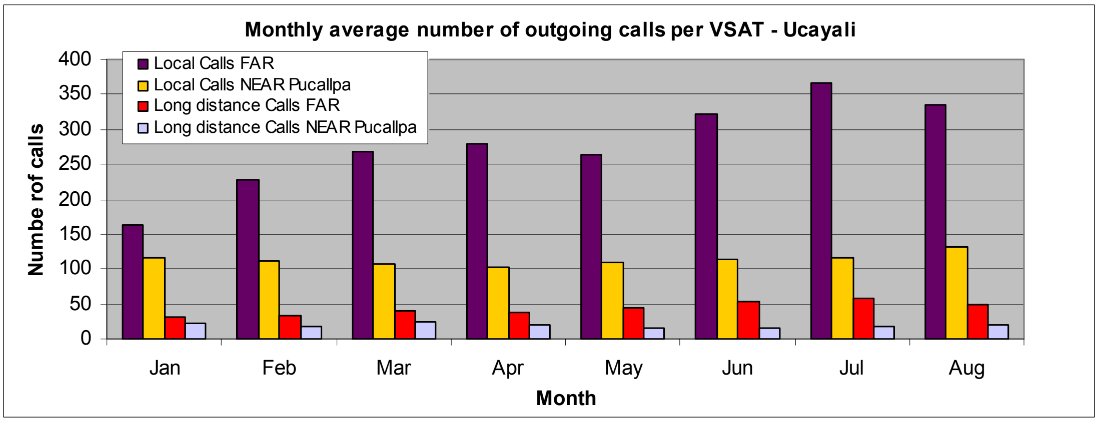

Figure 66 – Monthly average number of outgoing calls – by call type distribution - test-case 2 - Ucayali

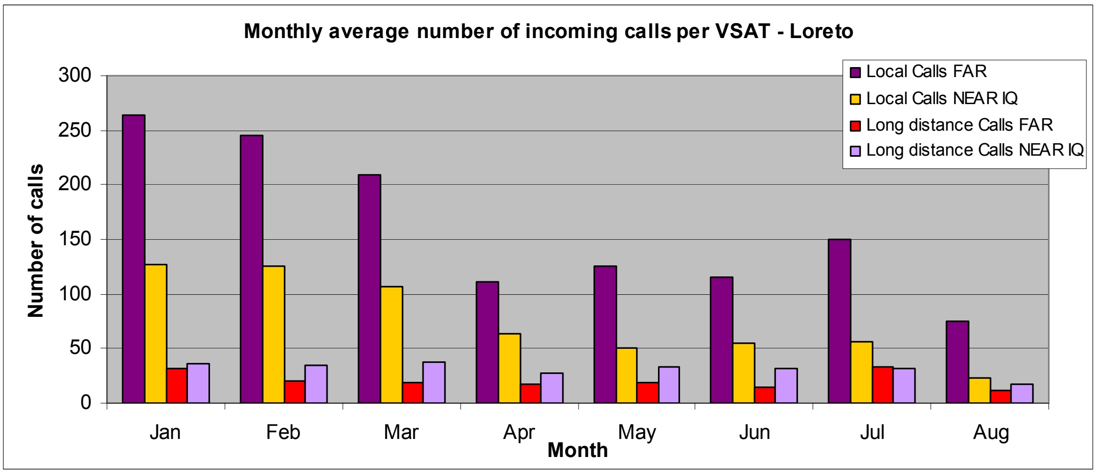

Figure 67 – Monthly average number of incoming calls – by call type distribution - test-case 1 - Loreto

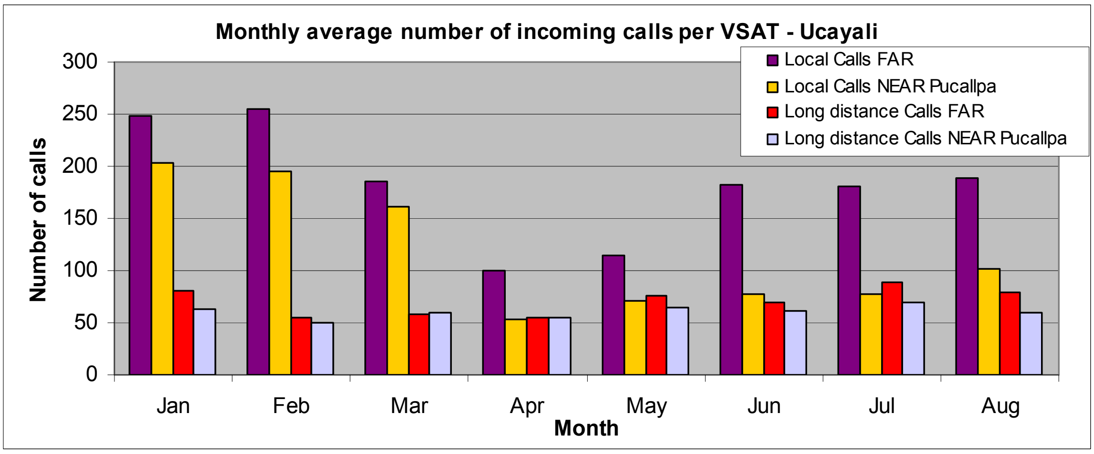

Figure 68 – Monthly average number of incoming calls – by call type distribution - test-case 2 - Ucayali

The patterns observed from these figures are generally similar to the patterns of total calls: "Far" VSATs generate more calls than "Near" VSATs, both incoming and outgoing. However, this is mainly so for local calls, where the difference is significant. In long distance calls the difference is notable mainly in Ucayali outgoing calls, and there is one instance of exception - incoming calls in Loreto, where the pattern is reversed - more calls are entering VSATs near Iquitos than the far VSATs. These findings provide a stronger support to the explanation in the previous section, since we can see that the main contributor to the difference is local calls within the department, evidence that most social and commercial relations in those remote Selva departments are done within each department.

4.6.2.3. Findings - the Selva – duration of calls

In this section I examined average duration of calls in the "Far" and "Near" VSATs. Figure 69 and Figure 70 present average duration of outgoing calls in each of the two Selva test-cases. Figure 71 and Figure 72 present average duration of incoming calls in those test-cases.

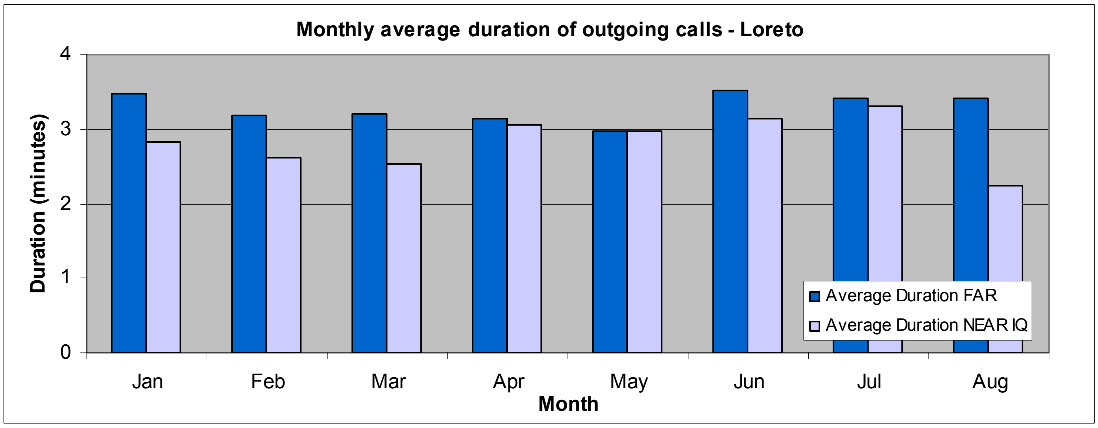

Figure 69 - Average duration of outgoing calls – test-case 1 - Loreto

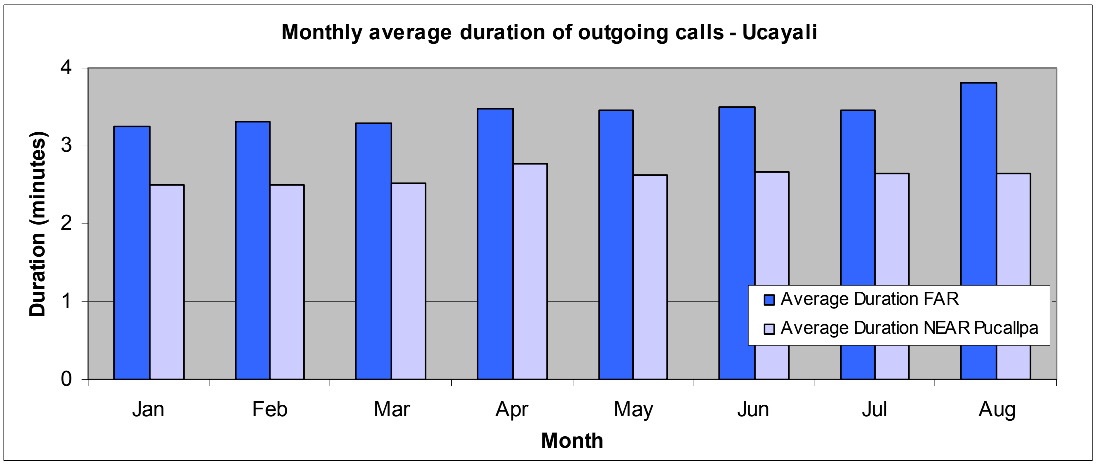

Figure 70 - Average duration of outgoing calls – test-case 2 - Ucayali

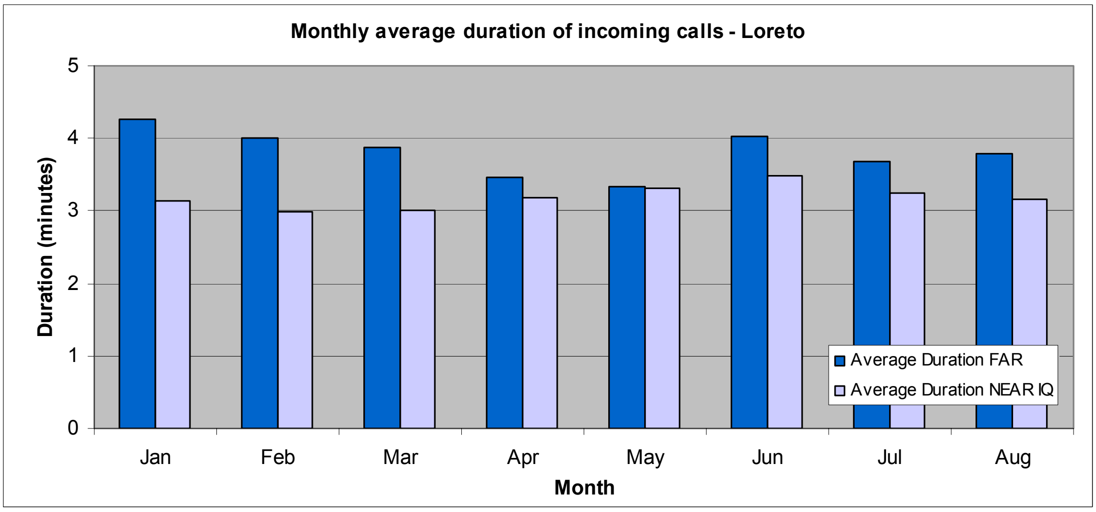

Figure 71 - Average duration of incoming calls – test-case 1 - Loreto

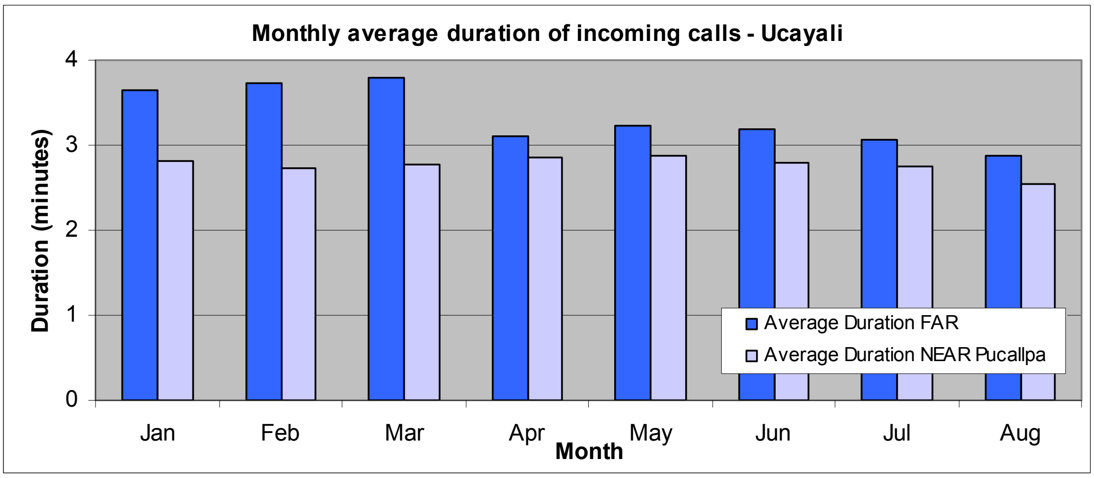

Figure 72 - Average duration of incoming calls – test-case 2 - Ucayali

The figures illustrate, that calls to and from "Far" VSATs are significantly longer than calls to and from "Near" VSATs. This provides another evidence to the necessity of people in remote and isolated communities for communications, which is reflected not only in the number of calls but also in their duration.

4.6.3. The Sierra region

For this case I searched for the largest remote mountainous area in Peru. I found such an area between longitude 74 and 72 degrees and latitude 16 and 14 degrees. Administratively, this area is under 4 departments: Apurimac, Cusco, Arequipa and Ayacucho.

I performed two comparisons with two sets of VSATs:

Test-case 3 - Ayacucho

14 "Far" sample VSATs from the specified area and in Ayacucho department, installed in May 2002 as part of FITEL II project.

15 "Near" sample VSATs, all located close to the city of Ayacucho, capital of Ayacucho department, installed in May 2002 as part of FITEL II project.

Figure 73 shows the locations of the selected VSATs for this test-case.

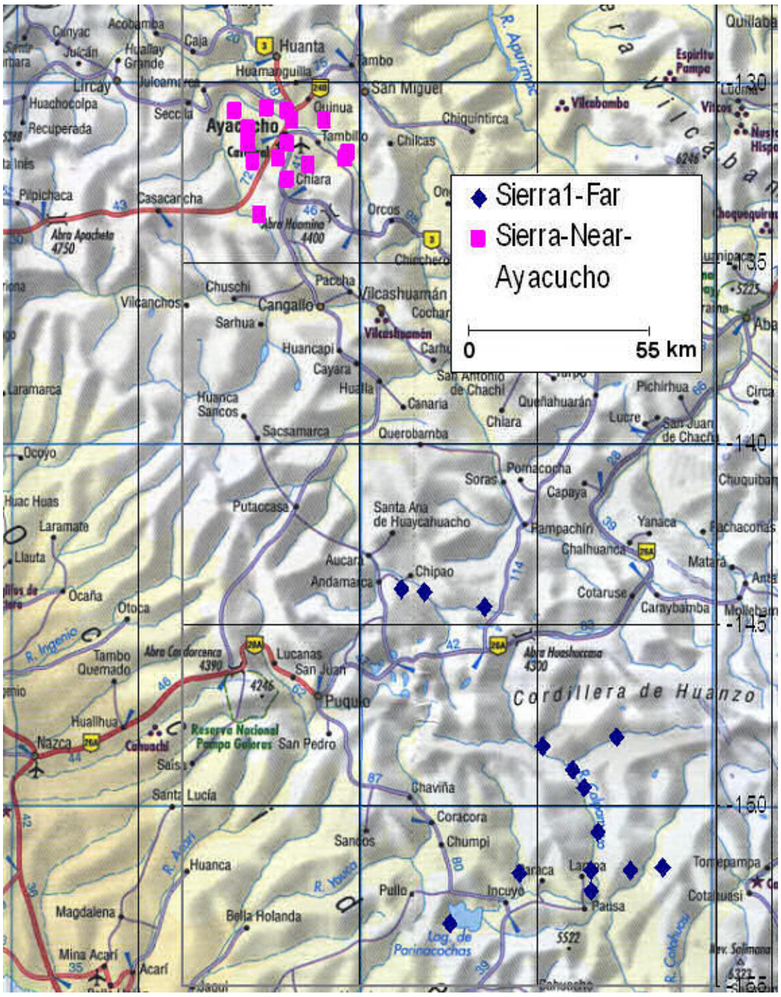

Figure 73 - Locations of test-case 3 selected VSATs in Ayacucho

Test-case 4

18 "Far" sample VSATs from the specified area and in Arequipa department, installed on July – August 2001 as part of FITEL II project.

9 "Near" sample VSATs, all located close to the city of Arequipa, capital of Arequipa department , installed in December 2001 as part of FITEL II project.

Figure 74 shows the locations of the selected VSATs for this test-case.

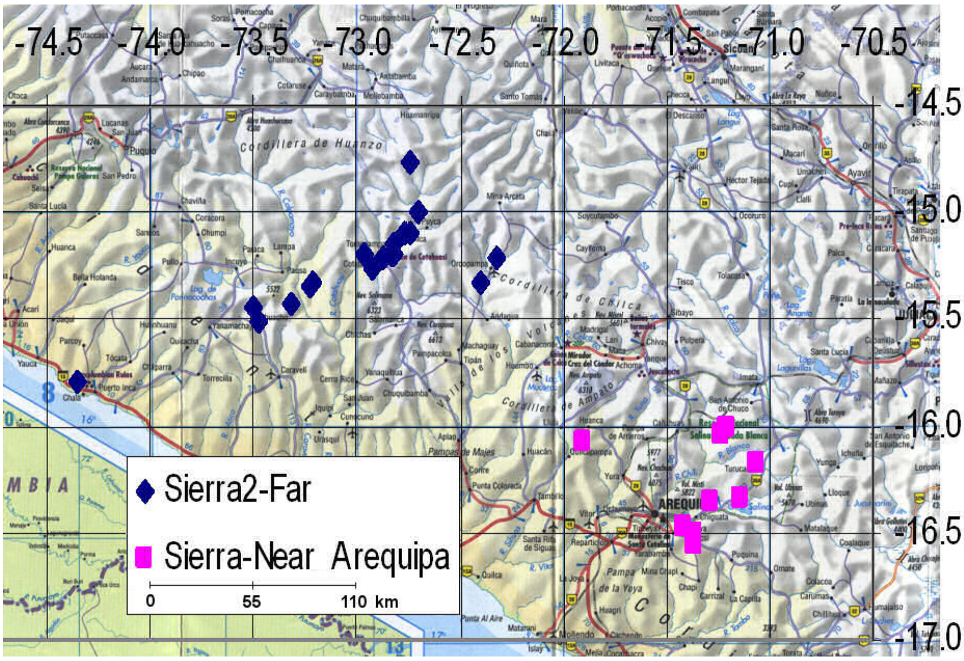

Figure 74 - Location of test-case 4 selected VSATs in Arequipa

4.6.3.1. Findings - the Sierra – number of calls

Figure 75 and Figure 76 present the total number of outgoing calls in each of the two Sierra test-cases. Figure 77 and Figure 78 present the total number of incoming calls in each of these test-cases.

