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IDENTIFYING TELECOMMUNICATIONS NETWORK NEEDS TO SUPPORT THE DEPLOYMENT OF SMART METERS IN A WATER UTILITY

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ABSTRACT

This case study, based on interviews and technical analysis of a Brazilian water utility with more than 10 million clients, aims to understand what kind of adjusts on a telecommunications network, developed for operational and corporate use, demands to support a smart metering system, identifying this synergies and challenges.

Keywords: smart water, smart grid, telecommunications

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1. INTRODUCTION

In the beginning, smart grid was a term used only in reference of the computer-based systems for meter the consumption, billing and manage the electricity usage, nowadays, this have been expanded as functional concept to other utilities companies with similar services, like water and gas. The smart grid changes completely the reality of the utility operation, because it allows that actions and decisions be made as soon as the information be available, what could mean huge savings to the operation and still provide essential elements to decision making strategies.

Two are the technological bases that support the concept of Smart Grid, on one hand automatic meters, installed on consumption points, capable of collecting information in real time. On the other side, the telecommunication distributed network capable of realizing the transport of information collected remotely to the data processing centers, where the billing are generated and the water distribution network management is done.

The automatic meter system, also called smart meters, describe the equipment that allow to collect billing and usage information on the consumption premises and send this to different business areas, enabling a more integrated management and actualized, or in real time, information availability.

On the point of view of telecommunication resources to support the water smart grid, we have as principal question the demand for connection between every meter installed in the system and a central point of information processing.

The concern explored in this article, consider that the treated water is available to large majority of the urban population in Brazil, 95% of Brazilian homes, in the southeast region, are attended by water distribution network (IBGE, 2014), what brings to a necessity of large amplitude communication network in order to support water smart grids, with connection capacity in all water distribution points.

2. SMART GRID

Smart Grid systems represent an application of information technology in service consumption meters, such as electricity, gas and water. The incorporation of new intelligent meters integrated to communication system and network infrastructure allow to stablish a trustful bidirectional communication system with

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several devices and the also an active automation systems. With his origin in energy distribution industry, allowing meter the consumption, billing and the management of electricity use, this system have been expanded like a functional concept to other utilities companies with similar services, like water and gas. (VIJAYAPRIYA; KOTHARI, 2011).

The demand for intelligent metering systems in the water distribution industry comes, among other factors, from the necessity of a sustainable management of urban systems of water distribution. As motivators to the adoption of Smart Grids in the water distribution segment, also called Smart Water Grid, there are external factors including climate change impact, drought, population growth and the consolidation of urban centers, leading the water utilities to adopt a more sustainable process in the water distribution management, especially in urban areas, as opposed to the processes existent in times of plenty of water (BOYLE, et al., 2013).

Besides the advantages related to improvement and simplification of the charging and billing process of the companies, these systems provide a better control over the consumption allowing a more effective loss prevention management and the waste of natural resources associated (BOYLE, et al., 2013). For example, in case of Brazil the estimate loss in the purified water distribution process is superior a 37% (SECRETARIA NACIONAL DE SANEAMENTO AMBIENTAL - SNSA, 2014), what is a clear problem that demand an urgent action to warranty the environmental sustainability and the consumption reduction.

Some of the benefits of use a Smart Water Grid are:

- Individual consumption reduction. When details of the consumption are easily accessible, the consumer immediately generates a reduction up to 15%;
- Macro scale (city to block) reduction of water consumption. The smart metering allows identifying non usual water consumption patterns and consequently helping reduce leakages.
- Identify seasonal needs of the water consumption. With real time knowledge of water demand of the population and to anticipate the volumes of needed resources. This information allows a more functional use of resources and contributes globally to reduce the consumption.

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- Define a new approach about pricing. The knowledge of real time water consumption opens the doors to a billing based on seasonal and even hourly values (GOURBESVILLE, 2011).

3. SMART METERING

There are two kinds of smart meters used by utilities, Automated Meter Reading (AMR) and Advanced Metering Infrastructure (AMI), both with origin in the electricity utilities, figure 1 shows the services differences between both devices. The first one, AMR is a simpler device that allows only Billing and Metering, did not allow the control of the meter itself, it is an unidirectional device, the information flows from customer premises to the processing central.

