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REMOTE CONTROL OF ENERGY GENERATION USING LOW ORBIT SATELLITES AND ITS USE IN AMAZONIA INTEGRATION

Luiz Eduardo Sauerbronn
Departamento de Engenharia Mecânica – PUC-Rio – Rua Marquês de São Vicente, 225 – Gávea – Rio de Janeiro – RJ – CEP 22453-900 – sauer@mec.puc-rio.br

Marcelo de Andrade Dreux
Departamento de Engenharia Mecânica – PUC-Rio – Rua Marquês de São Vicente, 225 – Gávea – Rio de Janeiro – RJ – CEP 22453-900 – dreux@mec.puc-rio.br

Rodrigo Castello Branco
Faculdade de Ciências Econômicas – UERJ – Rua São Francisco Xavier, 524 – Maracanã – Rio de Janeiro – RJ - CEP 20559-900 – ratfik@uol.com.br

Abstract. *The following paper describes a computational system that provides remote control of a generic system using low orbit satellites to establish communication between an http server and the system in analysis. A case study is described, where the system under analysis is an energy generator.*

Keywords: *monitoring, supervision, remote control, satellite, energy*

1. INTRODUCTION

The quality of industrial projects is of key importance nowadays. Several new ideas are being developed to fulfill its increasing minimum requirements. Whenever the partial (or entire) loss of a system represents greater costs (or risks) than controlling (or supervising) it, a control system is applicable and becomes economically justifiable.

Until recently, most of industrial projects actually did not make use of supervisory systems, mostly because of its costs and the industrial degree of quality commitment at that time. Nowadays, each tiny loss during an industrial production has become unacceptable and efforts are being made to decrease them progressively.

An action on this direction has been the development of remote control and inspection using internet, mainly by http broadcasting. The HyperText Transfer Protocol provides a friendly and reliable interface and can be accessible worldwide through the internet. New languages are often being created to provide the best in dynamical and friendly interfaces. Examples of these languages are: xml (Ozu et al.,2001 e Kropog, 2000), asp (Homer,1999; Kropog, 2000 e Geary, 2001), javascript (Goodman, 2001), vbsript (Prussak, 1999), dhtml (Goodman, 1998), java (Horstmann, 2000), etc.

In specific tasks, that involve long distance processes, or where cable connections should be avoided, the use of new wireless technologies is desirable. In these cases, the use of the wave spectrum provides many possible solutions. One of them is the use of low orbit satellites.

2. CONSIDERATIONS ABOUT THE USE OF SATELLITES

Moore's Law, which says that a microprocessor will do twice as much for the same cost every 18 months, has correctly predicted the exponential growth of the computer industry for over 20 years. However, while computers today are thousands of times faster than those available a decade or two ago, networking has shown only linear growth. Improvements in networking performance have replaced antiquated copper with modern fiber-optic technology but have not come close to keeping pace.

Unlike wireline technologies, the cost of wireless access is largely indifferent to location. But to get the bandwidth required for fiber-like service through wireless means, it is necessary to move way up into the millimeter-wavelength frequencies, in the 20 to 30 GHz range (the Ka band). But, sending signals horizontally, over the land, in those frequencies is problematic. They are subject to rain attenuation and blocking by terrain, foliage, and buildings. The solution adopted is simple: send the signals vertically. It leads to a satellite-based solution.

The next issue faced was: what kind of satellite system? Viewed from some years ago, it is difficult to predict with certainty all the advanced applications and data protocols that such a network will be called upon to accommodate in the 21st century. But it is reasonable to assume that those applications will be developed for the wireline networks in the advanced urban areas, in other words, the fiber networks.

To ensure seamless compatibility with those fiber networks, it is important that the satellite network have the same essential characteristics as fiber. Those characteristics include: broadband channels, low error rates, and low delay.

The advanced digital broadband networks will be packet-switched networks in which voice, video, and data are all just packets of digitized bits. In these networks you cannot separate the applications that can tolerate delay from those that cannot. People will not want to maintain two networks: one for delay sensitive applications and another for applications that can tolerate delay. Traditional geostationary orbit (GSO) satellites will never be able to provide fiber-like delays.