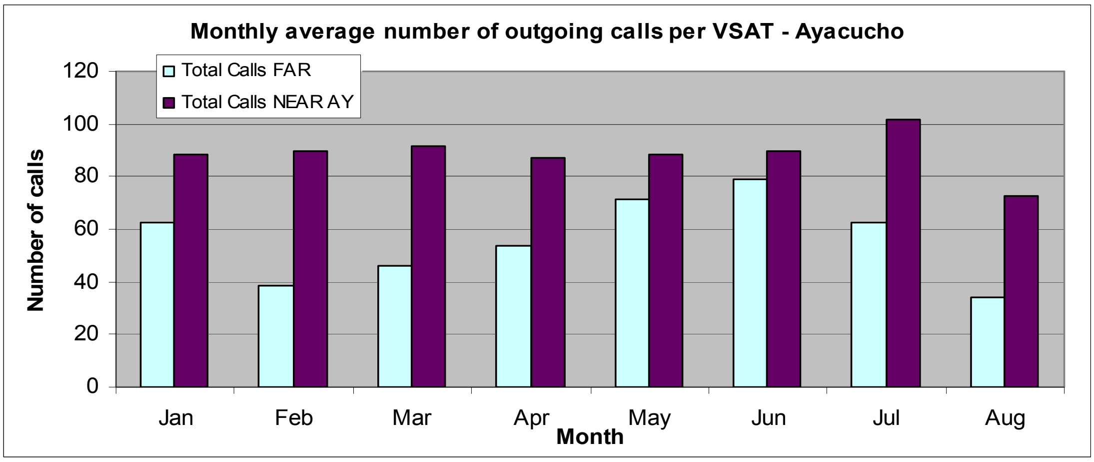

Figure 75 – Monthly average number of outgoing calls per selected VSATs - test-case 3 - Ayacucho

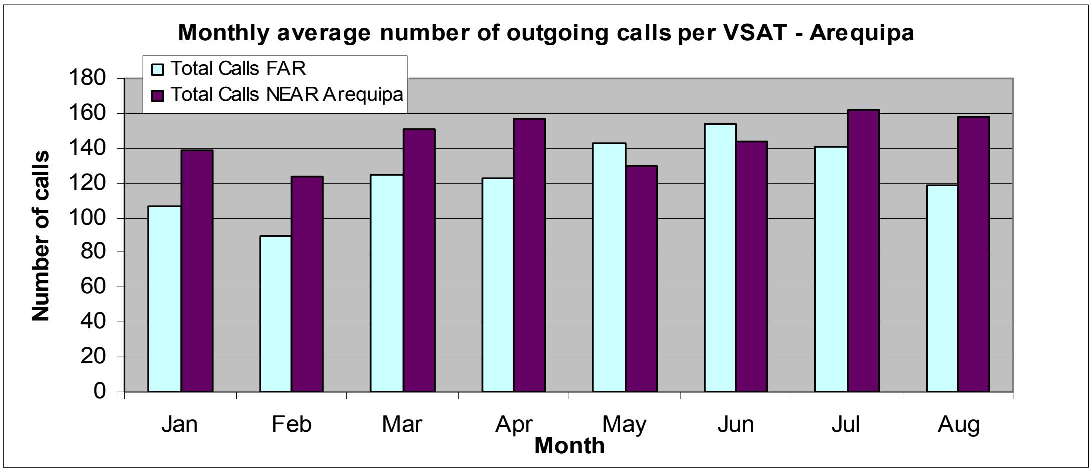

Figure 76 – Monthly average number of outgoing calls per selected VSATs - test-case 4 - Arequipa

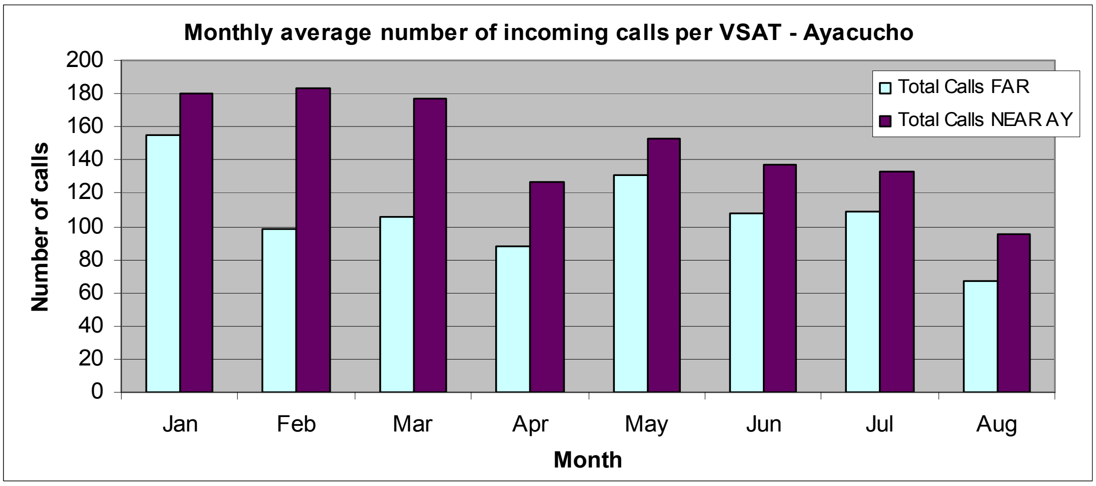

Figure 77 – Monthly average number of incoming calls per selected VSATs - test-case 3 - Ayacucho

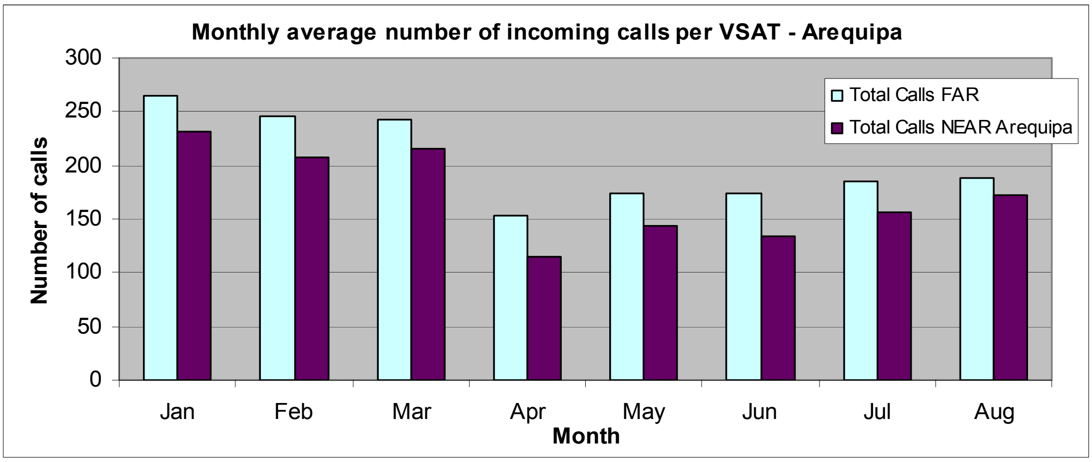

Figure 78 – Monthly average number of incoming calls per selected VSATs - test-case 4 - Arequipa

The comparison of calls in the Sierra reveals results which are almost the opposite. The total number of calls is lower in remotely located VSATs, except for incoming calls in Arequipa. This can be explained by the poverty of the remote community of the sierra, which lacks the economic means to make calls.

4.6.3.2. Findings – the Sierra – call types distribution

Figure 79 and Figure 80 illustrate the number of outgoing calls by distribution of call types for each of the two Sierra test-cases. Figure 81 and Figure 82 illustrate the number of incoming calls by distribution of call types for each of these test-cases.

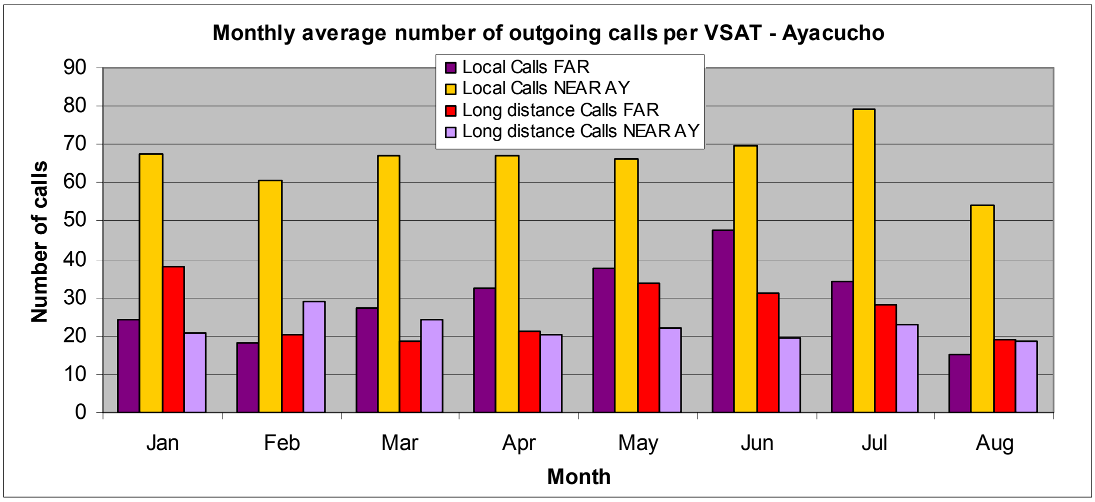

Figure 79 – Monthly average number of outgoing calls – by call type distribution – test-case 3 - Ayacucho

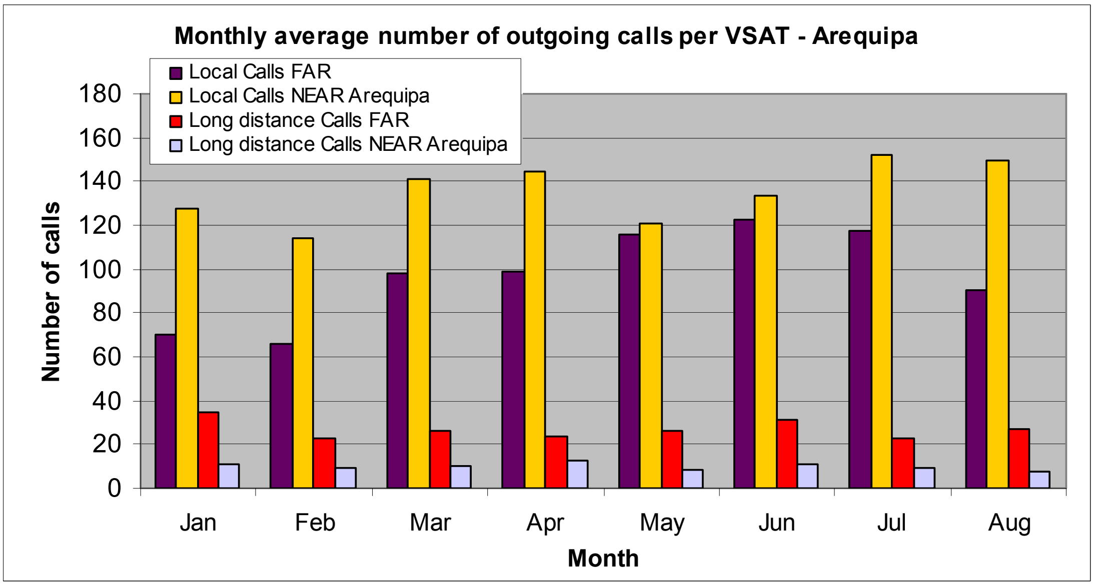

Figure 80 – Monthly average number of outgoing calls – by call type distribution – test-case 4 - Arequipa

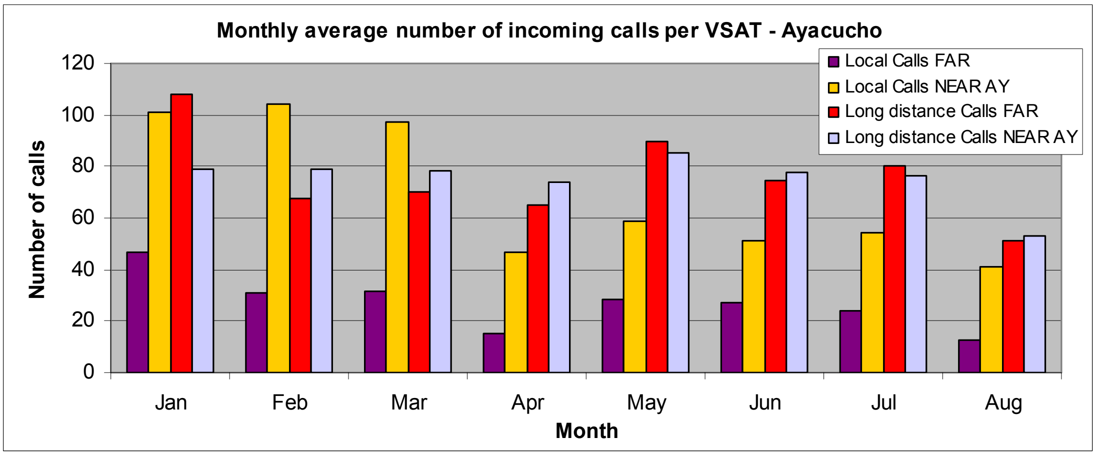

Figure 81 – Monthly average number of incoming calls – by call type distribution – test-case 3 - Ayacucho

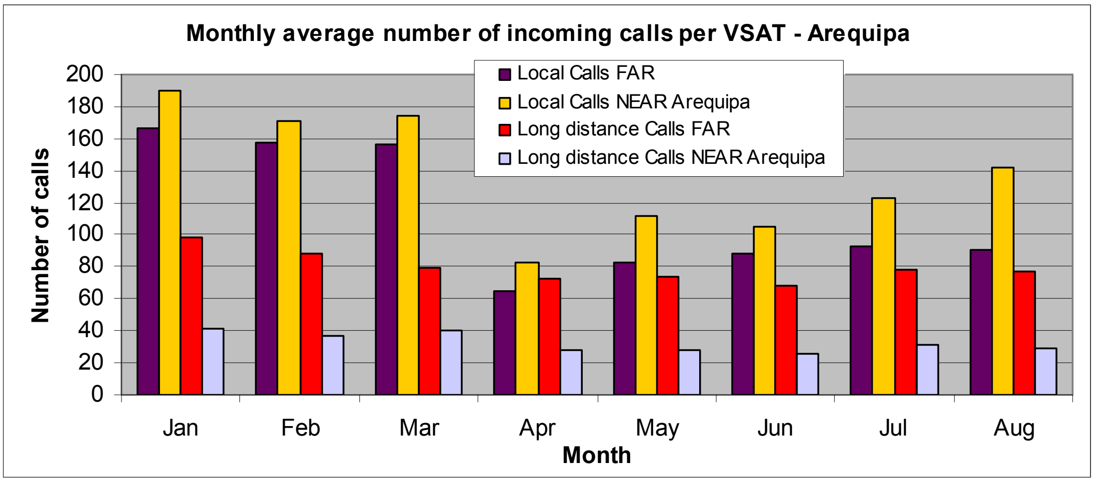

Figure 82 – Monthly average number of incoming calls – by call type distribution – test-case 4 – Arequipa

When taking a closer look at call type distributions we can see that the amount of long distance calls is higher in remote areas than in areas near the big cities (this is clear except for incoming calls in Ayacucho). This can be explained by the fact that the remote area chosen for the VSATs sample is not far from the border of several departments – Apurimac, Cusco, Areqiupa and Ayacucho, so it is likely that phone calls are made to and from other departments. This may imply, that remote villages do not necessarily communicate with the capital of the department they belong to, but to other urban centers in other departments, which are probably more accessible by transportation. In local calls the pattern is the opposite, higher number of local calls are made by the "Near" VSATs. It is likely that these calls are mainly between the villages and the large city.

4.6.3.3. Findings – the Sierra – duration of calls

Figure 83 and Figure 84 present average duration of outgoing calls in each of the two Sierra test-cases. Figure 85 and Figure 86 present average duration of incoming calls in each of these test-cases. As can be seen in the figures, calls to and from "Far" VSATs are significantly longer than calls to and from "Near" VSATs. These findings are similar to the call duration findings for the Selva test-cases.

