SELECTION OF INTERNET OF THINGS BASED COMMUNICATION NETWORKS FOR ONSHORE OIL FIELD MONITORING

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Abstract: Onshore oil fields usually operate in remote locations without continuous human assistance and communication facilities. In these fields, the transfer of oil from the wells to the separation and storage tanks usually occurs via pipelines and this whole system is prone to failures with significant and unpredictable environmental impacts. Proper monitoring of this production system is important to mitigate relevant problems such as leakages, for instance. This paper presents a comparative evaluation of the main candidate communication networks for this application on onshore oil field monitoring for potential leaks. Among the analyzed technologies, LPWANS, DigiMesh and CBRS stand out.

Keywords: Internet of Things; Network; Communication;

SELEÇÃO DE REDES DE COMUNICAÇÃO BASEADA NA INTERNET DAS COISAS PARA O MONITORAMENTO DE CAMPOS DE PETRÓLEO TERRESTRES

Resumo: Os campos de petróleo terrestres operam usualmente em locais remotos e sem assistência humana contínua e sem facilidades para comunicação. Nesses campos, a transferência do petróleo dos poços até os tanques de separação e armazenamento normalmente ocorre por meio de oleodutos e todo esse sistema é propenso a falhas com impactos ambientais importantes e imprevisíveis. O monitoramento adequado desse sistema de produção é importante para mitigar esses problemas de vazamento ,por exemplo. Este artigo apresenta uma avaliação comparativa das principais redes de comunicação candidatas a esta aplicação de monitoramento de campos de petróleo terrestres quanto a potenciais vazamentos. Entre as tecnologias analisadas destacaram-se as LPWANS, DigiMesh e CBRS.

Palavras-chave: Internet das Coisas; Network; Comunicação;

1. INTRODUCTION

In Brazil, onshore oil production refers to mature and marginal fields. The vast majority of these fields are located in inland regions, mostly in the Northeast. These areas have a lack of infrastructure such as roads, electricity, telephone, and data network [1]. Communication of information in this environment is challenging. Any feasible solution shall be based on wireless communication network, and its architecture needs to be compatible with the specificities of the environment and the kind of data package to be transfered.

When developing a network it is of utmost importance to analyze its characteristic points, such as: latency, transfer rate, reliability, range, whether the network is licensed or not, coverage, scalability and energy consumption, in order to choose a better configuration that meets the established requirements for the application [2].

Oil fields are remote environments, so the development of remote wireless network is necessary, and real-time networking is paramount. The network latency is the response time to the stimulus. To achieve a real-time communication the latency needs to be as low as possible [3][4].To send the message it is necessary to know the packet size for transmission, which will depend on the data generated by the selected sensor. The more complex the message to be sent, the higher the transfer rate needed. Bandwidth is directly proportional to the concept of transfer rate [5,4].

The monitoring of onshore oil fields aims to reduce the number of failures, so it is necessary to be sure that the message will arrive, being represented by the reliability, which is usually higher when the network bandwidth is licensed. Paying for the spectrum there is a guarantee of service, but when it is not licensed, it becomes susceptible to interference or even lack of prioritization. The pipelines present in the oil field are extensive, making it necessary to use a high-range network, and affecting the cost of implementation, because the longer the network range, the fewer repeaters are required.

For data security, the licensed network is recommended, but it has an additional cost for licensing. Since the described environment has low infrastructure, it becomes impractical to use most networks for not presenting coverage in the application area of the project. For the possibility of network expansion, it is necessary to consider scalability [6]. To reduce expenses as much as possible, it is necessary to analyze energy consumption, since a high-energy expenditure will result in high costs.