This leads to a low-Earth-orbit (LEO) network. To put this in perspective, the space shuttle orbits at about 250 kilometers above Earth's surface. There is only one geostationary orbit, and that is over the equator at 36,000 kilometers--almost 150 times further out than the space shuttle. By contrast, LEO satellites would orbit at about 700 kilometers--50 times closer to Earth than geostationary satellites.

With the combination of a very high minimum vertical angle to the satellite--to overcome the blocking and attenuation problems associated with the Ka band--and the low altitude, geometry takes over, and a constellation of hundreds of satellites is required to cover Earth. The large number of satellites also allows economy of scale in manufacturing and creates a system with very large capacity which allows a low cost of service.

The concept of a network consisting of hundreds of satellites may seem like a radical concept when compared to traditional geostationary satellites but it is less radical when compared with the evolution of networks on the ground. Computer networks have evolved from centralized systems built around a single mainframe computer to distributed networks of interconnected PCs. Similarly, satellite networks (for switched network connections) are evolving from centralized systems built around a single geostationary satellite to distributed networks of interconnected LEO satellites. The evolution in both cases is being driven by some of the same forces.

A decentralized network offers other advantages: A distributed topology provides greater reliability. Redundancy and reliability can be built more economically into the network rather than the individual unit. Also, because a LEO satellite has a smaller footprint within which frequencies can be reused, it is inherently more efficient in its use of spectrum resources. Geostationary satellites will continue to have an important role to play, particularly for broadcast applications where their large footprint is advantageous. But increasingly, geostationary satellites will co-exist with non-geostationary orbit (NGSO) satellite networks.

This evolution toward NGSO systems has resulted in three LEO system types, each focused on a different service segment and using a different portion of the radio frequency spectrum. The best way of distinguishing among these three LEO system types is by reference to their corresponding terrestrial services:

The so-called "little LEOs", like OrbComm (Orbcomm, 2001), are the satellite equivalent to paging. They operate below 1 GHz, and provide simple store-and-forward messaging. These systems offer low data rates but can provide valuable services in a wide range of settings, such as remote monitoring and vehicle tracking.

The so-called "big LEOs", like Iridium (Iridium, 2001), Globalstar (Globalstar, 2001) and ICO (Ico, 2001), have received most attention. They are the satellite equivalent to cellular phone service, and operate between 1 and 3 GHz.

The so called "broadband LEOs" provide the satellite equivalent to optical fiber. Because they operate in the Ka band, essentially line-of-sight from the user terminal to the satellite is required, which makes them more appropriate for fixed applications, or mobile applications like maritime and aviation use, where line-of-sight is not an issue. They provide the advanced digital broadband network connections to all those parts of the world that are not likely to get those capabilities through wireline means.

This paper presents an industrial application of the "little LEOs".

3. THE DEVELOPED SYSTEM

There are remote regions in the world where the use of wireless technology becomes obvious. Amazonia, a very dense equatorial forest, located in the north region of Brazil, that also extends to Colombia, Venezuela and Bolivia, is for sure, one of these regions. Wherever inside, due to the density of the forest and the height of water level, any type of movement requires a tough effort and is preferably avoided. The only terrestrial ways are the rivers, but unfortunately, they do not lead you everywhere you want.

All those difficulties have been met by the Brazilian authorities in their efforts to bring social benefits to local citizens, mainly to those located in the Brazilian states of Acre, Rondônia, Roraima, Amazônia and Pará.

In the last years, due to the satellite technology, this population started to broadly receive cheaper benefits in the areas of power supply, information and in some other related areas like sanitation and even transportation (with the construction and maintenance of airports).

The developed system consists in a supervisory system that control power supply generators. These generators are responsible for providing the entire power suplly used in many important cities, like Rio Branco (AC), Porto Velho (RO), Humaitá (AM) and Borba (AM). In Porto Velho (RO), for example, a set of 40 generators keep the city on. A simple failure in this system would leave the cities without energy.