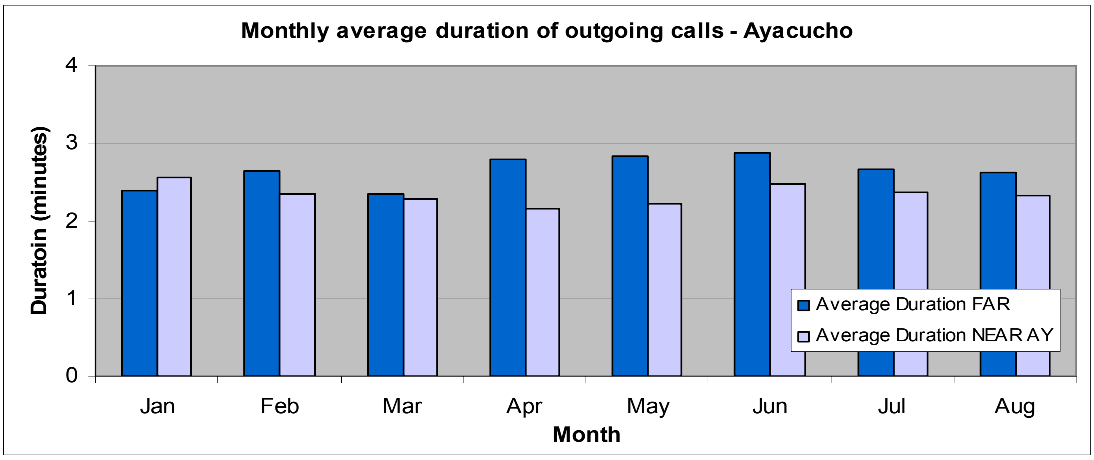

Figure 83 - Average duration of outgoing calls – test-case 3 - Ayacucho

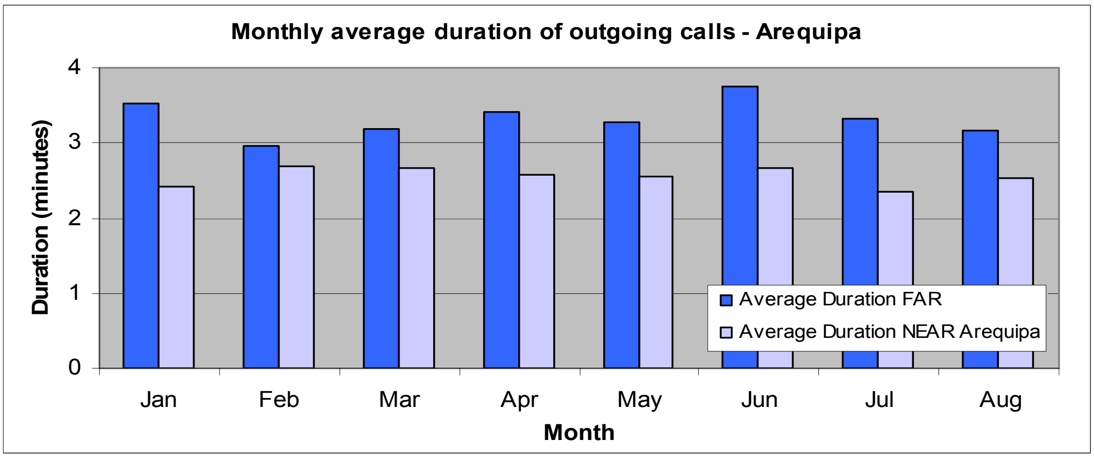

Figure 84 - Average duration of outgoing calls – test-case 4 - Arequipa

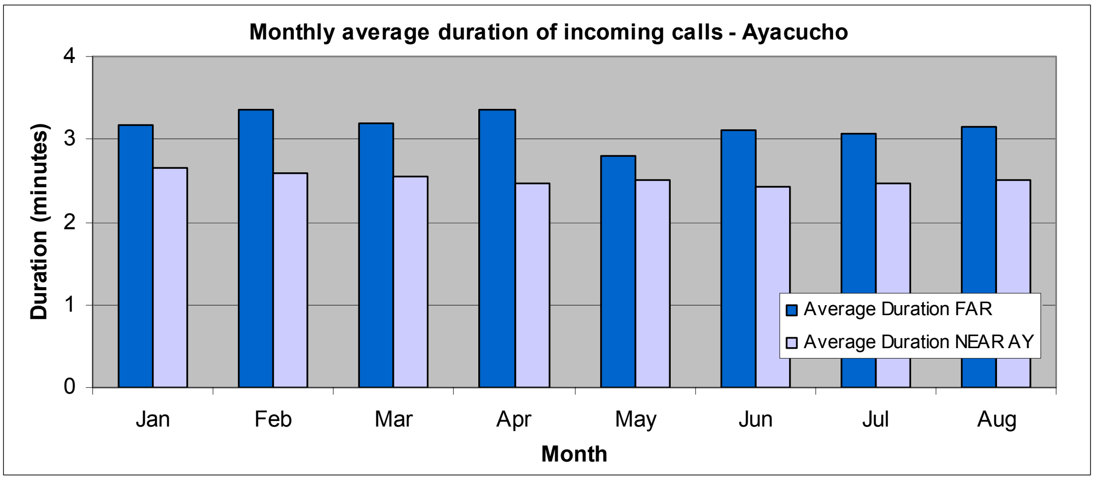

Figure 85 - Average duration of incoming calls – test-case 3 - Ayacucho

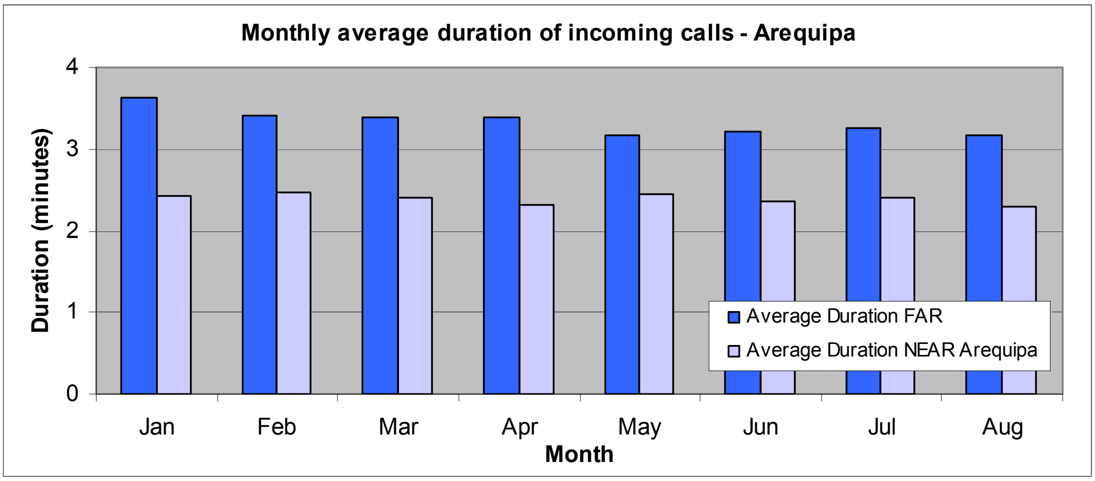

Figure 86 - Average duration of incoming calls – test-case 4 - Areqiupa

4.7. Analysis of International incoming calls to VSATs

This analysis deals with the distribution of international incoming calls to VSATs in the various departments. The purpose is to find out whether a difference exists in the nature of incoming international calls to VSATs among the various departments. The calculations are based on analysis of source numbers, identification of incoming international calls, and sorting of the findings by departments.

4.7.1. Steps of analysis

Methodology used: direct queries on CDR database.

4.7.1.1. Query

The query was done on CDR Dataset 2. In the query, I counted the number of international incoming dials to each one of the VSAT lines (Query syntax appears in Appendix 2 in section 7.2.3.1).

Identifying incoming international calls was done according to the special mask used to identify international calls:

Calls routed by Telefonica del Peru: 2-19YY-XXX

Calls routed by Telmex Peru: 5623380155 and 5623387595.

The query result was a table in the format presented in Table 18.

Table 18 - Query results -
Amount of international incoming dials

Destination VSAT Phone number	Total international incoming dials
16000022	5
16000066	2
16000100	246
16000101	138
16000102	44
16000104	16
16000105	5
16000106	21
16000109	2
16000111	10
:	:

4.7.1.2. Excel analysis

1. Data was copied to an excel sheet and sorted according to Destination VSAT phone number.
2. On the sorted table, the total number of dials per area code was counted (dials for each group of phone numbers that belong to the same area code were summed).
3. Number of lines per area code was counted.
4. A new sheet with a new table was prepared with the headings:
   Department; Total number of dials; Total number of VSATs.
   Another column was added to the table, containing the number of active VSAT phone lines per department, obtained from calculation of outgoing long distance dials.
5. Calculations between columns were performed to get the following final table.

4.7.2. Findings

Findings are presented in Table 19.

Table 19 - Incoming international calls - departments summary

Department	Total incoming international dials	Total number of VSAT phone lines dialed	Average incoming international dials per line	Active VSAT lines (based on outgoing LDN dials query)	Average incoming international dials per active lines	percent of lines getting at least one international incoming call
Apurimac	19707	272	72.5	281	70.1	96.8
Amazonas	23816	341	69.8	344	69.2	99.1
Ayacucho	22804	345	66.1	354	64.4	97.5
Cajamarca	49371	779	63.4	795	62.1	98.0
San martin	16928	281	60.2	285	59.4	98.6
Ucayali	4988	96	52.0	97	51.4	99.0
Loreto	13889	244	56.9	274	50.7	89.1
Junin	17030	314	54.2	336	50.7	93.5
Huanuco	19585	374	52.4	391	50.1	95.7
Huancavelica	13575	273	49.7	288	47.1	94.8
Pasco	6962	144	48.3	158	44.1	91.1
Arequipa	7617	171	44.5	194	39.3	88.1
Piura	15931	396	40.2	406	39.2	97.5
Madre de dios	1393	36	38.7	40	34.8	90.0
Cusco	14467	442	32.7	514	28.1	86.0
Tumbes	1175	43	27.3	46	25.5	93.5
Ica	1737	62	28.0	75	23.2	82.7
Moquegua	1794	65	27.6	78	23.0	83.3
Tacna	951	32	29.7	44	21.6	72.7
Lima	4640	186	24.9	253	18.3	73.5
Puno	8059	393	20.5	492	16.4	79.9

Figure 87 spatially shows the volume of incoming international calls to the various departments. It is based on the average incoming international dials per active lines column of Table 19.

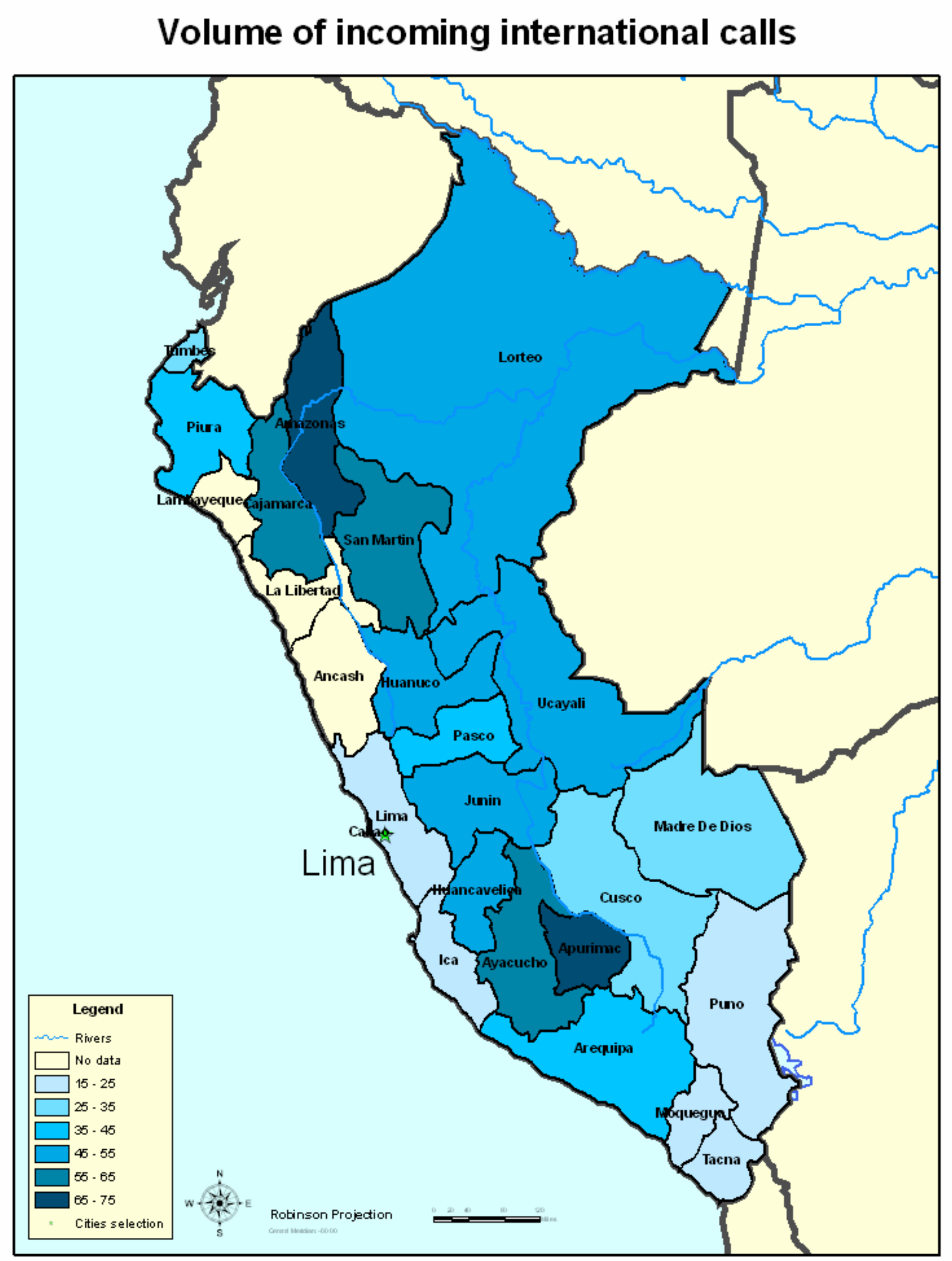

Figure 87 – Volume of incoming international calls

Findings from the table and the figure are as follows:

The top departments (Over 98% of the VSATs get international incoming calls) are: Amazonas, Ucayali, San Martin and Cajamarca. In the bottom (Less than 80%) are: Tacna, Lima and Puno. It is interesting to see, that in no department, the percentage of VSATs getting at least one international call is less than 72.7%. Regarding average number of calls per VSAT line (lines getting at least one international call), the top departments are: Apurimac, Amazonas, Ayacucho, Cajamarca and San Martin. In the bottom are: Puno, Lima, Tumbes and Moquegua. Since most incoming international calls to villages are made by Peruvians who live abroad and call families and friends back at home, these findings may shed some light on the nature of emigration abroad. According to findings presented in chapter 4.5, VSATs in the Selva and Montana departments are the leaders in number of call minutes. However, the findings in this section show, that departments of Apurimac, Ayacucho, Cajamarca, Junin, Huanuco and Huancavelica, which are not located on the Selva and Montana regions, have a significant activity of incoming international calls. This may provide evidence for the connections between Peruvian callers abroad and people in these specific departments, and for the extent of emigrants abroad from these departments. Looking at the in and out migration table (Table 3, page 39) supports this notion, showing high figures of out-migrants from these departments.

I also checked and found a correlation between the percentage of VSATs getting at least one international call and the average number of calls entering those VSATs phone lines, as presented in Figure 88. Each dot in the graph represents one of the departments.

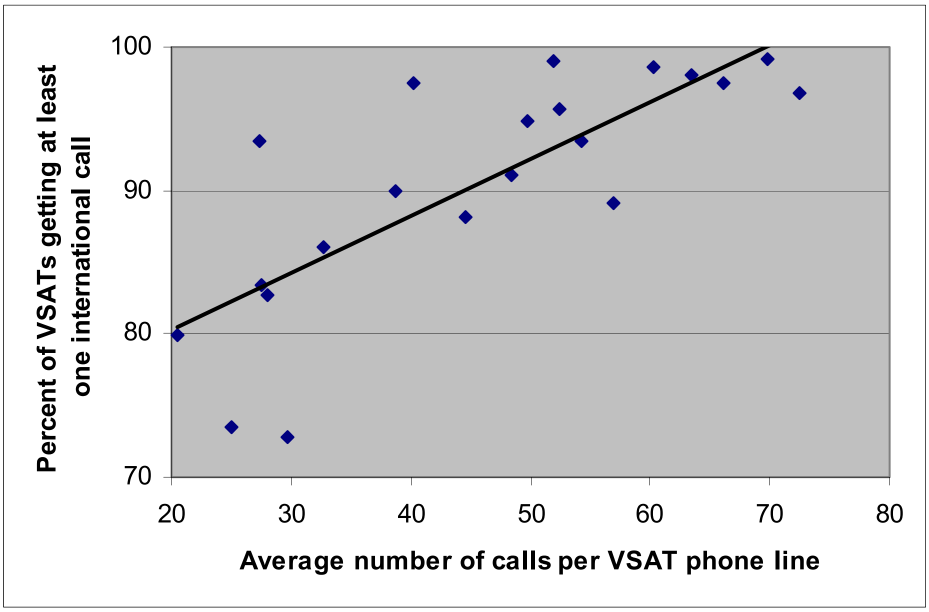

Figure 88 – Incoming international calls - correlation

The correlation graph better emphasizes the intensity of international calls activity in the various departments. It shows that departments where more VSATs get international calls also get more calls per each VSAT. Note, that a couple of exceptions can be identified: in Lima and Tacna (on the bottom left) the number of VSATs getting any international incoming calls is less than expected. The socio economic level of Tacna is one of the highest in Peru. According to the in and out migration table, Tacna has positive migration (the number of in-migrants was over three times higher than the number of out-migrants), explaining the smaller number of VSATs that get calls from abroad. As for Lima, it is probably natural for villagers from the department of Lima to move to the metropolitan area of the capital rather than migrate abroad.

4.8. Analysis of origin of incoming dials to VSATs – by service type

This analysis will be focused on the source phone numbers dialing to VSATs. Using the numbering plan guide, service type of lines where the dials come from (such as public pay phones and other Gilat VSATs) can be identified. The analysis is done per department, counting dials coming from the selected departments and services to VSATs. It is focused on selected departments: Lima (The capital and most developed department), Loreto (Remote Selva department), Puno (Remote Sierra department), Ica (Remote, frontier, and relatively developed department), and Huancavelica (Poor sierra department).

4.8.1. Steps of analysis

Methodology used: direct queries on CDR database

4.8.1.1. Query

The query was done on CDR Dataset 2

In the query, I counted the number of times that a dial was made from each one of the source phone numbers (Query syntax appears in Appendix 2 in section 7.2.3.2). The result is a list of all source phone numbers that ever called to VSATs, together with the number of times that they dialed to VSATs. The query searches for calls with duration larger than zero, in order to focus on actual calls made, and reduce the "noise" that can be caused by numerous repeated unsuccessful dials. The result list was 138,991 lines long, sorted by source phone number.

4.8.1.2. Excel analysis

1. Since Excel sheet cannot contain more than 65,536 rows, I split the result table to 3 excel sheets:
   a. Numbers beginning with 0 to 1 – 60,616 rows
   b. Numbers beginning with 2 to 6 – 49,920 rows
   c. Numbers beginning with 7 to 9 – 28,455 rows

2. On the "Maestro del numeracion"

   The analysis of phone numbers was done using the "Maestro del numeracion" (see section number 3.4.1.3 page 60). Since the assignment of numbers ranges to various areas, exchanges and services is quite complex, I examined selected services: public pay phones and rural telephony.

   At the first place I intended to examine only public phones, but then learned that numbers assigned to "rural telephony" should also be taken into consideration, since they usually mean public payphones in rural areas. Even Gilat prefixes appeared in the "maestro" sometimes as service "rural telephony" and sometimes as "public phones".

   Therefore, used the "maestro" Excel sheet as follows:

   - Limiting the search for the desired department.
   - Limiting the search for "Public phones" service and identifying the prefixes and number ranges that are assigned for this service.
   - Limiting the search for "Rural Telephony" service and identifying the prefixes and number ranges that are assigned for this service.
   - Limiting the search for "Gilat" operator and identifying the prefixes and number ranges that are assigned for this operator.

3. Back on the Excel dials sheets, the total number of dials coming from each of the desired prefixes as counted. For example, Table 20 shows the result of the counts for the department of Puno:

Table 20 - Analysing service types - example

Area code & prefix	Num of dials	Service type
51-54	45972	Public phones
51-8101	571	Gilat
51-812	14848	Gilat
51-814	0	Telephonia Rural
51-8006	60	Telephonia Rural
51-8007	31	Telephonia Rural
51-7090	116	Telephonia Rural
51-701	0	Telephonia Rural
51-7000	4	Telephonia Rural
51-3604	0	Telephonia Rural
51-3602	2	Telephonia Rural
51-320	6	Telephonia Rural
51-ALL	78370	

4. After repeating the above step for the selected departments, a final table was made, summarizing the distribution of service types of numbers called to the VSATs.

4.8.2. Findings

Table 21 presents the analysis summary.

Table 21 - Incoming calls to VSATs by selected service types – results summary

	Lima	Loreto	Puno	Ica	Huancavelica
Total Dials from this department to VSATs	1070761	204831	78370	48411	35104
Dials originating in Gilat VSATs	19628	24997	15419	2020	19997
Percentage of dials originating in Gilat VSATs	**1.83**	**12.20**	**19.67**	**4.17**	**56.97**
Dials originating in public phones (including in rural areas, including Gilat)	713191	133879	61610	35759	25366
Percentage of dials originating in public phones (including in rural areas, including Gilat) services	**66.61**	**65.36**	**78.61**	**73.87**	**72.26**

The most striking result observed is that the majority of incoming calls to VSATs originated in public phones. This is a clear evidence for the nature of callers to the villages where VSATs are installed: people who do not have access to a fixed line or mobile line – at home or at work, people from lower socio economic levels.

Another finding is the percentage of dials to VSATs coming from other Gilat VSATs. In Lima, just a small amount of calls is coming from other VSATs. The interaction between villages is small, because places in Lima are relatively close to Lima metropolitan area, and social as well as economic relations are likely to be done with the capital.

