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Article

A Theoretical Approach to Optimize the Pipeline Data Communication in Oil and Gas Remote Locations Using Sky X Technology

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Abstract. Oil, gas, and water distribution networks in remote locations require optimized data transmission from their sources to prevent or detect leakage or improve production flow in their manufacturing units. Remote oil and gas installations frequently encounter substantial obstacles in terms of data connectivity and transfer. Slow data transmission rates, data loss, and decision-making delays can all be caused by a lack of dependable network infrastructure, restricted bandwidth, and severe climatic conditions. The purpose of this research work is to identify critical concerns concerning data communication and data transfer in oil and gas distant areas and to investigate feasible approaches to these challenges. The survey was carried out to gather feedback from oil and gas experts on issues concerning data transmission in remote locations. This study provides a theoretical approach to optimizing data transmission and communication in remote areas using Sky X technology. This study presents a new theoretical method that improves the performance of IP over satellite using the critical aspects of data transmission issues from experts. This technology's contribution can improve the reliability of all users on a satellite network by delivering all features with a successful data transfer rate discreetly. This attempt may also aid oil and gas companies in optimizing data transmission/communication in remote regions.

Keywords: Data communication, data transmission, oil & gas, Sky X, satellite.

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1. Introduction

Data communication and transmission are crucial in the oil and gas industry for guaranteeing safe and efficient operations. Real-time data is widely used in industry to monitor and regulate production processes, discover abnormalities, and avoid equipment breakdowns. Data communication is the process of exchanging information between devices, whereas data transmission is the act of delivering data across a communication channel. Both are required for data transmission from remote sensors and equipment to control centers, allowing operators to make educated decisions based on current information. Data communication and transfer, in addition to boosting operational efficiency and safety, are critical in optimizing exploration and production activities. The data transmission of water, oil, and gas pipelines is critical for the safety and administration of pipeline systems [1, 2]. Adequate procedures should be developed to reduce pipeline data disruptions while transferring the data from one source to another. Security, monitoring, integrity, configuration, condition, location, and contents of the oil and gas sector are essential concerns in the oil and gas business [3]. Most notably, optimizing operations with pipeline system maintenance, monitoring pipeline system failures while limiting hazards to health and safety, and monitoring and increasing production performance while lowering costs are all critical [4, 5]. Oil and gas industrial activities need optimized data transmission and ongoing monitoring to guarantee the overall stability of all operations in the industrial environment [6]. Several studies have been undertaken throughout the years to address the topic of data transmission network optimization [7-12]. To minimize latency while ensuring reliability in ubiquitous sensing data communication systems, an adaptive persistent data transmission protocol is presented by Liu et al. [13]. In one research, employing power line communication technology, the motor feeder wire was utilized for data transfer instead of a separate additional cable. They highlighted the possibilities of communication, and the transmission restrictions and challenges are exposed [14]. Aref et al. carried out a detailed study of the most recent strategies utilized for backing up and interacting via a third-party base station with a medical device [15]. Menaka et al. conducted a comparison of several secure adaptive routing methods in Mobile Ad Hoc Networks to represent connection stability as nodes relocated [16].

There are various difficulties that are now being addressed in oil and gas remote locations. Accessibility and logistics, environmental and economic challenges, repair and maintenance, security/safety, and data transmission/communication are only a few aspects. In other words, remote sites frequently provide obstacles in terms of accessibility and logistics, making it difficult to get equipment and workers to the site. In terms of environmental and regulatory issues: Oil and gas pipeline projects in distant regions frequently confront environmental issues, such as protecting delicate ecosystems and dealing with extreme weather conditions. Furthermore, these projects must meet several regulatory criteria, which can be difficult in remote places. In terms of repair and maintenance, Due to a lack of infrastructure and resources, maintaining and repairing pipelines in remote locations can be problematic. In the case of a breakdown, this might result in higher expenses and lengthier downtime. while in terms of security and safety issues may exist in remote areas, such as the possibility of manipulation or theft. This can be especially difficult in places with a high level of social or cultural instability.

Interference, restricted connectivity, weather-related difficulties, missing data issues, data security, cost, limited supplies and other factors can all contribute to data transmission/communication challenges. To learn more in depth, Interference: Oil and gas pipelines frequently pass through locations with high levels of electromagnetic interference, which can disrupt data transmission and create data mistakes. Remote places may have inadequate or unstable connectivity, making it challenging to transport data across long distances. This might result in data transmission delays as well as missing or incomplete data. Extreme weather events like storms, floods, and strong winds can destroy transmission infrastructure and impair data transfer. Missing data: Usage of mode while transferring the data could be a possible error or due to the negligence of operators or engineers could be possible. Data Security: Remote sites are frequently subject to cyber-attacks that might endanger security. Cost: Due to the necessity for sophisticated facilities and tools, the cost of data transmission in remote regions might be expensive. Limited supplies: Because remote areas may lack stable power sources, keeping transmission equipment powered and operating can be problematic. Because the oil and gas industry relies significantly on data communication and data transmission for day-to-day operations, various technological challenges might occur in this context, such as bandwidth constraints that can impair the speed and reliability of data transmission. Compatibility concerns, such as different data formats and protocols, can often make ensuring excellent data transmission and interoperability challenging. Furthermore, data integrity concerns can have an impact on the accuracy and dependability of data analysis and decision-making. To address these technological challenges, a mix of modern technologies, such as satellite and wireless communication, as well as strong security measures and standardization initiatives, is required.