To maintain it working, the supervisory system must periodically receive each generator status, process it and analyze possible cases of future failure. Hundreds of cases have already been mapped and predictions can be made thereby. For example, a tiny but constant decreasing of oil pressure informs that it is losing viscosity and that is time to change oil, before the motor critically fails. The set of information received by the supervisory is given in table 1. An example of an energy generator is shown below (figure 1):

Figure 1 – An energy generator

Table 1 – Values transmitted, at least three times a day, by a power supply generator.

	Minimun	Maximun	Average
Total Operation Life (Hours)[1]	-	-	8000
Generator Frequency (Hertz)	57	63	60
Battery Tension (Volts)	22	28	24
Motor Revolutions (RPM)	1710	1890	1800
Water Temperature (Celsius)	5	95	80
Oil Pressure (kPa)	350	450	390
Phase AB Tension (Volts)	450	550	490
Phase BC Tension (Volts)	450	550	490
Phase CA Tension (Volts)	450	550	490
Phase AB Current (Amperes)	1700	2400	1800
Phase BC Current (Amperes)	1700	2400	1800
Phase CA Current (Amperes)	1700	2400	1800
Another 8 digital sensors			

The values given in table 1 show the alarm values current used. If any received value is below the minimum or above the maximum, the system sends an alarm to the administrators. For comparison, it is also provided the average value of any of the parameters monitored.

All of its data are transmitted using the smtp (Simple Mail Transfer Protocol). It has been chosen because it does not need a full duplex connection as well as great connection performance. It is one of the simplest method to transfer data. As the generator does not need a “real time” connection, or similar, this protocol fits perfectly.

Once sent by the generator, data are reflected by the satellite and are received by large antennas located near Itaboraí (RJ). There, routers retransmit the signal to the office of OrbComm in Brazil, wherefrom it is delivered to its final destiny.

In the destiny, the information is extracted (Freed, 1996) and stored into a database and the homepages that will be accessed by the system users and/or supervisors are generated. Furthermore, whenever an alarm is automatically set off, provoked by a failure detection, mail messages and pagers notifications are sent to a responsible staff with all the valuable information.

[1] There is no alarm related to operation life.

At any time, the user can also access the homepage and see the current and historical values of any given property of any specific generator, as well as a general view of all of them. The system screens are shown below.