In Huancavelica, almost 57 percent of calls are coming from other Gilat VSATs, implying for the strong rural connection between villages in such a remote sierra area.

4.9. Analysis of VSAT outgoing calls – departments matrix

In this analysis I am interested to examine the spatial communications relations between departments, by analyzing source numbers and destination numbers of VSAT outgoing domestic calls. As illustrated in Figure 89, this analysis will take into account calls originating in VSATs and terminating in any other type of line. The calculations will be gathered into a full matrix containing figures for calls from all departments where VSATs are installed to all of the departments.

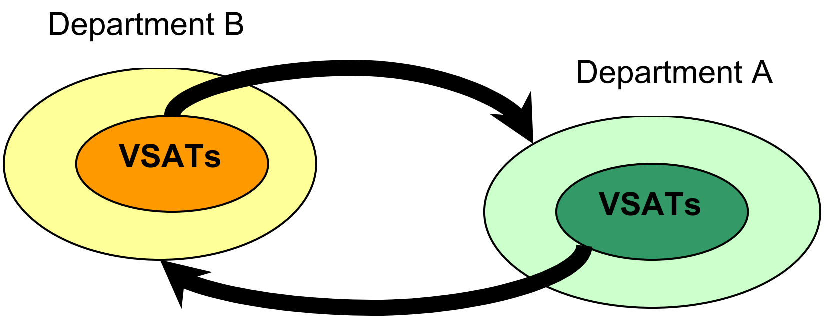

Figure 89 – VSAT outgoing calls

4.9.1. Steps of Analysis

Methodology used: direct queries on CDR database

The query I made is based on analyzing the area code of the numbers, and counting total calls from all area to area combinations. The area code of the source phone number (the VSAT number) was obtained by examining the first two digits of the number, while the area code of the destination phone number (dialed from the VSAT) was obtained by examining the first three digits of the number, because "0" is added to the dial. The query also counts the number of distinct phone numbers dialed from each area code to area code (Query syntax appears in appendix 2 in section 7.2.3.3).

4.9.1.1. Query limitations

The query searches only for dialed numbers which are 9 digits long, in order to analyze only valid domestic numbers. It searches for calls with durations larger than zero, in order to focus on actual calls made, and reduce the "noise" that can be caused by numerous repeated unsuccessful dials. The dataset used is Dataset 2.

4.9.1.2. Query results

The query result was a table in the format sample presented in Table 22:

Table 22 - Area codes analysis – outgoing calls - query result sample

Source Area	Destination Area	Total distinct numbers	Total dials
62	054	125	381
65	051	27	98
62	082	13	21
56	041	4	11
41	065	217	872
83	043	29	141
63	006	2	2
51	041	8	44
67	073	18	37
72	016	2	8
41	084	41	92
76	083	47	125
56	018	8	12
73	067	1	2
41	056	64	251
:	:	:	:

4.9.1.3. Excel Analysis

1. Table was sorted according to originating area code.
2. A "special treatment" had to be given to Lima numbers – the area code of Lima is a single digit one, so as can be seen in the above table, Lima numbers were separated to "two digits" sub division. Therefore, results of Lima had to be manually grouped – all "areas" 11 to 19 were summed to area "1".

3. A new sheet was prepared in the form of a matrix. Results were copied into this sheet in order to get the full table of total dials from originating area codes to destination area codes.
4. Additional calculation was added - the percentage of calls as distributed between the departments.
5. The percentages table was then transposed and sorted by all columns. Thus, providing a sorted list for each department, for the dialed destination departments.

4.9.2. Findings – departments matrix

Table 23 presents for each department the five most "popular" departments dialed from the VSATs in that department.

Table 23 - Top dialed destinations from VSATs - by departments

VSATs from department	To Destination departments (percentage)				
Lima	Lima	Junín	Ancash	Huánuco	Ica
	91.746	2.687	1.497	1.013	0.724
Amazonas	Amazonas	Lima	Cajamarca	Lambayeque	San Martin
	70.203	8.536	6.646	5.828	4.139
San Martin	San Martin	Lima	Cajamarca	Amazonas	Lambayeque
	76.456	5.296	5.202	3.039	2.336
Puno	Puno	Lima	Arequipa	Tacna	Cusco
	81.300	6.850	6.304	2.103	1.471
Tacna	Tacna	Puno	Lima	Arequipa	Moquegua
	85.720	4.909	4.482	2.514	1.053
Moquegua	Moquegua	Arequipa	Lima	Tacna	Puno
	64.875	26.061	2.850	2.419	2.345
Arequipa	Arequipa	Lima	Puno	Cusco	Ica
	83.811	7.264	2.142	1.759	1.706
Ica	Ica	Lima	Ayacucho	Huancavelica	Junín
	73.947	12.981	3.674	2.475	1.404
Ucayali	Ucayali	Lima	Huánuco	Junín	San Martin
	76.875	8.341	4.930	2.664	1.857
Huánuco	Huánuco	Lima	Ucayali	Junín	Pasco
	68.908	18.208	3.346	2.537	1.613
Pasco	Pasco	Lima	Junín	Huánuco	Ucayali
	51.135	24.919	11.838	5.727	1.293
Junín	Junín	Lima	Huancavelica	Ayacucho	Huánuco
	75.177	14.332	2.384	1.675	1.265
Loreto	Loreto	Lima	Ucayali	San Martin	Lambayeque
	90.832	3.023	1.740	1.534	0.673
Ayacucho	Ayacucho	Lima	Ica	Arequipa	Junín
	68.149	19.027	4.599	1.833	1.574
Huancavelica	Huancavelica	Junín	Lima	Ica	Ayacucho
	46.580	20.649	18.540	7.836	3.051
Tumbes	Tumbes	Piura	Lima	Lambayeque	La Liberated
	70.139	14.477	7.803	2.773	1.313
Piura	Piura	Lima	Lambayeque	San Martin	Tumbes
	80.871	8.721	3.695	1.435	1.392
Cajamarca	Cajamarca	Lima	Lambayeque	La Liberated	San Martin
	68.754	9.554	8.266	4.425	3.532
Madre de Dios	Madre de Dios	Cusco	Lima	Arequipa	Puno
	63.202	20.163	6.692	3.235	2.892
Apurimac	Apurimac	Lima	Cusco	Arequipa	Ayacucho
	63.532	22.867	6.853	1.746	1.301
Cusco	Cusco	Lima	Arequipa	Puno	Ayacucho
	82.536	6.336	2.894	1.915	1.556

The results well demonstrate the geographical connections between neighboring departments, and the role of Lima as capital:

1. In all of the departments, most of the dials from the VSATs are to the same department (hence – a local call). This makes sense, since most interaction is done with the local department capital as the main urban center – for both social and economic aspects.
2. In most of the departments, the most dialed destination for long distance calls is Lima, as Lima is an important emigration destination, and economic center. However, some departments are exceptional, as detailed in Table 24.

Table 24 – Most dialed long distance destination - exceptions

Department	**Most dialed long distance destination**
Tacna	Puno
Moquegua	Arequipa
Huancavelica	Junín
Tumbes	Piura
Madre de dios	Cusco

There are two explanations for these exceptions:
First, as the areas are getting far from Lima, their urban center with which they interact is not the capital, but the closest urban center to their geographical location. The city of Puno serves as a close urban center to Tacna; The city of Arequipa is an urban center for people in Moquegua; Huancayo in Junín is an urban center for residents of Huancavelica; People of Tumbes are close to city of Piura, and people of the Selva department of Madre de dios use Cusco as a convenient urban center. Second, is that for some villages, the closest or more accessed urban center is not the department capital or Lima, but another urban center on a neighboring department. For example, Huancavelica is a neighbor of Lima, but for lots of villages Huancayo in Junin is more accessible.

Following explanation number one, we should expect that remote departments such as Loreto, Ucayali, Puno and Amazonas will also have more interactions with closer urban centers than Lima. And indeed, when examining the total destinations dialed from VSATs in those departments, 90% of the dials from VSATs in Loreto are dials to Loreto area code – showing the strong isolation of this department. 76% of the dials from Ucayali are to Ucayali destinations, 81% of the dials from Puno are within Puno, and 70% of dials from Amazonas are to Amazonas. As opposed to Pasco, for instance, where only 51% of the calls are to Pasco.

The graphs in Figure 90 and Figure 91 present the dialing matrix from all departments to all departments – in percentages. Each column represents calls made from VSATs in a specific department (marked at the bottom of the column). Destination departments appear as colored bars inside the column. The size of each bar inside the column represents percentage of calls to this destination department. The findings explained before are seen here as well – in general, VSATs in each department call to destinations within the same department, then to Lima, and then to neighboring departments. The high percentage of dials within the same department is well seen in Figure 90, which shows all the departments. The dials to Lima and neighboring departments are well seen in Figure 91, which shows only long distance destinations.

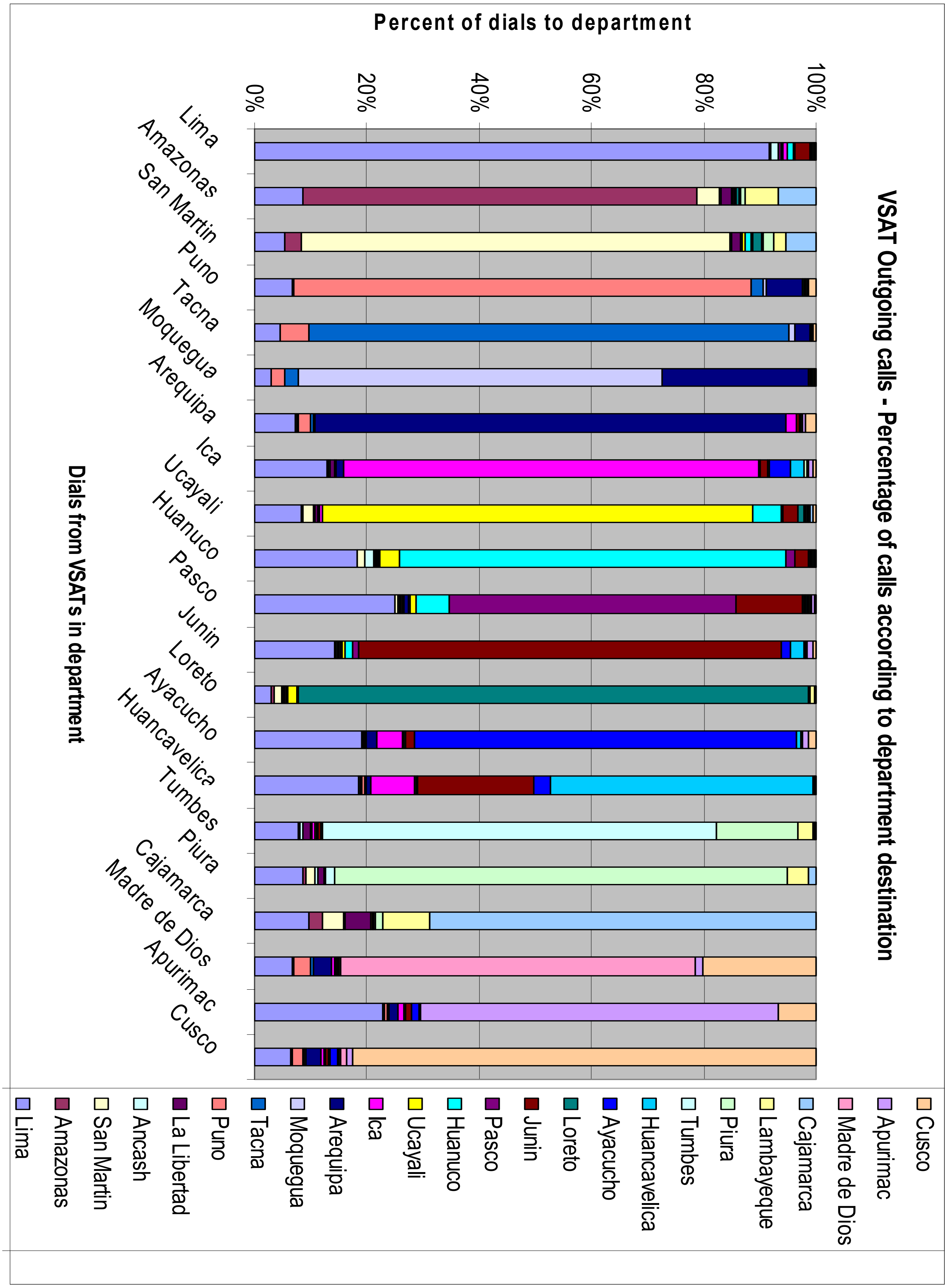

Figure 90 -VSATs outgoing calls – distribution of destinations by departments

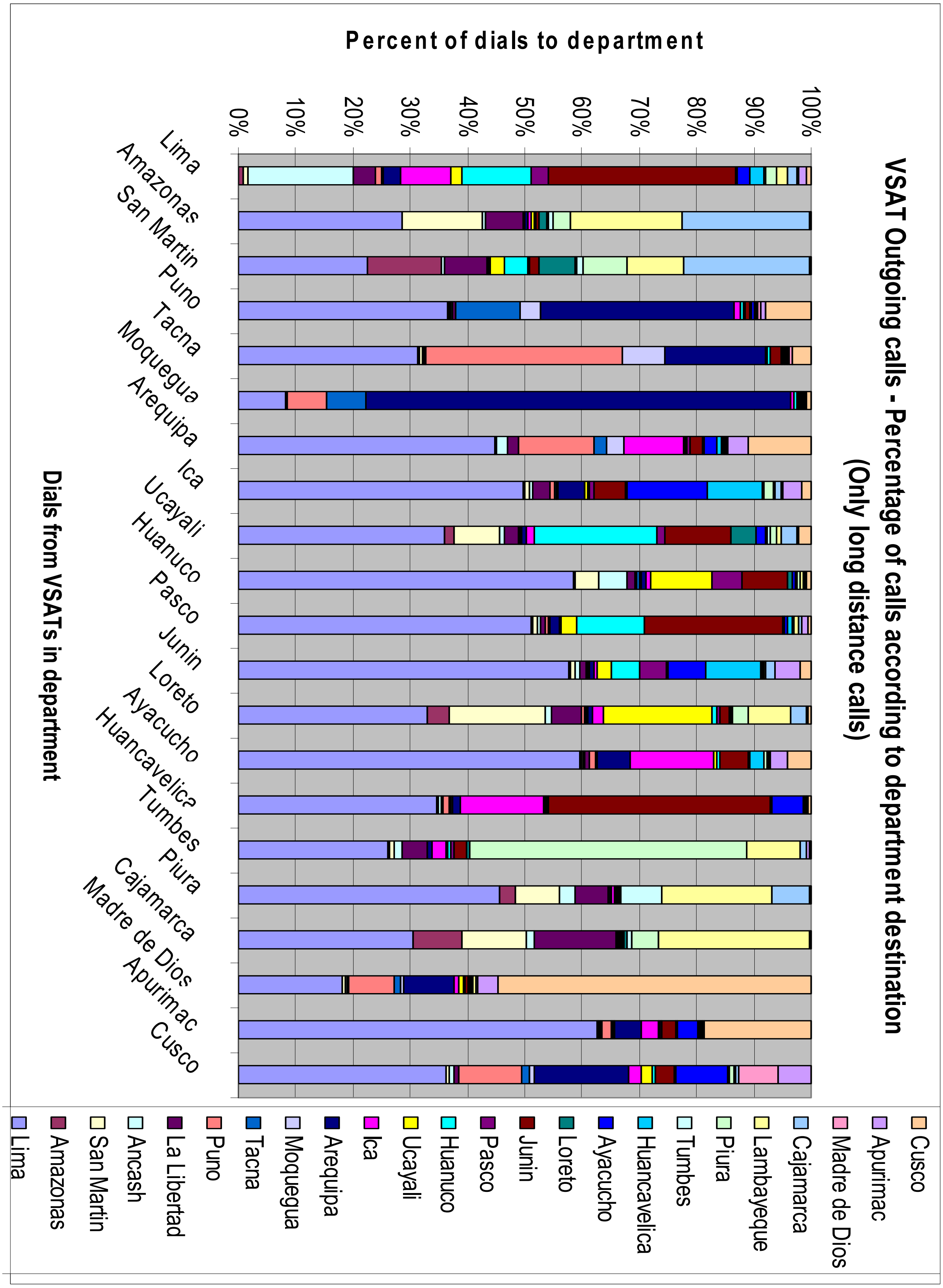

Figure 91 -VSATs outgoing calls – distribution of destinations by departments – only long distance calls

4.9.3. Findings - Analysis of distinct numbers

Another interesting output from this analysis is not only the amount of total calls made from VSATs but also the amount of distinct numbers dialed. Table 25 is comprised of aggregated data per departments and the number of VSAT lines in each department.

Table 25 - Analysis of distinct numbers dialed from VSATs

From Area	From Department	Total distinct numbers dialed	Number of dialing VSAT lines	Total number of dials	Distinct numbers per line	Dials per line
1	Lima	30550	253	131171	120.8	518.5
41	Amazonas	24078	344	212281	70.0	617.1
42	San Martin	23391	285	186594	82.1	654.7
51	Puno	16185	492	87501	32.9	177.8
52	Tacna	2095	44	10063	47.6	228.7
53	Moquegua	3719	78	17651	47.7	226.3
54	Arequipa	19624	194	109936	101.2	566.7
56	Ica	4825	75	18589	64.3	247.9
61	Ucayali	11469	97	67042	118.2	691.2
62	Huánuco	23971	391	157497	61.3	402.8
63	Pasco	11848	158	57989	75.0	367.0
64	Junín	28165	336	137053	83.8	407.9
65	Loreto	21485	274	187919	78.4	685.8
66	Ayacucho	25139	354	152596	71.0	431.1
67	Huancavelica	17022	288	88558	59.1	307.5
72	Tumbes	2281	46	8151	49.6	177.2
73	Piura	23316	406	121828	57.4	300.1
76	Cajamarca	51866	795	350885	65.2	441.4
82	Madre de Dios	5025	40	25670	125.6	641.8
83	Apurimac	14729	281	77888	52.4	277.2
84	Cusco	30941	514	202251	60.2	393.5

When examining the results per line, VSATs in Madre de dios, Lima, Ucayali and Arequipa have the highest diversity of numbers dialed – over 100 different numbers per VSAT line in average. On the other hand, VSATs in Puno, Tacna, Moquegua and Tumbes have the lowest diversity of numbers dialed – less than 40 per VSAT line in average. The diversity of dialed numbers provides evidence to the extent of social and commercial relations maintained by people in those departments.

I also looked for a correlation between the activity of a VSAT, that is to say, the amount of calls made from the VSAT, and the amount of distinct numbers dialed from the VSAT. The correlation graph was made from the total departmental figures, and presented in Figure 92.