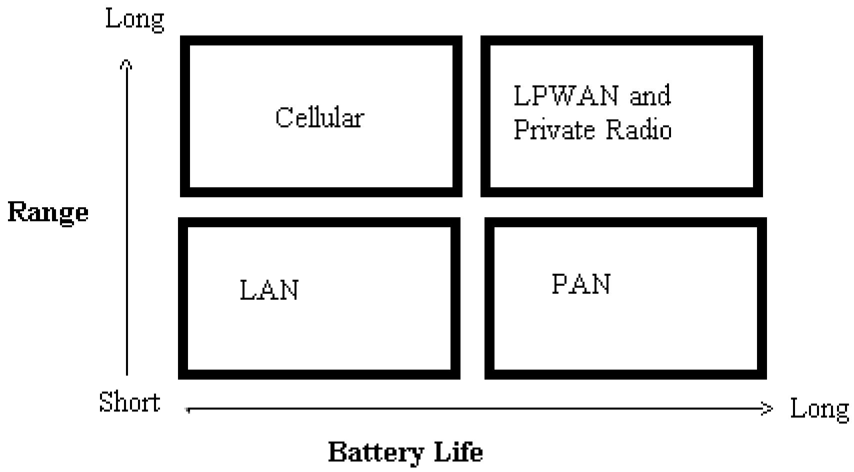
This paper aims to show a comparative evaluation of the main candidate communication networks for onshore oilfield monitoring application for potential leaks. The technologies analyzed are LPWANS, DigiMesh and CBRS.

2. WIRELESS NETWORK

Radio waves network make possible to develop better equipment related to wireless technologies [7]. The wireless communication network became popular because it promotes portability and mobility to the user, since it eliminates the use of cables. The rise of the IoT concept accentuated the relevance of wireless networks. Despite the advantages of this model, the network can have disadvantages if it is implemented or managed incorrectly, which can result in network problems [8].

Wireless communication network can be divided into 5 categories: Private Radio, LPWAN, (Low- Power Wide-Area Network), Cellular Network, LAN (Local Area Network) and PAN (Personal Area Network). DigiMesh and CBRS (Citizens Broadband Radio Service) network operate in the Private Radio Frequency. Figure 1 shows their characteristics in range and power consumption.

Figure 1 - Range and power consumption of network categories



2.1 LPWAN

LPWAN is a communication system focused on IoT featuring 3 different communication protocols, NB-IoT, Sigfox and LoRaWAN, each of which has its own particularities and distinct applications. As described by the name, LPWAN features high area coverage, high network range, low power consumption, low bandwidth, so only sending small packets is possible [9,10].

2.1.1 NB-IoT

NB-IoT (Narrow Band-Internet of Things), is the only one of the LPWAN technologies that features a licensed network. 3GPP (3rd Generation Partnership Project), technology based on the LTE network. It is known for its narrowband and cellular network operation. It has a maximum transfer rate of 200 Kbps and can send 1600 bytes per packet [2]. It is considered real-time because it has a latency of 0.02 seconds. It has a long battery life, until 10 years, because it does not stay connected in the cellular network, connecting only when it is activated [11].

Furthermore, its range in rural areas is up to 10 km. However, towers/ antennas are essential for the network operation, meaning that in areas with low infrastructure, such as some interiors, it is difficult to deploy an NB-IoT system [12].

2.1.2 Sigfox

The Sigfox network is characterized by ultra-narrow bandwidth, which makes it more resilient to interference than the LoRaWAN network. The technology was developed to have a battery life of until 10 years, because it is not connected all the time, but the battery only lasts 5 to 7 years at the most. The authors also stated that it is possible to set up a base station in remote areas that have no connection, being indispensable only power and internet, being able to use a solar panel , as the internet does not need to be fast [13].

It has the advantage that the network can be exported without additional costs [13]. However, it is not in real time, the latency of the product is 10 seconds. There is a maximum number of daily transmission depending on the package purchased, the simplest being 3 daily sends, and it is paid by service. Due to the low transfer rate of 100 bps and maximum sending of 12 bytes [2], it has a longer packet transmission time, generating an increase in power consumption. It has a range of up to 50 km in rural areas [14].

2.1.3 LoRaWAN

The LoRaWAN protocol makes use of the Radio-Frequency LoRa technology, [15]. One of its advantages is that it can be developed as a private network. The network makes use of shared spectrum, receiving more self-interference, which ends up limiting the scalability of the network [16,17]. It connects in two different ways, in the first way access keys are generated for each use, increasing the security of the network, but resulting in increased network complexity. The second way is without the use of access keys [14].

The transfer rate is 50 Kbps, the latency of this network is 5 seconds. There is no daily packet limit, but each packet must contain a maximum of 243 bytes [2]. The range of the network is approximately 15 Km in rural areas, and there is no coverage in remote locations [17].

2.2 DigiMesh

The module analyzed in this paper is the Digi XBee-Pro 900HP-RF Module. The technology is related to Mesh Networks, which acts creating a wireless mesh network, performs multiple hopping making possible the communication of all devices in the network, which makes the network highly scalable [18]. As nodes send packets to other nodes, they act as "routers" [7].