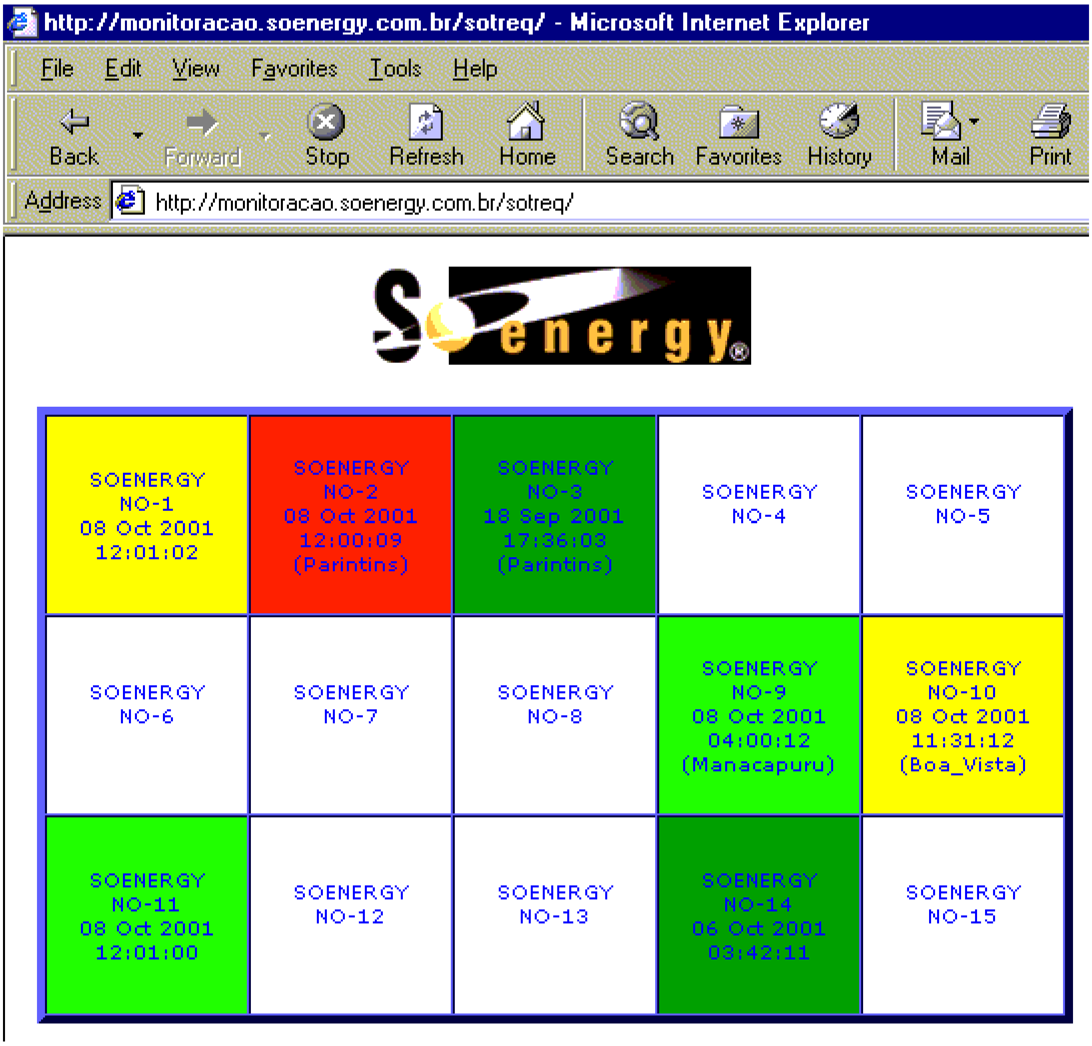

Figure 2 – A color table displays the last status of any generator in a given set.

Cells in dark colors (dark green, dark yellow or dark red) show that no email was received until that moment during the current day. The dark state means that the last information received was not sent in the current day. Whenever an email (with the informations of a specific generator) is received, if an alarm is set, the cell turns to light red and remains like that until the alarm condition no longer exists. Light yellow cells inform a pre-alarm situation in the current day.

In figure 3, the present status of a generator is showed by the use of analogic displays. The user requested an image similar to the physical panel presented in any generator.