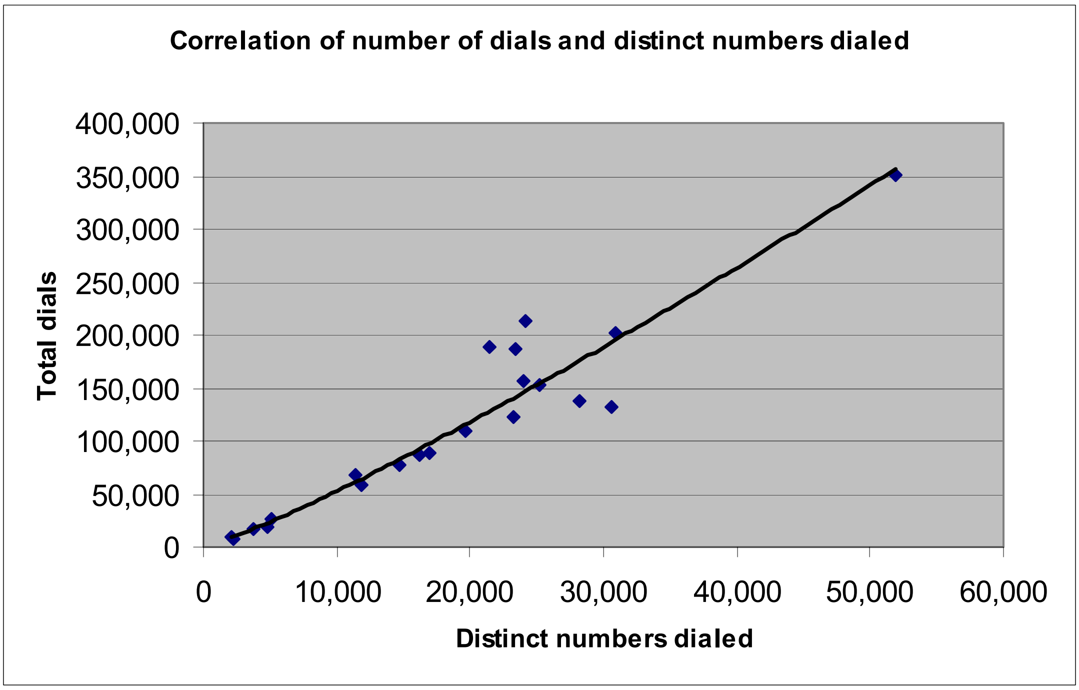

Figure 92 – Correlation of total dials with distinct numbers dialed

A correlation was found between total dials from VSATs and the volume of distinct numbers dialed. A few departments divert from the trend line: On the bottom: Lima – with more distinct numbers than expected. On the top: Loreto, San Martin and Amazonas – with more dials per number than expected. The explanation may be, that people in the rural areas of Lima are close to the urban center of Lima, and may conduct more diverse relations – business as well as social, which is reflected in the diversity of numbers dialed. On the other hand, Loreto, San Martin and Amazonas are remote Selva departments. They conduct relations with less entities, but those relations produce relatively more interactions.

4.10. Analysis of incoming calls to VSATs – departments matrix

This analysis is similar to the former one, but this time I am analyzing source numbers and destination numbers of incoming calls to VSATs. As illustrated in Figure 93, this analysis will take into account calls originating in any type of line and terminating in VSATs.

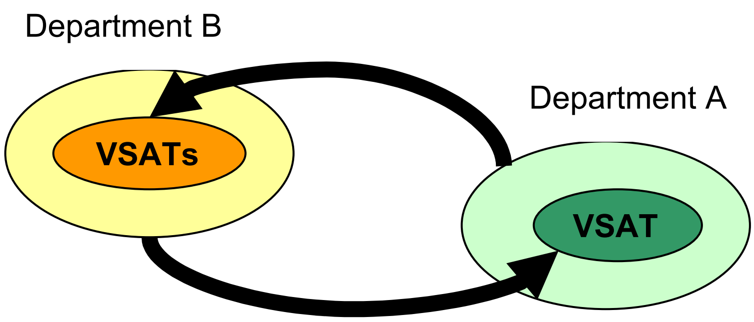

Figure 93 - VSATs incoming calls

4.10.1. Steps of analysis

Methodology used: direct queries on CDR database

The query made is based on analyzing the area code of the numbers, and counting total calls from all area to area combinations. Area code of the source phone number was obtained by examining the first two digits of the number, while the area code of the destination phone number (The VSAT number) was obtained by examining the first three digits of the number. The analysis here demanded some extra manual manipulation of the results, because sometimes VSAT numbers appear with "0" before the number and sometimes not.

4.10.1.1. Query limitations

The query searches for calls with durations larger than zero, in order to focus on actual calls made, and reduce the "noise" that can be caused by numerous repeated unsuccessful dials. The query eliminates source phone numbers which are known as masks for incoming international calls. The dataset used is Dataset 2 (Query syntax appears in appendix 2 in section 7.2.3.4).

4.10.1.2. Excel analysis

The analysis here was similar to the former, but was preceded by some extra manipulation on the query result list, due to the two formats of VSAT phone numbers: with and without "0".

Steps done to solve the problem:

1. "Destination area" column was turned from text to number, thus, removing the "0" prefix from the "destination area".
2. The list was sorted by "destination area" column and "then by" "source area" column. In this stage numerous "double lines" of identical source area to destination area (one to area XY and the other to the "former" 0XY area) appeared.
3. Identical source to area figures were manually summed, in order to form the final area to area matrix.

Results were ordered in a table in the form of Table 26.

Table 26 – Area codes analysis – incoming calls - query result sample

Source Area	Total distinct numbers	Destination Area	Total dials
:	:	:	:
53	18	41	123
54	1	41	1
54	62	41	378
56	1	41	6
56	33	41	311
61	6	41	57
61	47	41	397
:	:	:	:

4.10.2. Findings – departments matrix

Table 27 shows the top 5 departments dialing to VSATs in each department.

Table 27 - Top dialing departments to VSATs – by departments

Calls to VSATs in	From departments (percentage)					
Lima	Lima	Junín	Ancash	Ica	Pasco	Huánuco
	95.101	1.488	0.748	0.427	0.398	0.314
Amazonas	Amazonas	Lima	Lambayeque	Cajamarca	san martin	la liberated
	58.506	22.511	5.933	4.537	3.342	2.220
san martin	san martin	Lima	Cajamarca	Lambayeque	Loreto	Amazonas
	60.819	19.469	3.722	2.824	2.701	2.361
Puno	Puno	Lima	Arequipa	Tacna	Moquegua	Cusco
	54.360	20.970	10.543	6.572	2.224	1.608
Tacna	Tacna	Lima	Puno	Arequipa	Moquegua	Ancash
	71.831	10.005	7.371	4.428	3.649	0.570
Moquegua	Moquegua	Arequipa	Lima	Tacna	Puno	Cusco
	53.090	30.591	9.523	2.517	2.414	0.384
Arequipa	Arequipa	Lima	Puno	Ica	Cusco	Moquegua
	76.970	15.926	1.396	1.303	0.766	0.642
Ica	Ica	Lima	Ayacucho	Arequipa	Huancavelica	Junín
	65.239	25.960	1.966	1.897	0.842	0.768
Ucayali	Ucayali	Lima	Huánuco	Junín	san martin	Loreto
	69.663	16.458	5.197	1.918	1.256	0.876
Huánuco	Huánuco	Lima	Ancash	Ucayali	Junín	Pasco
	45.559	41.419	3.114	2.486	2.080	2.005
Pasco	Pasco	Lima	Junín	Huánuco	Ucayali	la liberated
	47.822	37.851	5.573	5.069	0.890	0.696
Junín	Junín	Lima	Pasco	Ayacucho	Huancavelica	Ucayali
	58.567	33.014	1.588	1.283	0.940	0.809
Loreto	Loreto	Lima	Ucayali	san martin	la liberated	Lambayeque
	82.675	9.482	2.777	1.487	0.572	0.568
Ayacucho	Ayacucho	Lima	Ica	Arequipa	Cusco	Junín
	51.063	38.932	4.438	1.180	0.942	0.860
Huancavelica	Lima	Junín	Huancavelica	Ica	Ayacucho	la liberated
	43.815	25.131	18.993	6.172	2.925	0.593
Tumbes	Tumbes	Lima	Piura	Lambayeque	la liberated	Cajamarca
	58.386	21.039	10.968	3.298	1.972	0.845
Piura	Piura	Lima	Tumbes	Lambayeque	san martin	Cajamarca
	60.406	25.923	3.033	2.582	2.277	1.805
Cajamarca	Cajamarca	Lima	Lambayeque	la liberated	san martin	Amazonas
	46.612	27.654	8.959	6.587	4.048	2.487
Madre de dios	Madre de dios	Cusco	Lima	Arequipa	Puno	Tacna
	62.745	17.829	10.784	3.360	1.898	0.540
Apurimac	Lima	Apurimac	Cusco	Arequipa	Ayacucho	Junín
	45.801	39.829	6.725	2.238	1.291	1.172
Cusco	Cusco	Lima	Arequipa	Ayacucho	Madre de dios	Apurimac
	64.443	20.423	4.996	2.897	2.282	1.250

Observations from this table are as follows:

1. In most departments, incoming calls to VSATs come from the same department of the VSAT (local calls), except for Huancavelica and Apurimac, where in both cases Lima is the main source of incoming calls. This can be explained by the location of Huancavelica and Apurimac on the socio economic chart – they are located on the bottom. The tables of in and out migration show a strong out-migration from these departments. This means that most communications interaction is not within those poor departments but rather with Lima – which is stronger economically and the destination for out migrants.
2. Examining incoming long distance calls reveals that in most departments, incoming long distance calls come mainly from Lima, except for Moquegua (Mainly coming from Arequipa) and Madre de Dios (mainly coming from Cusco). This shows the importance of Arequipa as an urban center for Moquegua and Cusco as an urban center for Madre de dios, as well as the relative proximity of these cities to villages in the neighboring departments.

The graphs in Figure 94 and Figure 95 graphically illustrate the findings described above by presenting the incoming calls matrix from all departments to all departments in percentages. Each column represents incoming calls to VSATs in a specific department, marked at the bottom of the column. Calling departments appear as colored bars inside the column. As in the previous analysis, the first graph - Figure 94 - shows all dials, while the second graph - Figure 95 – merely shows long distance calls.

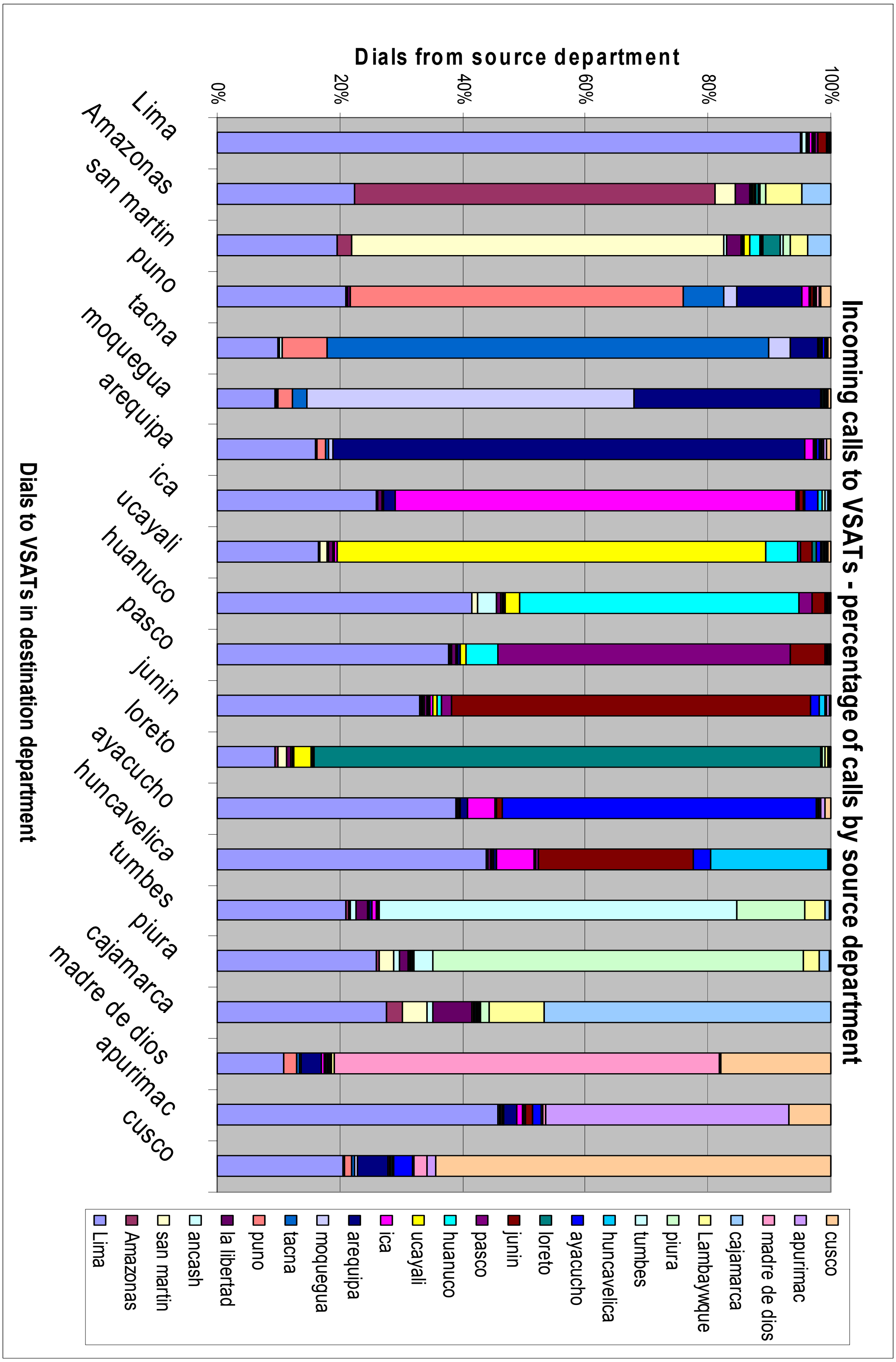

Figure 94 - Incoming calls to VSATs –distribution of source calling departments

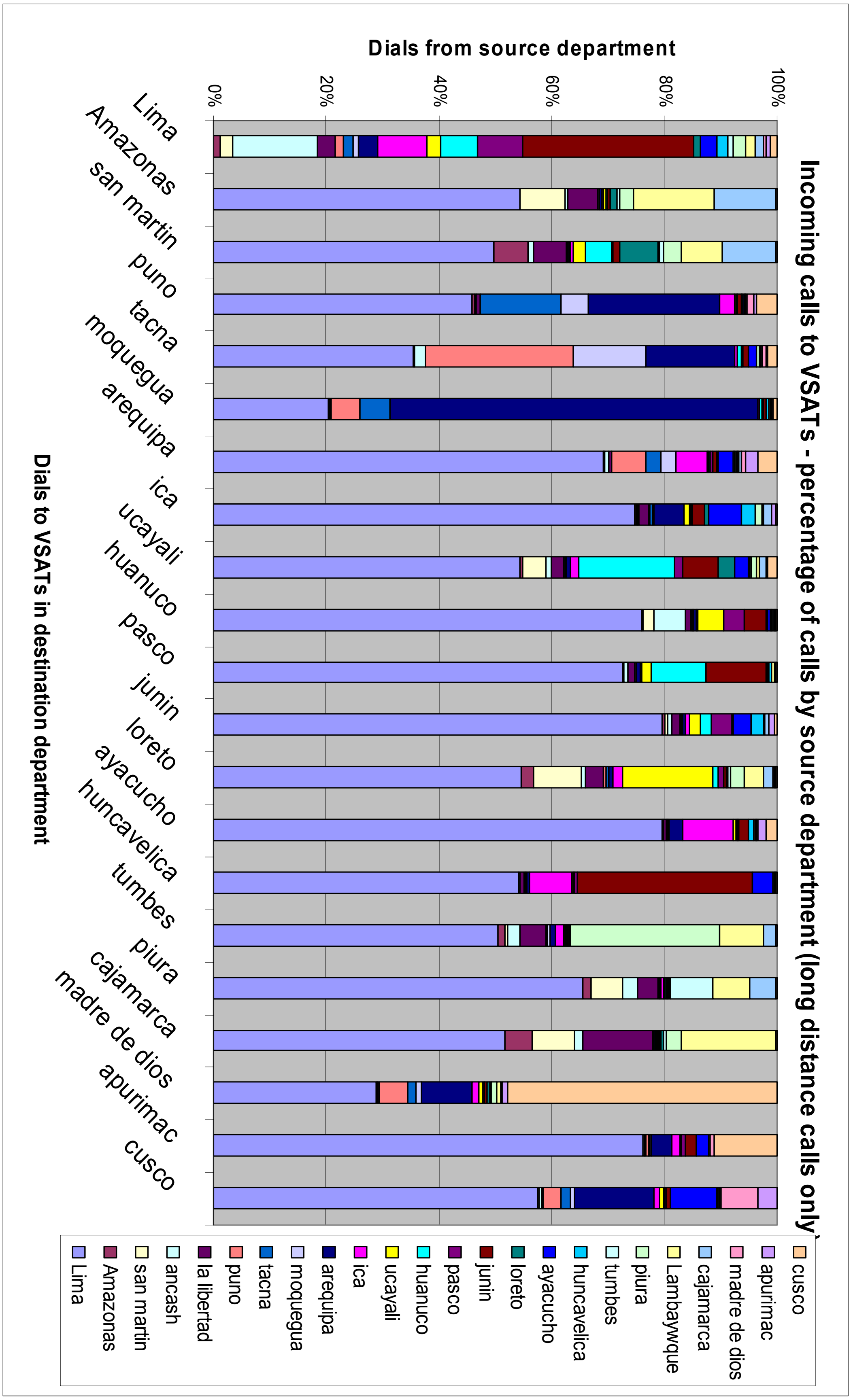

Figure 95 - Incoming calls to VSATs –distribution of source calling departments – Long distance calls only

4.10.3. Spatial presentation of findings

Following are spatial presentations of findings described in sections 4.9 and 4.10. The presentations take into account incoming as well as outgoing calls data. Figure 96 shows the percentage of calls conducted within the same department. Figure 97 shows the share of calls to and from Lima.