It was the first one in the market, and a predecessor of the AMI. This second type in addition of the basic functions, allows a more complex set of functions that leverage to the next level the control of water distribution, when installed in a customer premises enable demand-side management and is the start point for the smart grid (CRAEMER; DECONINCK, 2010).

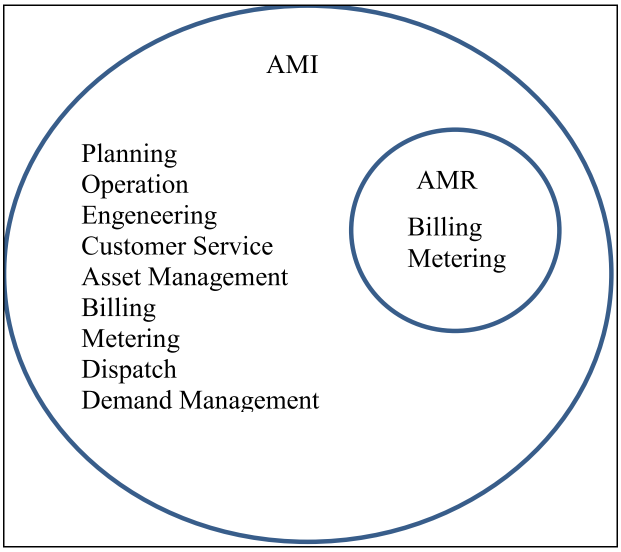

Figure 1: Differences between AMI and AMR

The concentration of this paper is in Smart Grid using AMI technology, which is based in connections between hardware components and pieces of software. Where smart meters in the customer side, the premise area network (PAN), within the same neighborhood, equipped with wireless communication interfaces, are connected to a central unit, called neighborhood area network (NAN). Each NAN is

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connected to the wide area network (WAN), also called backhaul, which provides consolidation for metering data. All data sent by smart meters and other control devices are relayed to an operation central where is running a management application for data processing.

4. TELECOMMUNICATIONS

The three levels of communication network, as showed in figure 2, are used to support smart grid application. The telecommunication network in smart grid has to support all smart grid functionalities and meet the performance requirements. As the infrastructure connects a huge volume of devices and manages the complex communications between them, the better approach is developed a hierarchical architecture with interconnected sub networks and each one being responsible for a unique geographical region. Normally, the communication networks are divided into three levels: wide area networks – WAN, neighborhood area networks - NAN and home area networks - HAN (WANG, et al., 2011).