The DigiMesh network presents a latency of approximately 0.035 seconds, its power consumption is low since it presents a hibernation mode, consuming 2.5 microamps, during reception, 29 microamps, and during packet transmission it consumes up to 120 microamps [19].

However, this network does not provide coverage in remote locations [19]. In addition to not being a licensed network, which results in information vulnerability [20] the transfer rate changes according to the range of the network and the environment where it will be applied, as can be seen in table 1.

Table 1-DigiMesh operating characteristics

	Indoor	Indoor	Outdoor	Outdoor
Range	610m	305m	15.5Km	6.5Km
Transfer rate	10Kbps	200Kbps	10Kbps	200Kbps

2.3 CBRS

CBRS is a network that was developed for 'military' use, and can use licensed radio frequencies or not. Its latency is 0.02 seconds, but the military activity will have priority in the network, followed by the licensed networks and lastly the unlicensed ones [21]. In rural areas, it presents a range of until 16 km. It has coverage in remote areas, and is even cheaper than in urban areas, due to its proportionality with population density [22].

The licensed spectrum refers to the LTE radio interface, the network differentiator is in the spectrum distribution. Leaving the SAS (Spectrum Allocation Server) responsible for allocating from the calculation of RF density (Radio Frequency) [22]. The CBRS network has a throughput attribute of 1Mbps [23], which is an average bandwidth. The power consumption of this system is 47 dBM [24].

3. METHODOLOGY

The research carried out is of an explanatory nature, literature review of articles from Google Academic and IEEE Xplore periodical. It aims to assist in the choice of communication networks for monitoring onshore oil fields. Performing an analysis in order to simplify the choice of the network.

4. RESULTS AND DISCUSSION

After knowing each network individually, and analyzing Table 2, it becomes possible to make a conscious choice of the network that will be acquired. In some cases there will not be a network that fits all parameters, so it is essential to use two or more types to have an approximation of the required standard.

Table 2- Comparison of the wireless network categories

	NB-IoT	Sigfox	LoRaWAN	DigiMesh	CBRS
Rural area range	10 Km	50 Km	15 Km	15,5 Km	16 Km
Coverage in remote areas	No	Possible	No	No	Yes/No
Reliability	High	Medium	Medium	Medium	Medium
Energy Consumption	Low	Low	Medium	Low	Low
Scalability	Medium	Medium	Low	High	High
Latency	0.02 s	10 s	5 s	0.035 s	0.02s
License	Yes	No	No	No	Yes/No
Transfer rate	200 Kbps	100 bps	50 Kbps	200 Kbps	1Mbps

By observing the table, it becomes clear that LPWAN and the DigiMesh network do not have coverage in remote regions, which makes their application in the oil fields difficult. Sigfox, LoRaWAN and DigiMesh networks are not licensed, compromising the user's data security. Sigfox has the lowest data transfer rate, restricting packet size. The low scalability of LoRaWAN makes it hard to grow the system.

The energy consumption is low for all the networks. LoRAWAN´s spectrum has susceptible to interference, which compromises the reliability of the system. The CBRS and NB-IoT are configured with the lowest latency, transferring data in real time. Ultimately, the larger range is CBRS. For connecting, NB-IoT needs a previous antenna to act in the cellular network.

The LPWANs has many positive aspects, such as high bandwidth, low latency, licensed network, low power consumption and high transfer rate, however it lacks coverage in areas that lack electricity and internet. CBRS network's main use is military, and it is unlikely to be applied in another spectrum, but when this happens, the cellular network is employed. However, it results in difficult usability in the project due to the need for operation in remote fields.

5. CONCLUSION

After analyzing the information laid out in this article, it was possible to conclude that the perfect fit does not exist, but some points are worth it to record. The Sigfox has the best range, however it has inferior transfer rate. The NB-IoT is licensed, has lower latency, higher reliability and data transfer rate, although doesn´t have coverage in remote areas.

DigiMesh network is famous for scalability and the facility of the installation, also having high transfer rate, but is not reliable and licensed. LoRaWAN has the lowest cost for implementation and good range nevertheless this network is susceptible to interference at the spectrum. Finally, CBRS has the highest range, reliability, scalability, lowest latency. The only factor that is not good is the weak resilience.

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