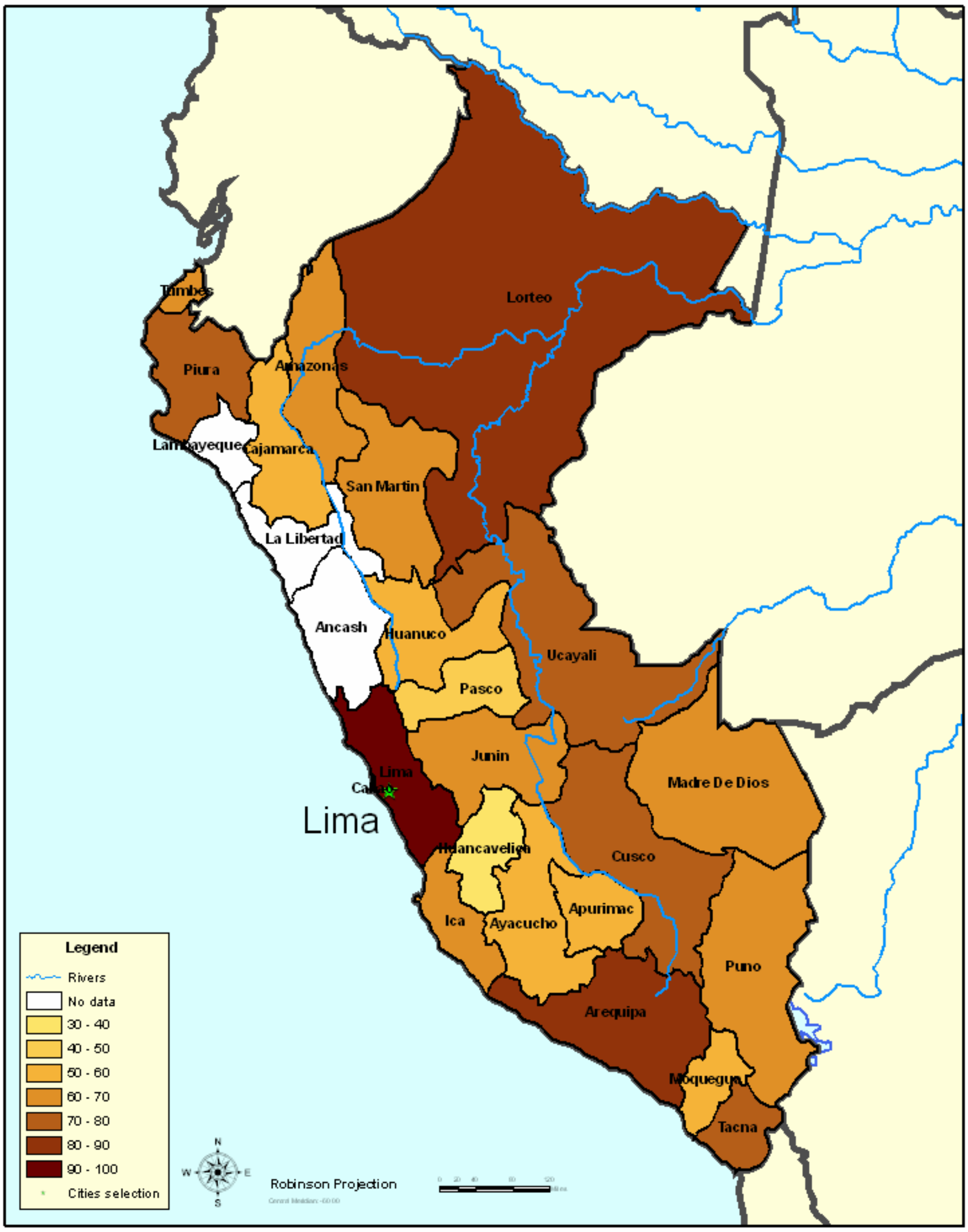

Figure 96 - Percentage of calls conducted within the same department

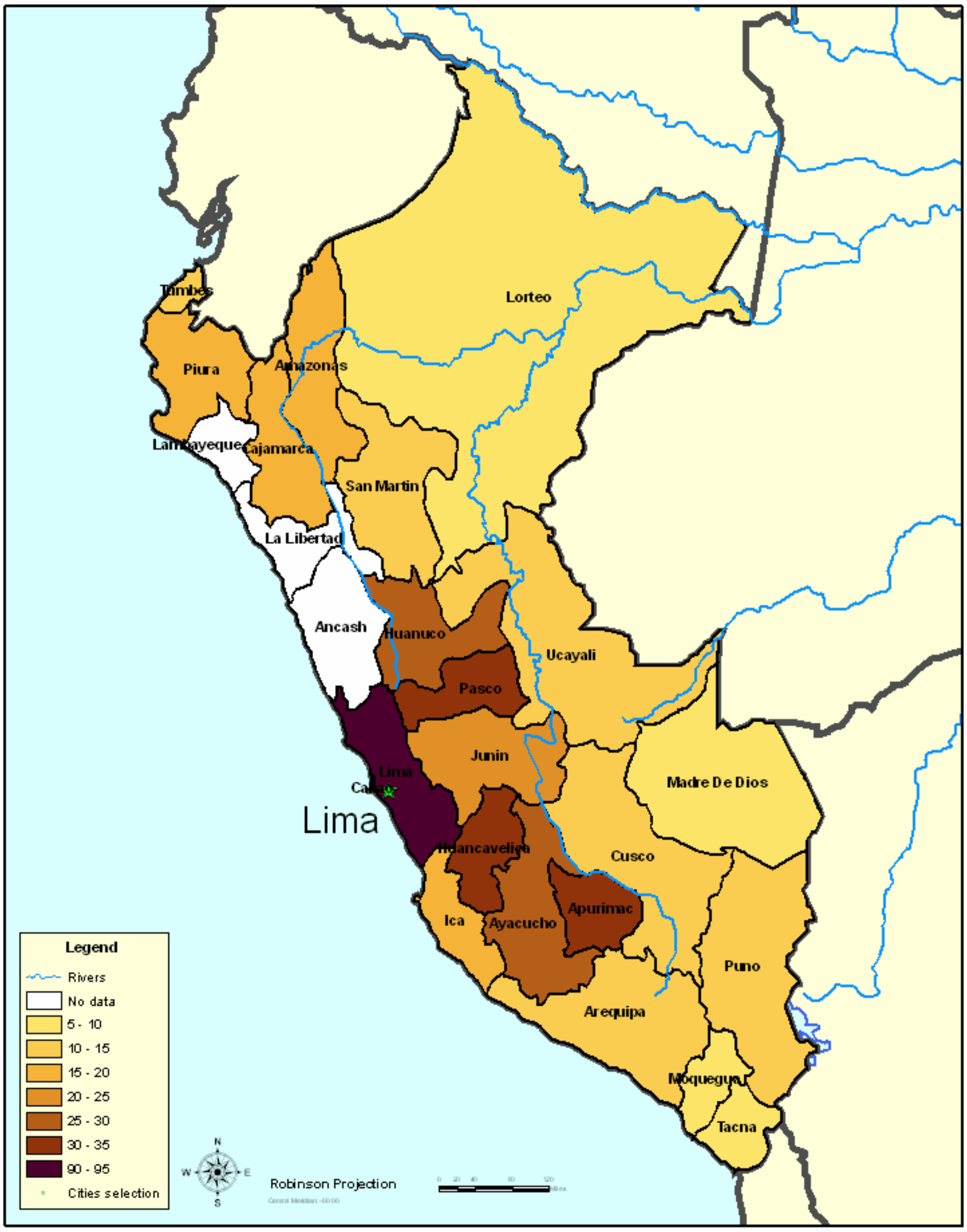

Figure 97 - Percentage of calls to and from Lima

Figure 96 well demonstrates the findings according to which higher percentage of calls within the same department is found in areas which are isolated or far from Lima: Loreto, Piura, Tacna and Ucayali. Note that high percentage of calls within the same department can also be found in Cusco and Arequipa, which are relatively less remote or isolated. This is explained by the important role of the capital cities of Cusco and Arequipa as economical and social urban centers in Peru. Figure 97 shows that departments which are closer to the state capital of Lima tend to communicate with it more intensely, while such interactions decrease as the distance of the department from Lima increases.

4.10.4. Comparison between outgoing and incoming dials

As seen in previous sections, calls to and from the same department and calls to and from Lima produce the foremost volume of VSAT calls. It is interesting to find out if there is a difference in the share of these types of calls between outgoing and incoming calls. Calculating those figures from the outgoing and incoming calls matrices provides the following results:

Average percentage of outgoing calls to Lima: 14.7%
Average percentage of outgoing calls to the same department: 70.1%
Average percentage of incoming calls from Lima: 28.2%
Average percentage of incoming calls from the same department: 59.2%

According to these findings, the share of Lima calls is lower in outgoing calls than in incoming calls, and the "missing share" of outgoing calls to Lima is "replaced" by local calls in the same department. This can be explained by the fact that most people migrate to Lima, and generally the economic power of people in Lima is stronger than can be found in the provinces, hence the more dominant share of calls from Lima.

4.11. Focus on selected VSATs

In this section I was interested to examine cases of specific VSATs, analyzing incoming and outgoing dials, in order to understand the spatial relations of the villages in which these VSATs are installed.

4.11.1. Steps of analysis

Methodology used: direct queries on CDR database

The analysis was done in the following steps:

1. **Selection of VSATs**

   4 VSATs were selected for this analysis.

   3 VSATs were randomly selected from three departments – Cajamarca, Ucayali and Loreto. One additional VSAT was selected from Cusco department – the VSAT installed in the district capital of Caicay, which I visited while traveling in Peru.

2. **Conducting SQL queries to retrieve the desired data**

   For each VSAT, two SQL queries were performed: one for incoming calls and the other for outgoing calls. The first query mapped the entire source phone numbers that dialed to the VSAT and counted the number of calls received from each number. The second query mapped all the destination phone numbers dialed from the VSAT and counted the number of calls to each number.

3. **Excel Analysis**

   a. **Correlating area codes and prefixes to locations and services**

      Using the "Maestro de Numeracion" each area code and prefix was matched with its corresponding location and type of line. Type of lines that were identified are:

      - Fixed lines.
      - Social lines – fixed lines with limited service and special payment conditions, for poor subscribers.

- Public pay phone lines.
- Rural lines (operated by Gilat as well as by other operators).
- Cellular lines.

b. Summing the total dials to/from specific location and service

Total dials to/from specific location and service were summed, and organized in a table sorted by the percentage of dials.

4. Preparing maps

In order to prepare the maps, location of the various sources and destinations of calls had to be obtained. As was described in section 3.6, coordinates of villages where VSATs are installed were obtained directly from NMS VSATs table, while coordinates of other settlements were obtained from an online locations database.

4.11.2. Findings – by VSATs

4.11.2.1. Santa Barbara, Cajamarca

Table 28 and Figure 98 present findings for the village of Santa Barbara, Cajamarca.

Table 28 - Santa Barbara, Cajamarca distribution of calls

Outgoing calls from Santa Barbara, Cajamarca, to:	Percent
Cajamarca	62.3
Cajamarca - social lines	15.9
Cajamarca - Cellular	8.7
Lima	5.1
Junín	4.3
Cajamarca - Rural - Gilat	1.4
Ancash - Huaraz	0.7
La Libertad - Trujillo	0.7
Puno - Juliaca	0.7

Incoming calls to Santa Barbara, Cajamarca, from:	Percent
Cajamarca - Public phones	41.1
Lima	20.1
Cajamarca	17.0
Junín - Huancayo - public phones	12.9
Cajamarca - rural - Gilat	2.7
Piura - Piura	2.2
Puno - Juliaca - public phones	1.8
Cajamarca - Social lines	0.9
San Martin - Soritor	0.4
Ancash - Chimbote	0.4
La Libertad - Trujillo	0.4

Figure 98 - Santa Barbara, Cajamarca - sources and destinations of calls on the map

We can see that the striking majority of outgoing calls are to destinations in the department of Cajamarca, specifically to the city of Cajamarca, while sources of incoming calls are more spread geographically. This can be clearly seen in the map: pink dots show places where incoming calls are originated and blue triangles show destination of outgoing calls. It can be clearly seen that the variety of places where incoming calls originate is much higher than destinations of outgoing calls. In addition, Incoming calls originate in places which are spread in a large area over Peru, while most outgoing calls destinations are in Cajamarca and vicinity. In addition, note the considerable volume of outgoing calls to social lines in Cajamarca, which implies for the low socio-economic level of the called subscribers.

4.11.2.2. Caicay, Cusco

Caicay is a big village, which serves as a district capital. It is about 1.5 hours drive from Cusco, the department capital, most of it on a dirt road. 200 families live in the village, and there is an elementary school there. Many Caicay people work in Cusco. They commute daily to Cusco and back, or stay there for the whole week and return for the weekend (This encourages higher usage of the phone). The VSAT was installed in February 2002, in the back yard of the village's small grocery store (Figure 99). It is connected both to a telephone and a PC, providing Internet access, which is popular with the village children for both school assignments and entertainment.

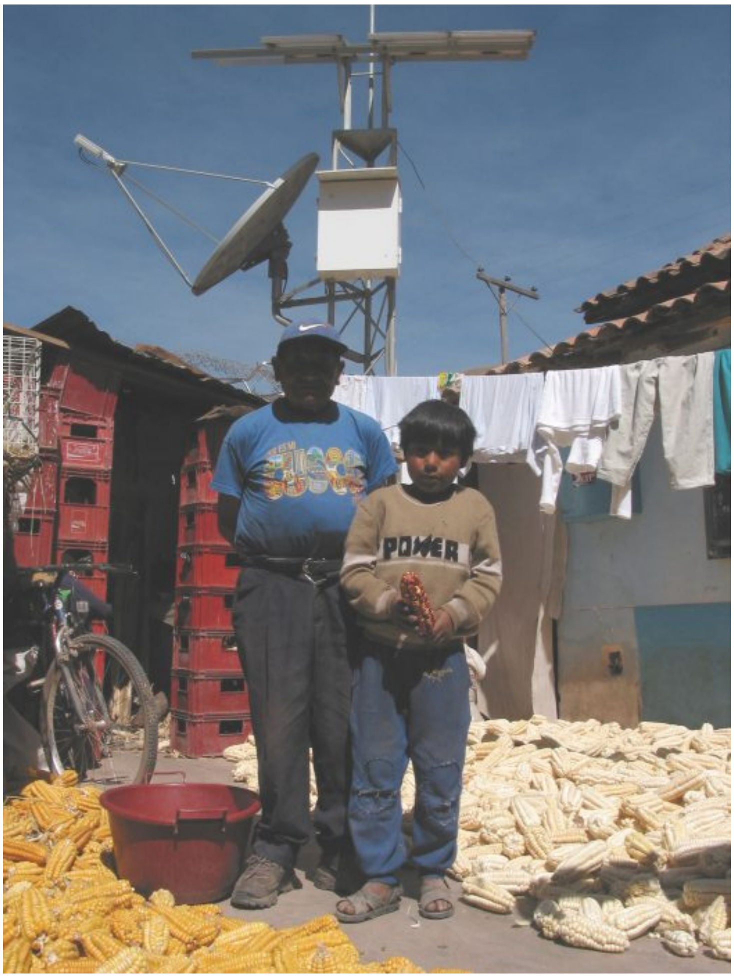

Figure 99 - Family, Yard and VSAT in Caicay grocery store

The lady who operates the grocery store, and meets the people who use the phone provided information about the telephone usage. Among the rest, people in Caicay use the phone for medical purposes, such as pregnant women who prefer to give birth in Cusco. In addition, people from Caicay call Lima to seek for work opportunities. She estimated that subjects of calls are divided half social and half business/economic. The VSAT also gets a significant number of incoming calls, among them calls from abroad, including the US and Chile.

Table 29 and Figure 100 present findings for the village of Caicay.

Table 29 - Caicay, Cusco distribution of calls

Outgoing calls from Caicay, Cusco, to:	percent
Cusco - cusco center	33.3
Cusco - social lines	12.7
Cusco - rural	12.5
Cusco	9.2
Lima	9.0
Cusco - Rural - Gilat	8.3
Cusco - cellular	5.6
Apurimac - rural - gilat	3.3
Arequipa	2.5
International	0.6
Cusco - QUILLABAMBA	0.6
Cusco - URCOS	0.6
Cusco - SICUANI	0.6
Cusco - Pisac	0.4
Puno - cellular	0.2
Cusco - Urubamba	0.2
Cusco - Ollantaytambo	0.2
Cusco - Aguas Calientes	0.2
Cusco - CHINCHERO	0.2

Incoming calls to Caicay, Cusco, from:	percent
Cusco - Cusco public phones	30.5
Cusco - Cusco	19.5
Lima - public phones	13.8
Lima	13.8
Cusco - rural - gilat	4.8
Madre de dios - puerto maldonado - public phones	3.8
Arequipa - matarani	3.4
International - Chile	3.3
Cusco - rural	2.7
Cusco - Ollantaytambo	1.0
Puno - juliaca	0.8
Cusco - social lines	0.7
Cusco - URCOS	0.4
Cusco - SICUANI	0.3
International - others	0.2
Arequipa	0.2
Cusco - Urubamba	0.2
Cusco - Pisac	0.2
Tacna - social lines	0.1
Apurimac - Abancay	0.1

Figure 100 - Caicay, Cusco - sources and destinations of calls on the map

The relations of Caicay with the city of Cusco can clearly be seen in the table - both in the high percentage of incoming calls from Cusco and outgoing calls to Cusco. Here, like in the Cajamarca example, we can also see the spread of source locations of incoming calls as opposed to destinations of outgoing calls, and the considerable number of calls to social lines.

4.11.2.3. Alianza Cristiana, Loreto

Table 30 and Figure 101 present findings for the village of Alianza Cristiana.

Table 30 - Alianza Cristiana, Loreto distribution of calls

Outgoing calls from Alianza Cristiana, Loreto, to:	percent
Loreto - Rural - Gilat	54.7
Loreto - Rural - Telefonica	15.1
Loreto - Iquitos	14.1
Loreto - Iquitos - Social lines	8.7
Loreto - Yurimaguas	7.1
Lima	0.3

Incoming calls to Alianza Cristiana, Loreto, from:	percent
Loreto - Rural - Gilat	55.4
Loreto - Iquitos - Public phones	11.1
Loreto - Iquitos	10.6
Loreto - Rural - Telefonica	8.3
Loreto - Yurimaguas	6.3
Lima	2.5
Loreto - Iquitos - Social lines	2.2
Cusco - Rural - Gilat	1.2
International calls	1.2
Ucayali - Pucallpa	0.5
San Martin - Tarapoto - Public phones	0.2
San Martin - Tarapoto	0.2
Loreto - Lagunas	0.2
Lambayeque - Chiclayo	0.2

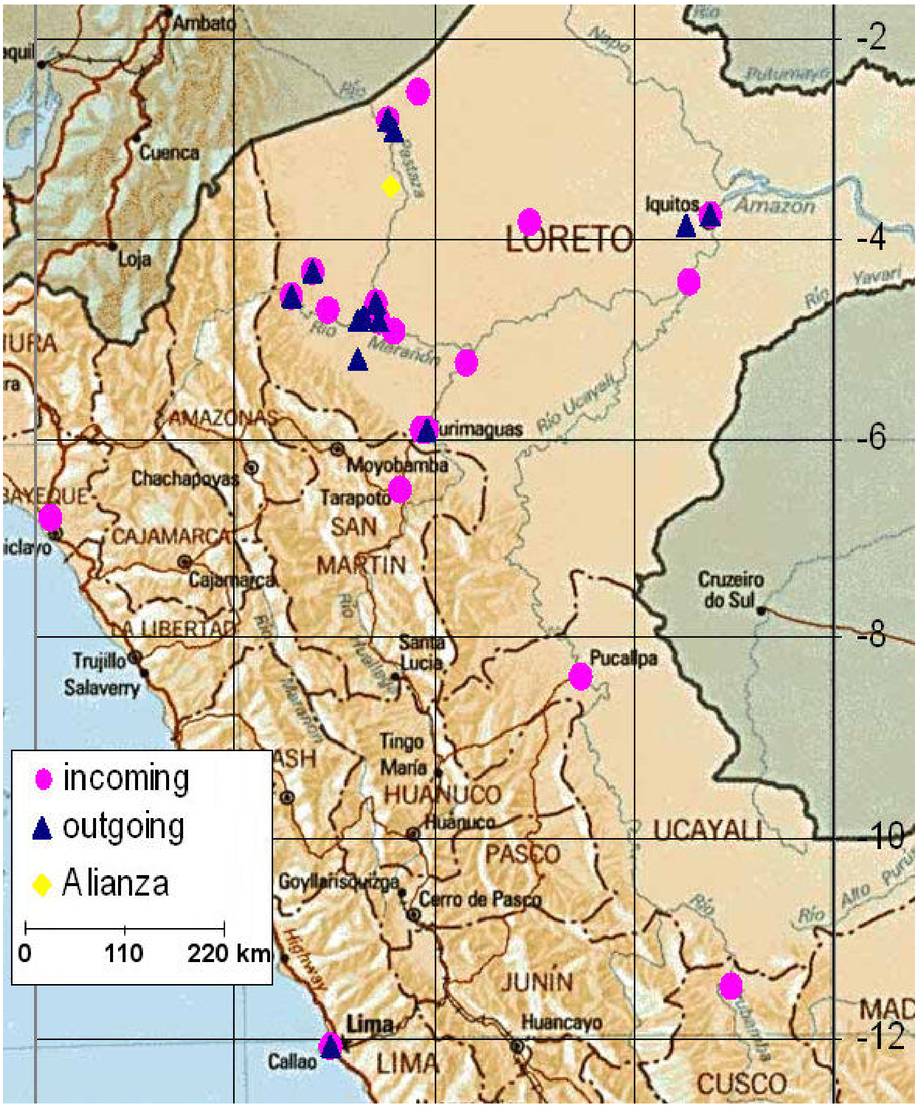

Figure 101 - Alianza Cristiana Calls - sources and destinations of calls on the map

In this remote village in Loreto we can see that the significant percentage of both incoming and outgoing calls is from and to other Gilat VSATs. This provides evidence to the strong connection between the villages, which are all located in remote areas far from large urban centers. It can be seen on the map, that communications is made with other villages which are accessible via waterways. This village also demonstrates the diversity of sources of incoming calls.