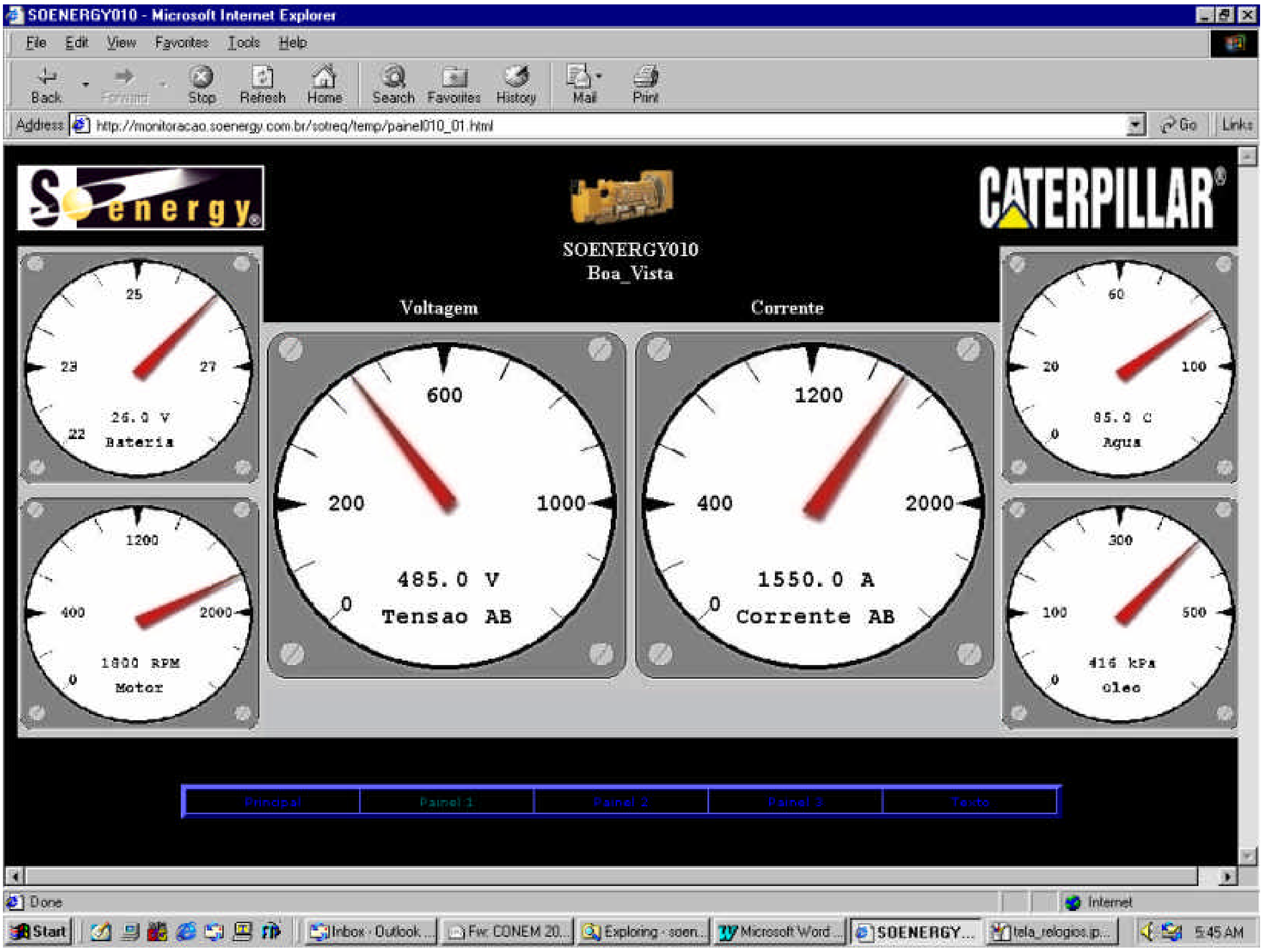

Figure 3 – Analogic displays present the status of a chosen generator.

In figure 4, the operator can see each generator's position as well as its last status (red, yellow or green).