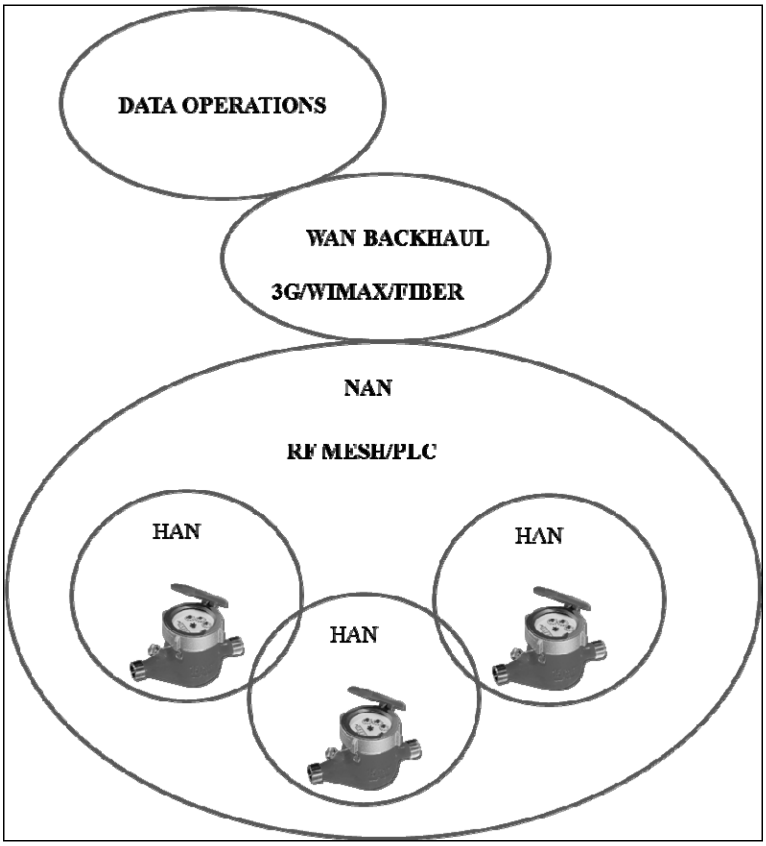

Figure 2: Network levels

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4.1. Home area networks

Home area networks (HAN) are needed in the customer domain, because besides water measurement they can support the implementation of monitoring and control of smart devices in customer premises and to implement new functionalities and advanced applications such as demand management, response and control events remotely, acquire real-time information, automatic fault detection and isolation. (CRAEMER: DECONINCK, 2010).

Typically, they can be based in wireline (e.g., Ethernet) or wireless (e.g., ZigBee) communication mediums. And each smart device, alone, has a low demand for bandwidth, with small pieces of information send periodically, and also it is not affected by transmission delay. The issue is the aggregate demand for bandwidth, when the need of each device is added to another in the same neighborhood area networks.

The table 1, based on the work of Kuzlu, Pipattanasomporn, & Rahman (2014), shows the individual demand of a smart meter; it shows the amount of data and frequency of this communications for the most important information exchanged between the smart meters and the central data processing facilities.

Table 1-Network usage

Application	**Typical data size (bytes)**	**Typical data sampling requirement**	**Latency**
Meter reading – scheduled interval	1600–2400	4–6 times per residential meter per day (24 / 7), 12– 24 times per commercial/industrial meter per day	<4 horas
Neighborhood area network administration (from utility to customer devices)	25	As needed (24 / 7)	<20 s
Firmware updates (from utility to devices)	400K–2000K	1 per device per broadcast event (24 / 7)	<2 min – 7 days
Program/configuration update (from utility to devices)	25K–50K	1 per device per broadcast event (24 / 7)	<2 min – 3 days

4.2. Neighborhood area networks

Neighborhood area networks (NAN) form the communication facility for the water distribution systems, in ideal world it will be the same infrastructure for all utilities, in a kind of shared services. The application residents in the operation center utilize field area networks to share and exchange information with the smart

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meter in the home area network. These applications may be related to distribution facilities, sensors, system regulators, etc. or customer based related to end customers, like houses, buildings, industrial users, etc.

Each of these operational applications has different critical requirements. For example, customer based applications require the communication network between the utility and the customer premises be highly scalable, allowing addition of more applications and customers in future and are not time sensitivity (KUZLU, et al., 2014).

At this point, occur the traffic aggregation from all the home area networks located in the same neighborhood, it may sum the messages of thousands of devices, each one trying to send information to the central data processing facilities at the same time.

4.3. Wide area networks

Wide area networks (WAN) are the communication backhaul allowing the connection of the highly distributed field area network, which aggregates the information produced in each customer premise. These real-time measurements taken at the metering devices are transported to the operation centers through the wide area networks and, in the inverse direction, the wide area networks transport the instruction from processing centers to the end consumers premises (KUZLU, et al., 2014).

For use of smart grids the needs of telecommunications corresponds to aggregated demand of the NANs, which are constituted by the aggregated volume of all meters installed in the homes.

5. METHOD AND DISCUSSION

The survey about the existing network were executed on the period of 05/16/2014 to 06/23/2014, in which the researchers had access to electronic and print documentation of a big utility in southeast region of Brazil, where it was possible to verify the amount of the corporative communication circuits, its contracted velocities, amongst other technical characteristics.

There are two kind of networks to support the corporate demands of the utility studied, Frame Relay an old technology more common in the network, and it is in

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replacement process MPLS, both are nowadays in use for corporate applications. As shown in Figure 3, 62% of the telecommunications services are based in Frame Relay technology, which means small bandwidth.