4.11.2.4. Santa Teresita, Ucayali

Table 31 and Figure 102 present findings for the village of Santa Teresita in Ucayali.

Table 31 - Santa Teresita, Ucayali calls

Outgoing calls from Santa Teresita, Ucayali, to:	percent
Ucayali - Rural - Gilat	52.5
Ucayali - Pucallpa	22.9
Lima	10.6
Ucayali - Atalaya	5.5
Ucayali - Cellular	2.1
Ucayali - Pucallpa - social	2.1
Amazonas - Rural - Gilat	1.7
Ucayali - Social lines	0.8
Huanucao - Tingo Maria	0.8
Junin - Junin	0.8

Incoming calls to Santa Teresita, Ucayali, from:	percent
Ucayali - Pucallpa - Public phones	43.4
Ucayali - Rural - Gilat	15.2
Ucayali - Pucallpa	12.8
Lima - Public phones	10.9
Lima - Others	6.4
Ucayali - Pucallpa - Social lines	4.4
Loreto - Iquitos - Public phones	2.2
Amazonas - Rural - Gilat	1.0
Huanuco - Public phones	1.0
La Libertad - Trujillo	0.4
Loreto - Rural - Telefonica	0.4
Amazonas - Bagua	0.3
Hunacayo - Public phones	0.3
Loreto - Yurimaguas	0.3
Loreto - Rural - Gilat	0.3
Cusco - Public phones	0.3
San Martin - Tarapoto	0.1
Cajamarca - Rural - Gilat	0.1

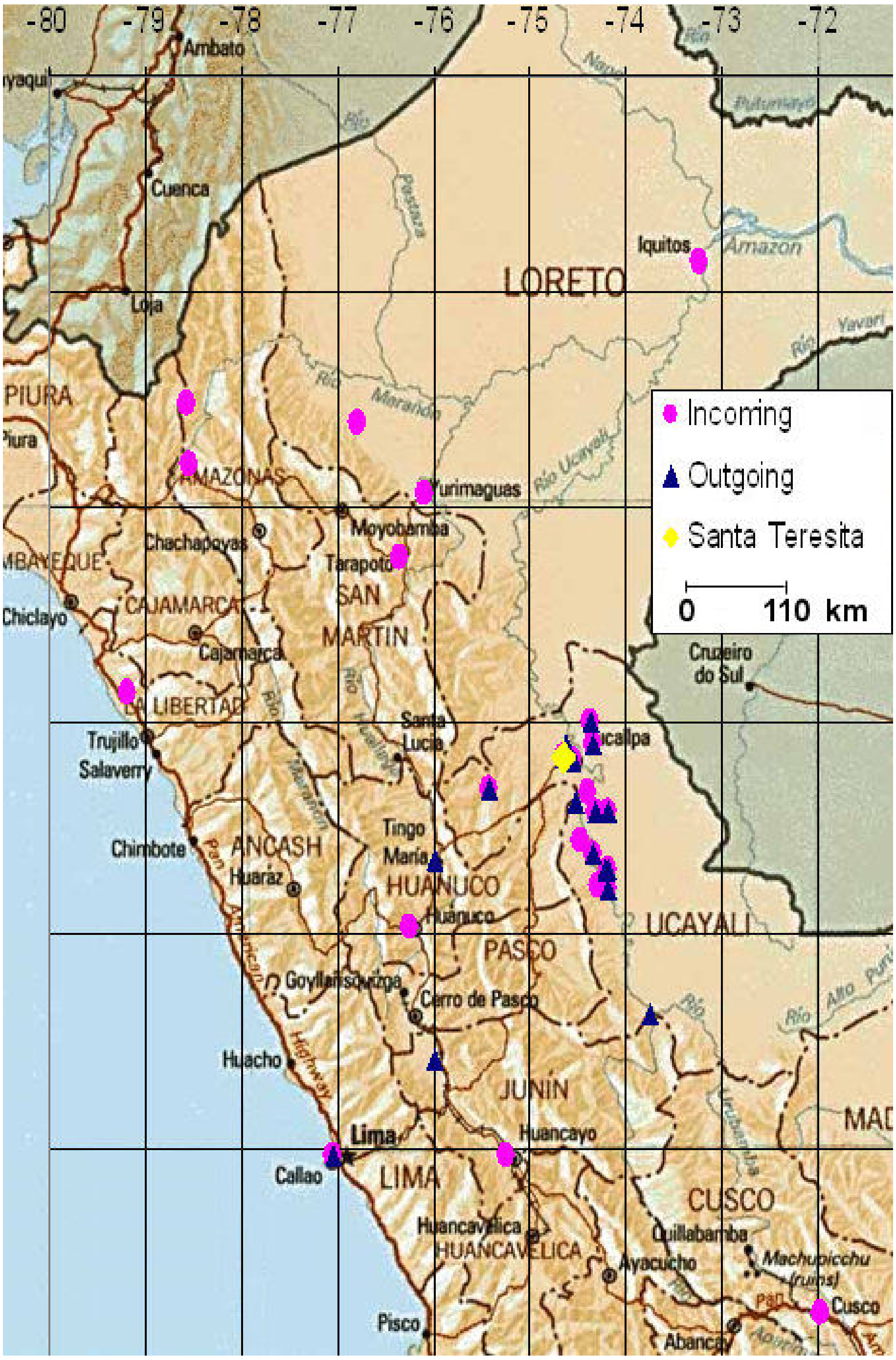

Figure 102 - Santa Teresita, Ucayali - sources and destinations of calls on the map

The relative proximity of this village to the city of Pucallpa is reflected in the high percentage of calls to/from Pucallpa. The spread of sources of incoming calls can be seen here as well.

The reason for the spread of sources of incoming calls relatively to the destinations of outgoing calls is the nature of callers. Many of the callers into the villages are friends and relatives that left the villages to live in other places, mainly large urban centers. They are eager to call the people they know in the villages, and usually have the means to afford the call, which is usually a long distance one. The villagers mainly call the close surroundings, because of budget and interest – their everyday life – economically and socially is focused in their near surroundings.

5. Summary

5.1. Summary of findings

When examining traffic of VSATs during the first year after their installation, a notable increase was observed in the number of both outgoing and incoming calls. This provides evidence that inhabitants as well as people whom they are in contacts with learn to use this new means of communications. While increase in the volume of outgoing calls lasts for 4 months, the increase in the volume of incoming calls lasts much longer – about 10 months, implying that it takes longer for people outside the village to make use of this new means of communicating with the village. And indeed, looking at incoming calls, the main contributor for this increase is long distance calls – calls made from other departments.

Looking at traffic patterns along the week reveals a significant role of Sundays. Sunday is the busiest time of the system, and the jump in the number of calls on Sunday is mainly caused by long distance calls. The peak days for international calls are Saturday and Sunday. Since calls on the weekend are mostly social, this demonstrates the significant role of social calls in the usage of the village phones. The increase in the volume of long distance and international calls over the weekend is closely related to the emigration in and out of Peru - friends and relatives who left the village and went to work or live in other departments (usually in large urban centers such as Lima) or in other countries. They usually schedule a fix time for calling during the weekend. While long distance and international calls are the major contributors to the Sunday peak, local calls behave differently along the week, as they form a peak in the middle of the week. This peak is not significant as the Sunday peak, and its volume varies from department to department. Whereas in Huancavelica I found a significant variation in the number of local calls, with a notable increase in the middle of the week and a decrease in the weekend, in Puno such a variation was negligible. Assuming that calls during workdays are mostly business related, the increase in the volume of local calls in the middle of the week may imply that villagers mostly maintain their business connections within the same department – with the nearest urban center or neighboring villages.

Examining traffic patterns during the day reveals two traffic peaks: one in the morning – before people go out to work and the other in the evening – after people go back from work. Duration of calls is higher in the evening – probably because people are more relaxed to talk.

Regarding duration of calls I found a notable difference between outgoing and incoming calls. While in outgoing calls the duration of local calls is significantly higher than long distance calls, in incoming calls the duration is almost the same. The explanation is that outgoing calls are made by the villagers, who cannot afford paying for a lengthy long distance call. Incoming calls, however, especially long distance ones, are usually conducted by people who can afford paying – whether they are friends or family members who migrated to other places or people who they're in contact with for economic purposes. This claim is also supported by the findings that in general, duration of incoming calls is higher than of outgoing calls. It is also interesting to note, that the longest calls conducted in the system are international incoming calls. Such calls are usually initiated by family members who went to live and work abroad. They can afford paying for such calls, and when they do call home, naturally they have many things to talk about.

Further analyses focused on spatial aspects of the traffic. I examined the distribution of types of calls – local and long distance calls in the various departments. I found that in the departments of Lima and Loreto most of the calls are local. The explanation for each of the cases is different – rural communities in the department of Lima naturally communicate mainly with Lima which is both the economic center of Peru, and their nearest urban center. Loreto is an isolated department located in the tropical rain forest of Peru, not even connected by road to the rest of the country. Therefore, due to this "isolation effect", most communications is done between villages inside Loreto, and their most accessible urban center is Iquitos – the capital of Loreto. The departments of Pasco and Huancavelica were found to be "long distance oriented". In these cases the explanation may be the relations with urban centers which are located in neighboring departments. Specifically looking at incoming calls, the portion of incoming long distance calls is striking in the departments of Huancavelica and Apurimac. These are the poorest departments in Peru, and the high volume of long distance incoming calls might be another evidence to the phenomenon of friends and relatives who left their homes and went to work and live in other departments.

Another spatial examination looked at how the volume of calls per VSAT and duration of calls vary among departments. The three Selva departments – Loreto, Madre De Dios and Ucayali are the leaders in both criteria. This is closely related to the physical characteristics of these areas and the nature of people living there - people in these departments talk more. This is no surprise, as they live in a tropical climate area and their nature and way of life is much more open, friendly and talkative than the way of life of people who live in the dry, cold and tough areas of the Sierra and the Costa. This was well observed during the field trip I conducted and backed up by stories of Gilat Peru personnel in the field. Not only do these departments generate the highest number of outgoing VSAT minutes, but also the volume of outgoing minutes is clearly higher than incoming minutes, as opposed to most other departments. Puno has the lowest volume of total minutes. This may also be explained by physical characteristics - it is a mountainous high altitude area with rough climate, which encourages people to remain closed in their homes, therefore talking less.

Further examining spatial aspects I tried to point to differences between VSATs located relatively close to an urban center ("Near" VSATs) and VSATs located in remote areas far away as possible from urban centers ("Far" VSATs). I performed four test-cases, two of which in the Selva and two in the Sierra. I found that calls to and from "Far" VSATs are significantly longer than calls to and from "Near" VSATs. Examining the volume of calls I found that the number of long distance calls is higher in "Far" VSATs. The volume of local calls did not demonstrate an obvious behavior.

Looking at international calls I checked the percentage of VSATs getting such type of calls in each department. I discovered that the top departments (Over 98% of the VSATs get international incoming calls) are: Amazonas, Ucayali and San Martin. In general, in no department, the percentage of VSATs getting at least one international call is less than 72.7%. I also found, that several Sierra departments get a considerable volume of international incoming calls. Such findings may imply for relatively high emigration of people from these departments (which are the poorest in

Peru) to other countries. This notion is supported by the departments' migration figures. In addition, I checked and found a high correlation between the percentage of VSATs getting any international call and the average number of calls entering those VSATs phone lines.

Another examination I performed involved analyzing calling numbers in order to identify the type of phones from which calls are made to VSATs. The most striking result from this analysis is that the majority of incoming calls to VSATs originated in public phones. Bearing in mind that calling to VSATs from public phones is more expensive than calling from fixed lines, this is a clear evidence for the nature of callers to the villages where VSATs are installed: people who do not have access to a fixed line or mobile line – at home or at work, people from lower socio economic levels.

Further findings relate to the percentage of dials to VSATs originating in other Gilat VSATs. In the department of Lima, just a small share of calls is coming from other VSATs. That is because the villagers mainly communicate with the Lima metropolitan area. But in Huancavelica, almost 57 percent of the calls are coming from other Gilat VSATs, implying for the strong rural connection between villages in such a remote Sierra area.

The "distinct numbers" analysis calculated the average volume of distinct phone numbers per department dialed from VSATs, correlated with the average amount of dials from VSATs. A correlation was found between total dials from VSATs and the volume of distinct phone numbers dialed. A few departments divert from the trend line: Lima – with more distinct numbers than expected – showing that people in rural areas of Lima are close to the urban center of Lima, and may conduct more diverse relations – business as well as social, reflected in the diversity of numbers dialed. Other diversions from the trend line are observed in the departments of Loreto, San Martin and Amazonas – with more dials per number than expected. This means that these remote Selva and Montana departments conduct relations with fewer entities, but those relations yield relatively more interactions.

An interesting spatial analysis which I performed was to create a department dialing matrix: which department/s call which department/s, both for incoming and outgoing calls. In all of the departments, the main destination department dialed from the VSATs is the same department (hence – a local call). This makes sense, since most interaction is done with the local department capital as the main urban center – for both social and economic aspects. Looking at incoming calls to VSATs the same pattern is seen, but with Huancavelica and Apurimac as exceptions - where in both cases, Lima is the main source of incoming calls. This can be explained by the location of Huancavelica and Apurimac on the bottom of the socio economic chart, implying for interaction with friends and family members who migrated to Lima and a better economic connection with Lima rather with the local capitals. Consequently, in most of the departments, the sources and destinations for long distance calls is Lima, except for several departments who mostly call and get calls from neighboring departments, probably because of a stronger dependency in urban centers which are closer and more accessible than Lima. The importance of Lima can be summarized in the following figures: The average percentage of outgoing calls to Lima is 14.7%, while the average percentage of incoming calls from Lima is 28.2%. The "missing outgoing calls" to Lima are "replaced" by local calls in the same department: the average percentage of outgoing calls to the same department is 70.1% while the average percentage of incoming calls from the same department is 59.2%. This provides evidence that most people migrate to Lima, and generally the economic power of people in Lima is stronger than can be found in the provinces, hence the more dominant share of incoming calls from Lima. The "isolation effect" demonstrated earlier regarding Loreto is well demonstrated in this analysis regarding other remote departments - 76% of the dials from Ucayali are to Ucayali destinations, 81% of the dials from Puno are within Puno, and 70% of dials from Amazonas are to Amazonas. As opposed to Pasco (a department neighboring Lima) for instance, where only 51% of the calls are to Pasco,

Additional spatial findings unfolded when examining cases of specific VSATs. I found that the variety of call origins is much higher than destinations. Furthermore, the origins are spread in a large area over Peru, while most destinations are in the vicinity of the same department and its urban centers. These findings further support the assumption regarding the nature of callers to VSATs – mainly family members and friends who left the village and were spread to a large number of places in Peru, thus reflecting in the variety of places where calls are coming from.

5.2. Conclusions

I believe that this study contributes to our knowledge of rural telephony in several major aspects. In the "local" aspect, the study presents actual findings about Peru. These findings not only deal with mere traffic characteristics, but also provide us with information regarding villagers' habits, way of life, and understanding of spatial relations among rural communities, between rural communities and urban centers and between Peruvians in Peru and Peruvians abroad. Such knowledge about spatial interactions was previously scarce in the literature, at least from a telecommunications point of view. A profound and comprehensive analysis of various aspects of the network was accomplished due to the "global" aspect of the study. It provided a pioneering quantitative approach by developing the methodology for transferring traffic figures of a telecommunications network (which are common to any telecommunications network in the world) to geographical conclusions. Such a methodology can now be implemented in any other network in the world. An advantage of the quantitative approach is the ability to collect findings based on the whole network, with access to data regarding each of the thousands of relevant sites. Thus, this study can be beneficial not only to the academic community, but also to policy makers, regulatory bodies, development organizations and funds, as well as commercial entities involved in the telecommunications market.

In general, the provision of telecommunications means in the villages proved successful, at least in terms of mere numbers: it was found that the volume of calls increases in the months following the phone installation in the village, and the general volume of traffic in the whole system is gradually growing ever since Gilat started its activity. Communities that had no access to telecommunications means can now communicate with the whole world, and findings even proved that some of the most isolated areas tend to use the phones more intensely, and that isolated communities tend to conduct more communications among them, thus implying for the importance of phones for those communities. Phones are not less important for villages which are relatively close to the capital – they tend to interact with it intensely, taking advantage of this means to maintain social and economic connections. Findings from the study prove that a major use of the phones is for social purposes, while only some findings imply business usage as well. Such findings are also supported by information gathered in the field trip. While visiting in villages where VSAT pay phones are installed I could spot aspects that I read about in the literature and noticed in the quantitative research findings. For example, people in one of the small and remote villages which I visited do not use the phone. In such a small and poor village, the villagers do not even have the idea of how they can benefit from this phone, a good example supporting the claims that developing telecommunications infrastructure is not enough to create socio-economic development. In larger villages, such as villages that serve as district capitals, the phone is used more frequently. This notion and the findings according to which a significant use of the phones is for social purposes imply for the need to leverage the provision of telecommunications media to economic development. Such leveraging can be accomplished by providing value-added services that will enhance the basic voice services. Services such as agricultural information centers, telemedicine and education were proven as beneficial to communities in other countries. They provide the users a reason to call, on the one hand, thus generating more revenues for the phone-service providers, and contribute to the development of the local communities, on the other hand. In addition, telephone use provides business potential for the local people operating the phone service. In the field trip I witnessed cases where shop keepers in charge of operating the phones and selling prepaid cards developed their own methods how to earn extra money from phone operations, such as by charging customers by the minute or by selling prepaid cards at higher prices. Following the findings of the quantitative research, the impressions I got while visiting villages, and understanding the activity of Gilat as an operator, I feel that a complementary project for enhancing the usage of this technology is inevitable, and is important no less than the mere provision of the infrastructure. Such a project may be beneficial both commercially for the operator and socially for the villagers.