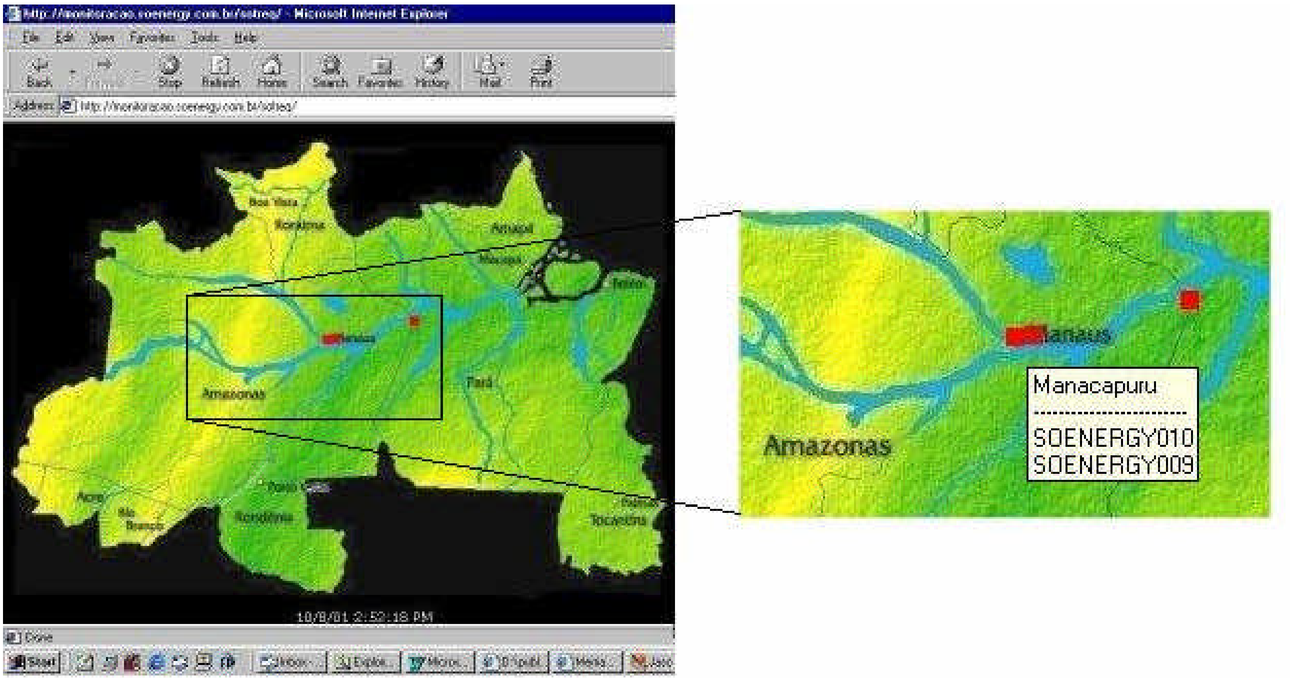

Figure 4 – A map displays the position and the last status of any generator. When the mouse passes over the city, a window shows which generators are within the city.

In figure 5, the historical values of all parameters of any generator can be seen and analyzed. It is presented as a Microsoft Excel Graph, generated by, and interfacing with, Microsoft Office with all of its facilities (copy and paste and so on).

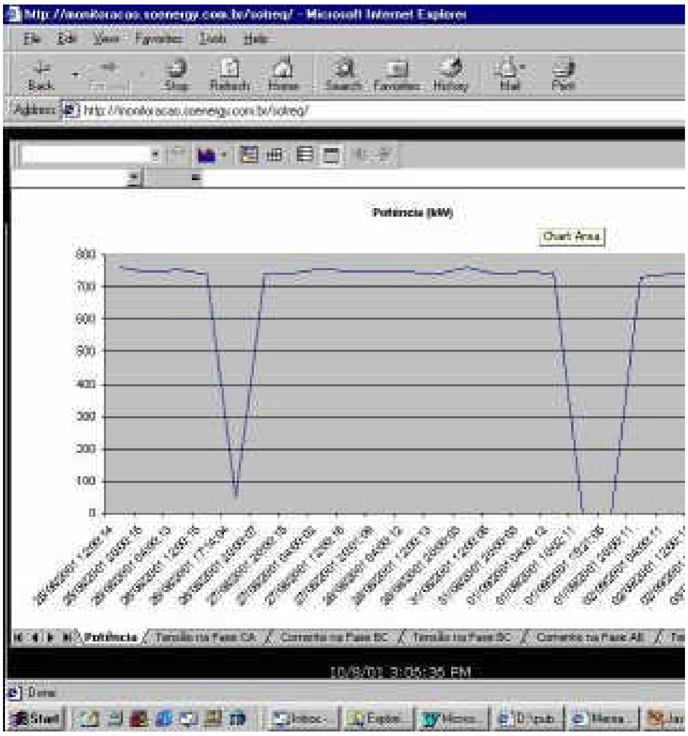

Figure 5 – Graphics display the historical behavior of a given generator property.

In figure 6, the set of generators in Porto Velho (RO) is presented.

Figure 6 – Porto Velho (RO) is one the cities supplied by the system in analysis.

4. CONCLUSION

The presented system has been largely used by SOENERGY, Caterpillar brazilian representative, and has proved to be a reliable and cheap way of supervising and maintaining the set of supply generators. The company has noticed so many advantages on using the system that it has already decided to adopt it in its whole set of generators throughout the country.

By what has been presented above, it is clear that the use of satellites is growing and becoming more available, no matter its purpose. There are virtually no more places over the Earth's surface where communication cannot be provided. This solution has plenty applications in industry, as well as in public interests, that concerns directly the government and their supervision needs.

5. ACKNOWLEDGMENT

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