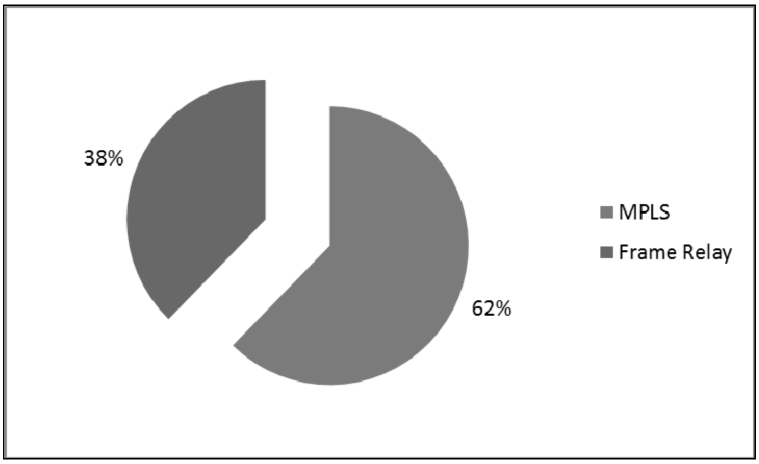

Figure 3: Number of circuits

As definition, multiprotocol label switching - MPLS - is an evolving technology that assures permanent and steady delivery of the communications services with lower network delay, efficient forwarding technique, scalability, high transmission speed and guaranteed performance. This features of MPLS technology makes it as an one of first choice to effective implementations for backbone communications and computer networks (SLLAME, 2014).

In other side, frame relay is a legacy protocol, a simplified form of packet-mode switching that provides access to high bandwidth on demand, direct connectivity to all other points in the network. To the customer, the frame relay technology offers a reduction in the cost of transmission lines and equipment and improved performance and response time. It was developed in nineties by vendors like StrataCom, Digital Equipment Corporation, Cisco Systems and Northern Telecom (RODEN; TAYLER, 1993).

Figure 4 shows the difference of bandwidth available in the complete utility corporate network, for all the services, is possible to identify that the actual service is based in slow capacity of transmission, indicating that 80% of the service speed is below 1Mbps.

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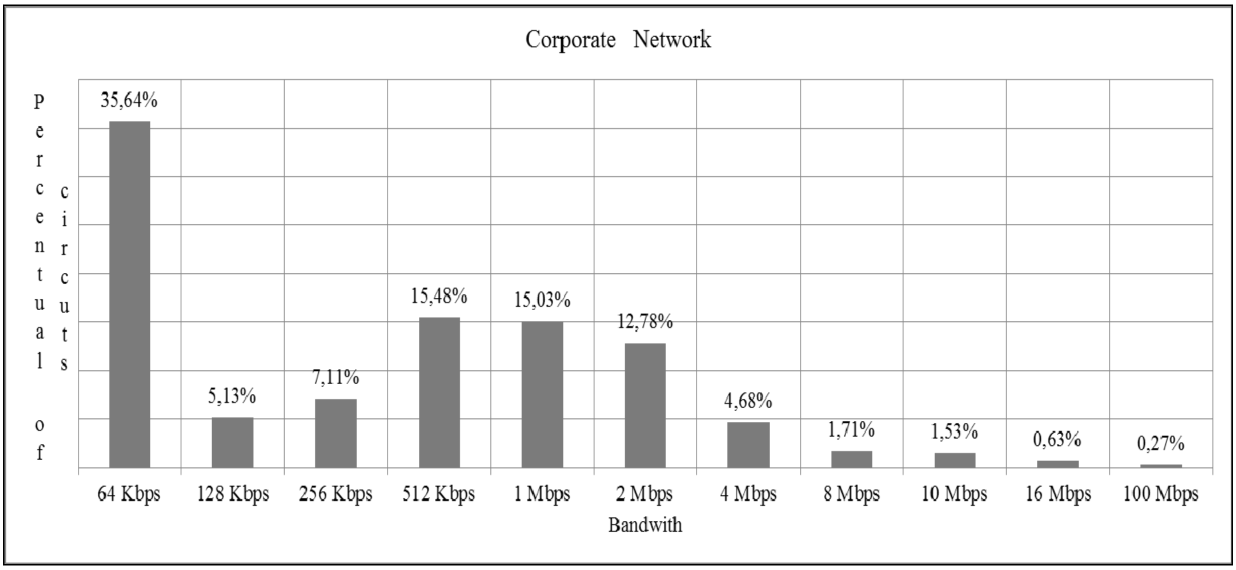

Figure 4: Percentage of circuits by bandwidth

This article uses as base for an estimative demand of telecommunication network, the average number of houses connected in general network of water distribution per city, based on IBGE 2010 census, this study are restricted to southeast region of Brazil, and consider the average between all the states, the numbers are shown in table 2 (IBGE, 2014).