5.3. Suggestions for further research

Further research can be performed in the following aspects:

- Widen the research of Gilat Peru network to additional test-cases:
    - Comparison between VSATs which are located near urban centers versus VSATs which are remotely located.
    - Comparing the characteristics of traffic patterns along the week in all of Peru's departments.
    - Calculating correlations between number of households in a village and activity of the VSAT.
- Expand the methodologies and create additional scenarios of analysis in order to reveal extra findings from raw traffic data.
- Apply the same methodologies and steps of analysis to other rural networks operated around the world and compare the findings.
- Combine the quantitative approach developed in this study with qualitative research in order to deepen the understanding of the influence of this technology on the life of rural communities.
- As Internet provision in rural communities widens - perform analysis on Internet traffic and Internet kiosks usage.

It is to be noted that due to the pioneering nature of this study, the intention was to develop several scenarios for analysis related to several aspects – general characteristics of network usage as well as characteristics of spatial relations. Each of these scenarios was implemented in this study of the satellite telephone network of Gilat Peru. Naturally, each of these scenarios can be studied more thoroughly. Thus, future studies on other networks and in other places may focus on one of the aspects focused on in this study.

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7. Appendixes

7.1. Appendix 1 – VSATs selected for "Near"-"Far" comparison test-cases

7.1.1. Test-case 1 – Selva – Loreto

"Far" VSATs:

VSAT	Location	Department	Installation	Phone	Longitude	Latitude	Project
1029	SAN JUAN MORONA	LORETO	16/07/2001	65812083	-77.64	-3.09	FITEL 2
1031	ALIANZA CRISTIANA	LORETO	08/08/2001	65812086	-76.43	-3.47	FITEL 2
1032	ANDOAS VIEJO (ANDOAS)	LORETO	17/08/2001	65812085	-76.40	-2.91	FITEL 2
1058	SANTA RITA DE CASTILLA	LORETO	21/06/2001	65812103	-74.37	-4.60	FITEL 2
1059	SANTA ROSA DE LAGARTO	LORETO	21/06/2001	65812106	-74.55	-4.49	FITEL 2
1065	NUEVA JERUSALEN	LORETO	22/08/2001	65812112	-76.19	-2.84	FITEL 2
1075	SAN JOSE DE SARAMURO	LORETO	24/06/2001	65812122	-74.92	-4.72	FITEL 2
1082	CUSHILLOCOCHA	LORETO	15/06/2001	65812124	-70.45	-3.94	FITEL 2
1085	SAN ANTONIO DE CACAO	LORETO	01/09/2001	65812127	-70.34	-3.80	FITEL 2
1086	SAN MIGUEL	LORETO	26/08/2001	65812128	-70.36	-3.91	FITEL 2
1087	VISTA ALEGRE	LORETO	26/08/2001	65812129	-70.27	-3.88	FITEL 2
1095	BUEN SUCESO	LORETO	16/06/2001	65812142	-70.42	-4.13	FITEL 2
1097	NUEVA JERUSALEN	LORETO	15/06/2001	65812144	-70.85	-4.22	FITEL 2
1099	RONDIÑA I ZONA	LORETO	27/08/2001	65812146	-69.99	-4.19	FITEL 2
1130	BUENA VISTA DE ARABELA	LORETO	11/06/2001	65812027	-74.87	-2.12	FITEL 2
1140	NUEVA ESPERANZA	LORETO	23/10/2001	65812037	-74.26	-0.99	FITEL 2
1145	ANGOTEROS	LORETO	14/06/2001	65812042	-74.61	-1.57	FITEL 2
1149	REMOYACU - BUEN PERU	LORETO	08/06/2001	65812046	-73.21	-5.27	FITEL 2
1180	CURINGA (CURINA)	LORETO	25/07/2001	65812180	-73.69	-6.01	FITEL 2
1183	NUEVO LOBO (EL LOBO)	LORETO	24/11/2001	65812181	-73.61	-6.32	FITEL 2

"Near" Iquitos VSATs:

VSAT	Location	Department	Installation	Phone	Longitude	Latitude	Project
1111	PANGUANA II ZONA	LORETO	30/05/2001	65812012	-73.15	-3.95	FITEL 2
1113	GENERAL MERINO	LORETO	04/06/2001	65812015	-73.08	-3.72	FITEL 2
1116	SANTA CECILIA	LORETO	05/06/2001	65812016	-72.96	-3.61	FITEL 2
1118	MISHANA	LORETO	29/05/2001	65812001	-73.49	-3.88	FITEL 2
1120	SAN JUAN DE MUNISH	LORETO	27/05/2001	65812003	-73.32	-3.93	FITEL 2
1121	VARILLAL	LORETO	09/06/2001	65812004	-73.34	-3.89	FITEL 2
1128	SALVADOR	LORETO	02/06/2001	65812025	-73.15	-3.44	FITEL 2
1135	BARRIO FLORIDO	LORETO	10/06/2001	65812032	-73.21	-3.63	FITEL 2
1136	GEN GEN	LORETO	10/06/2001	65812033	-73.31	-3.64	FITEL 2

7.1.2. Test-case 2 – Selva – Ucayali

"Far" VSATs:

VSAT	Location	Department	Installation	Phone	Longitude	Latitude	Project
7300	DIAMANTE AZUL	UCAYALI	13/11/2002	61821400	-73.96	-10.62	FITEL 3
7301	FLORESTA	UCAYALI	22/11/2002	61821401	-73.46	-10.66	FITEL 3
7302	MALDONADILLO	UCAYALI	23/11/2002	61821402	-73.72	-10.74	FITEL 3
7303	MAPALJA	UCAYALI	20/11/2002	61821403	-73.39	-10.74	FITEL 3
7304	OVENTENI	UCAYALI	28/11/2002	61821404	-74.22	-10.76	FITEL 3
7305	SAN PEDRO DE LAGARTO	UCAYALI	24/11/2002	61821405	-73.88	-10.60	FITEL 3
7306	BUFEO POZO	UCAYALI	15/11/2002	61821406	-73.11	-10.97	FITEL 3
7307	SEÑOR DE LOS MILAGROS	UCAYALI	29/11/2002	61821407	-74.04	-10.14	FITEL 3
7308	NAZARETH DE SHAHUAYA	UCAYALI	01/12/2002	61821408	-74.14	-9.84	FITEL 3
7328	AMAQUIRIA	UCAYALI	13/11/2002	61821428	-74.29	-9.53	FITEL 3
7329	COLONIA DE CACO	UCAYALI	11/11/2002	61821429	-74.19	-9.40	FITEL 3
7331	GALILEA	UCAYALI	19/11/2002	61821431	-74.47	-9.11	FITEL 3
7333	RUNUYA	UCAYALI	03/12/2002	61821433	-74.20	-9.57	FITEL 3
7338	NUEVO HORIZONTE	UCAYALI	30/11/2002	61821438	-73.78	-9.04	FITEL 3
7343	VINUNCURO	UCAYALI	02/12/2002	61821443	-74.03	-8.86	FITEL 3

"Near" Pucallpa VSATs:

VSAT	Location	Department	Installation	Phone	Longitude	Latitude	Project
7309	MASARAY	UCAYALI	13/11/2002	61821409	-74.25	-8.42	FITEL 3
7310	NUEVO SAN ANTONIO	UCAYALI	17/11/2002	61821410	-74.60	-8.16	FITEL 3
7311	NUEVO UTIQUINEA	UCAYALI	21/11/2002	61821411	-74.34	-8.22	FITEL 3
7313	SAN FRANCISCO	UCAYALI	23/11/2002	61821413	-74.47	-8.31	FITEL 3
7315	SANTO DOMINGO	UCAYALI	27/11/2002	61821415	-74.51	-8.47	FITEL 3
7317	ANTONIO RAIMONDI	UCAYALI	09/11/2002	61821417	-74.69	-8.40	FITEL 3
7319	NUEVO BELEN	UCAYALI	17/11/2002	61821419	-74.67	-8.47	FITEL 3
7323	PUEBLO LIBRE	UCAYALI	27/11/2002	61821423	-74.84	-8.39	FITEL 3
7324	SAN JOSE	UCAYALI	10/11/2002	61821424	-74.75	-8.44	FITEL 3
7325	SAN MARTIN MOJARAL	UCAYALI	17/11/2002	61821425	-74.77	-8.49	FITEL 3
7339	NUEVA PROVIDENCIA	UCAYALI	12/11/2002	61821439	-74.26	-8.49	FITEL 3
7342	SANTA ROSA DE MASISEA	UCAYALI	10/11/2002	61821442	-74.37	-8.57	FITEL 3
7348	MARISCAL SUCRE	UCAYALI	29/11/2002	61821448	-74.57	-8.31	FITEL 3
7349	NUEVA ALEJANDRIA	UCAYALI	19/11/2002	61821449	-74.62	-8.21	FITEL 3
7350	UNION SAPOTILLO	UCAYALI	26/11/2002	61821450	-74.74	-8.20	FITEL 3

7.1.3. Test-case 3 - Sierra– Ayacucho

"Far" VSATs:

VSAT	Location	Department	Installation	Phone	Longitude	Latitude	Project
2526	SAN MARTIN DE PALLCCA	AYACUCHO	09/05/2002	66822106	-73.65	-14.45	FITEL 2
2527	SANTA ROSA	AYACUCHO	30/04/2002	66822104	-73.88	-14.40	FITEL 2
2528	TACALLA	AYACUCHO	01/05/2002	66822105	-73.82	-14.41	FITEL 2
2574	ANISO	AYACUCHO	19/05/2002	66822149	-73.28	-14.81	FITEL 2
2575	PACAPAUSA	AYACUCHO	16/05/2002	66822150	-73.37	-14.95	FITEL 2
2579	TARCO	AYACUCHO	15/05/2002	66822152	-73.75	-15.33	FITEL 2
2580	LACAYA	AYACUCHO	12/05/2002	66822155	-73.55	-15.19	FITEL 2
2584	CALPAMAYO	AYACUCHO	19/05/2002	66822160	-73.49	-14.84	FITEL 2
2585	UPAHUACHO	AYACUCHO	15/05/2002	66822159	-73.40	-14.90	FITEL 2
2586	CAHUANAMARCA	AYACUCHO	15/05/2002	66822165	-73.24	-15.18	FITEL 2
2591	LAMPA	AYACUCHO	12/05/2002	66822167	-73.35	-15.18	FITEL 2
2592	HUATACA	AYACUCHO	11/05/2002	66822171	-73.33	-15.07	FITEL 2
2595	CCALACCACCHA	AYACUCHO	22/05/2002	66822173	-73.15	-15.17	FITEL 2
2598	MIRMACA	AYACUCHO	13/05/2002	66822161	-73.35	-15.24	FITEL 2

"Near" Ayacucho VSATs:

VSAT	Location	Department	Installation	Phone	Longitude	Latitude	Project
2433	ACOCRO	AYACUCHO	28/04/2002	66822000	-74.04	-13.21	FITEL 2
2436	ACOS VINCHOS	AYACUCHO	03/05/2002	66822002	-74.10	-13.11	FITEL 2
2439	CASAORCCO	AYACUCHO	13/05/2002	66822005	-74.23	-13.21	FITEL 2
2442	CHIARA	AYACUCHO	14/05/2002	66822007	-74.20	-13.27	FITEL 2
2451	MUYURINA	AYACUCHO	06/05/2002	66822016	-74.19	-13.11	FITEL 2
2452	CHACCO	AYACUCHO	23/05/2002	66822233	-74.20	-13.08	FITEL 2
2454	CHACAPUQUIO	AYACUCHO	10/05/2002	66822018	-74.31	-13.13	FITEL 2
2456	SIMPAPATA	AYACUCHO	02/05/2002	66822020	-74.26	-13.07	FITEL 2
2458	SANTA ROSA HUATATAS	AYACUCHO	15/05/2002	66822022	-74.20	-13.17	FITEL 2
2461	SANTIAGO DE COLCA	AYACUCHO	07/05/2002	66822025	-74.35	-13.08	FITEL 2
2462	LUYANTA	AYACUCHO	11/05/2002	66822029	-74.31	-13.17	FITEL 2
2463	MANZANAYOCC	AYACUCHO	13/05/2002	66822027	-74.28	-13.37	FITEL 2
2464	MAUCALLACCTA	AYACUCHO	13/05/2002	66822026	-74.30	-13.22	FITEL 2
2469	TINTE	AYACUCHO	25/04/2002	66822032	-74.14	-13.23	FITEL 2
2658	PANTIPAMPA	AYACUCHO	29/04/2002	66822238	-74.03	-13.20	FITEL 2

7.1.4. Test-case 4 – Sierra – Arequipa

"Far" VSATs:

VSAT	Location	Department	Installation	Phone	Longitude	Latitude	Project
1525	ATIQUIPA	AREQUIPA	26/07/2001	54812025	-74.36	-15.79	FITEL 2
1527	AYROCA	AREQUIPA	20/07/2001	54812028	-73.50	-15.45	FITEL 2
1528	CAHUACHO	AREQUIPA	26/06/2001	54812027	-73.48	-15.51	FITEL 2
1529	NAUQUIPA	AREQUIPA	24/07/2001	54812029	-73.32	-15.42	FITEL 2
1555	CHAPACOCO	AREQUIPA	21/12/2001	54812056	-72.40	-15.33	FITEL 2
1562	HUANCARAMA	AREQUIPA	24/12/2001	54812062	-72.32	-15.22	FITEL 2
1617	HUILLAC	AREQUIPA	19/07/2001	54812120	-72.75	-15.09	FITEL 2
1621	QUILLUNZA	AREQUIPA	17/07/2001	54812119	-72.88	-15.22	FITEL 2
1622	ANTABAMBA	AREQUIPA	20/07/2001	54812123	-72.77	-15.09	FITEL 2
1623	HUARCAYA	AREQUIPA	26/07/2001	54812124	-72.74	-14.76	FITEL 2
1624	VISVE	AREQUIPA	18/07/2001	54812125	-72.82	-15.14	FITEL 2
1625	HUARHUA	AREQUIPA	22/07/2001	54812126	-72.96	-15.19	FITEL 2
1627	HUACTAPA	AREQUIPA	24/07/2001	54812128	-72.70	-14.99	FITEL 2
1630	SAYLA	AREQUIPA	11/08/2001	54812131	-73.22	-15.32	FITEL 2
1631	TAURIA	AREQUIPA	08/08/2001	54812132	-73.23	-15.35	FITEL 2
1632	ACHAMBI (ACHOMBI)	AREQUIPA	17/07/2001	54812133	-72.82	-15.20	FITEL 2
1633	LOCRAHUANCA	AREQUIPA	15/07/2001	54812134	-72.83	-15.19	FITEL 2
1636	TORO	AREQUIPA	22/07/2001	54812135	-72.93	-15.26	FITEL 2

"Near" Arequipa VSATs:

VSAT	Location	Department	Installation	Phone	Longitude	Latitude	Project
1500	EL CHIRAL	AREQUIPA	18/12/2001	54812000	-71.29	-16.36	FITEL 2
1501	MACHAGUAYA	AREQUIPA	19/12/2001	54812001	-71.42	-16.47	FITEL 2
1502	PIACA	AREQUIPA	18/12/2001	54812002	-71.36	-16.50	FITEL 2
1503	POLOBAYA GRANDE	AREQUIPA	18/12/2001	54812003	-71.37	-16.56	FITEL 2
1507	SALINAS HUITO	AREQUIPA	19/12/2001	54812008	-71.14	-16.34	FITEL 2
1508	TARUCANI	AREQUIPA	20/12/2001	54812004	-71.06	-16.18	FITEL 2
1505	HUAYLLACUCHO	AREQUIPA	23/12/2001	54812006	-71.24	-16.04	FITEL 2
1584	MURCO	AREQUIPA	20/12/2001	54812086	-71.91	-16.08	FITEL 2
1593	PILLONES	AREQUIPA	23/12/2001	54812095	-71.21	-16	FITEL 2

7.2. Appendix 2 – SQL database structure and selected queries

7.2.1. Structure of CDR Database

The CDR files are imported to SQL Server database. The table into which the data is inserted is named original_tbl.

The records of the table contain various fields, not all of them are used by the queries I conducted.

Following is a description of the fields used for the queries:

Field name	Field contents	Remarks
Dt	Date of call	Date format
Source_Phone	Source phone number	Text
Source_Id	ID of VSAT or HVP (Voice gateway in the hub)	In case of VSAT outgoing call it will be the ID of the VSAT. In case of a call coming form PSTN it will be the ID of the HVP that routed the call.
Destination_Phone	Destination phone number	Text
Destination_Id	ID of VSAT or HVP (Voice gateway in the hub)	In case of incoming call to a VSAT it will be the ID of the VSAT. In case of an outgoing call to PSTN it will be the ID of the HVP that routed the call.
Call_duration	Duration of the call	hours : minutes : seconds

7.2.2. Limiting queries and analysis to FITEL VSATs

The Dialaway IP network operated by Gilat Peru provides services not only to VSATs installed as part of FITEL projects, but also to commercial organizations such as "Banco Nacion", "Repsol" and numerous other private users. In addition, a few dozen VSATs are part of Gilat's logistics and operations sites. Since I'm only interested in FITEL project VSATs which are installed in villages, I had to remove the unwanted VSATs from my analysis. I did so in two ways:

- Directly when performing SQL queries on the CDR database.
- In the Excel analysis stage.

Removal was done by identifying and excluding the ID of the unwanted VSATs (4500-4649, 4000-4107, 6060-6081, 3400-3479).

7.2.3. SQL Queries

7.2.3.1. Query for analysis of international incoming dials to VSATs

```
select destination_phone,count(distinct source_phone) as tot_distinct,count(*) as tot_dials
from Original_tbl
where (
destination_id>1000 and
(destination_id not between 4500 and 4649) and
(destination_id not between 4000 and 4107) and
(destination_id not between 6060 and 6081) and
(destination_id not between 3400 and 3479) and
(source_phone like '219%' or
 source_phone='5623380155' or
 source_phone='5623387595'
)and
Dt>'2003/03/01'
)
group by destination_phone
```

7.2.3.2. Query for counting number of dials grouped by source phone numbers

```
select source_phone,count (*) as tot_dials
from Original_tbl
where (
destination_id>1000 and
(destination_id not between 4500 and 4649) and
(destination_id not between 4000 and 4107) and
(destination_id not between 6060 and 6081) and
(destination_id not between 3400 and 3479) and
call_duration > 0 and
Dt>'2003/03/01'
)
group by source_phone
order by source_phone
```

7.2.3.3. Query for counting outgoing dials from VSATs grouped by area codes

```
select left(source_phone,2),left(destination_phone,3),count (distinct destination_phone) as tot_distinct
, count (*) as tot_dials
from Original_tbl
where (
source_id>1000 and
(source_id not between 4500 and 4649) and
(source_id not between 4000 and 4107) and
(source_id not between 6060 and 6081) and
(source_id not between 3400 and 3479) and
len (destination_phone)=9 and
call_duration > 0 and
Dt>'2003/03/01'
)
group by left(source_phone,2),left(destination_phone,3)
```

7.2.3.4. Query for counting incoming dials to VSATs grouped by area codes - 4

```
select left(source_phone,2),count (distinct source_phone) as tot_distinct
,left(destination_phone,3),count (*) as tot_dials
from Original_tbl
where (
destination_id>1000 and
(destination_id not between 4500 and 4649) and
(destination_id not between 4000 and 4107) and
(destination_id not between 6060 and 6081) and
(destination_id not between 3400 and 3479) and
call_duration > 0 and
source_phone <>'5623380155' and
source_phone <> '5623387595' and
Dt>'2003/03/01'
)
group by left(source_phone,2),left(destination_phone,3)
```