Table 2 - Houses connected to general network of water distribution

State	**Houses connected to general network of water distribution**	**Quantity of municipalities in the state**	**Average of houses connected per cities**
Espírito Santo	857.048	92	9.316
Minas Gerais	4.995.630	645	7.745
Rio de Janeiro	4.089.699	78	52.432
São Paulo	11.605.702	853	13.606
Totals	21.548.079	1668	12.919

Below, in figure 5, are showed the consumption of bandwidth in function of the size of the most common message, as seen in table 1, sent by the smart meters to the operation control center. Is possible to see that for a bandwidth smaller than 1Mbps the time needed to complete transfer of the messages is about 8 minutes. How bigger is the amount of bandwidth available less is the time needed to complete the transmission, trend to be near 1 second to complete the data transfer. For this study, there is no consideration about concurrent communications in the network, because the better case is aim of the article.

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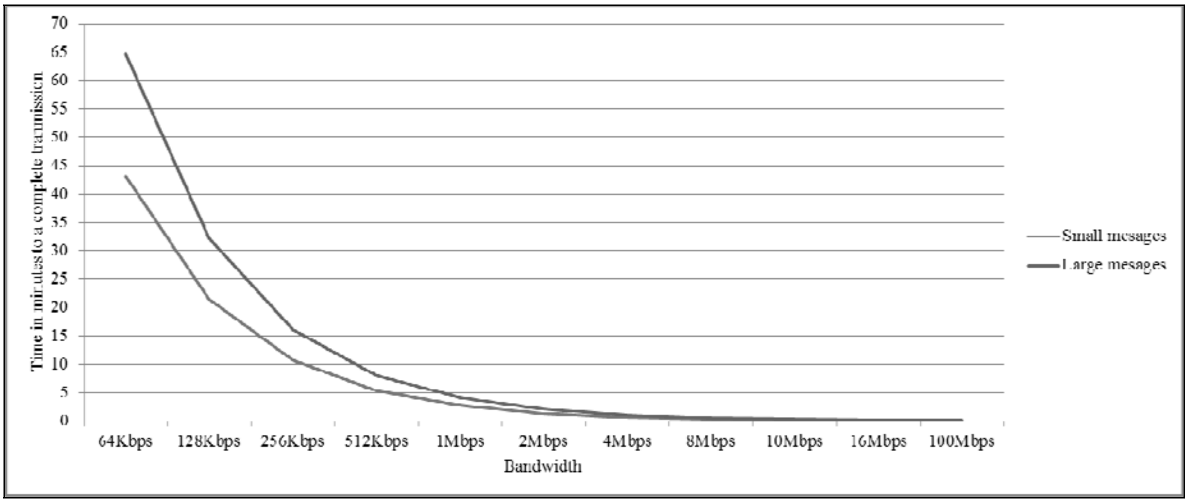

Figure 5: comparative bandwidth usage in function of smart meter message size

6. CONCLUSIONS

The impact of smart meter data over an existing network is very significant for slow telecommunication services. The network evaluated in this article needed to be upgraded in order to be able to support a smart grid network application.

There is another issue related to the definition of data aggregation. The utilities must understand where they will install the NAN to be capable of sum the information generated by the spread distribution of the smart meters.

Considering that in this paper are used an average city, and in Brazil southeast region there are some cities with more than 2 million inhabitants, which means a huge problem to connect every house to a collect network.

There is an imperative force to move forward from legacy networks to the Internet Protocol (IP) based ones, this transformation brings the promise of cost savings and agile, speedier networks. But, the changes also carry implications for utilities, even for those that are already moving aggressively, because the effort to evolve the network will affect the way the company use telecommunications today, in some cases involve changing data processing technology and equipment.

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