This study is concerned mainly with data transmission/communication challenges that often arise from pipeline experts in pipeline onshore and offshore systems. The operators/engineers of the oil and gas sector can decrease exploration risks and improve the accuracy of their asset estimations by gathering and interpreting data efficiently from multiple sources. Overall, data communication and transmission are critical

for the oil and gas industry's goals of increasing production efficiency and enhancing safety. This work provides a brief overview of the problems encountered by pipeline personnel and engineers in distant places when accessing and acquiring private data from pipeline systems.

2. Survey Conducted on Data Communication Issues

A survey was conducted to determine the data communication issues that pipeline engineers and technicians face. The survey questionnaires were distributed to people with various job titles, such as Manager, Assistant Manager, Data Analyst, Pipeline Engineer, Mechanical Engineer, Quality Analyst, Testing Engineer, and so on. Figure 1 depicts the breakdown of these survey results. As shown in Fig. 1, of the 50 given, 32 responded to the report, with a few at the managerial level and some at the data operation level, a few at the maintenance and engineer level, and the remaining percent being executives from various departments.

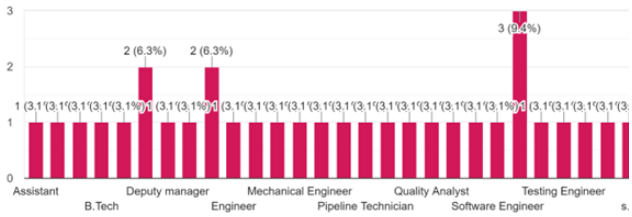

Fig. 1. Respondent's designation summary.

Data interruptions, missing data, slow progress in data transferring/communication, power failures, data formats, and miscommunication are the most common issues that oil and gas pipeline engineers face in remote locations. According to pipeline industry respondents, data interruptions and data missing play an essential role in data transmission issues, with 71% and 67.7% respondents, respectively, as shown in Fig. 2. Slow progress in data transferring/communication, data format, and miscommunication issues are also significant, according to 58.1%, 48.4%, and 45.2% of experts, respectively. Power cuts are also an issue, but at a lower percentage response rate than the top reasons, with a percentage of 38.7%, as shown in Fig. 2.

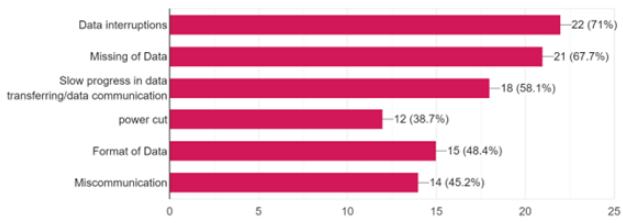

Fig. 2. Issues during data transmission.

The respondents are asked, "How well is the optimized data transfer/ communication important and necessary?" In responding to the inquiry, participants were given the options: extremely, moderately, less, and unimportant. The majority of experts, 61.3 %, stated that it is imperative; 32.3% indicated that it is relatively essential; and the remaining stated that it is less critical, as shown in Fig. 3.

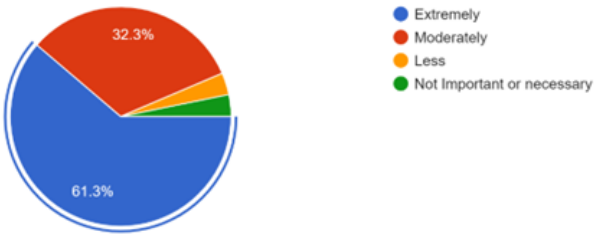

Fig. 3. Importance of data transmission optimization.

The bar chart in Fig. 4 depicts expert responses to the question, "What are the main communication gaps that have been encountered in remote locations (offshore, desert, or forest areas)?" They provided responses mentioning data formats, communication issues, miscommunication, lack of signals, weather issues, recourses, missing values in receiving data, communication between contractors and clients, timely document submissions, and so on.

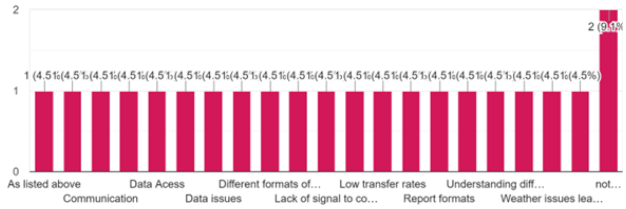

Fig. 4. Communication gaps summary in remote locations.

Figure 5 depicts pipeline engineers and technicians frequently encounter errors while transferring data. According to 38.7% of respondents, data transmission issues occur regularly, i.e., constantly. While 35.5% of respondents believe pipeline industry professionals frequently encounter data transmission issues in remote locations, the remaining 25.8% believe that issues rarely occur during data transfer/communication.

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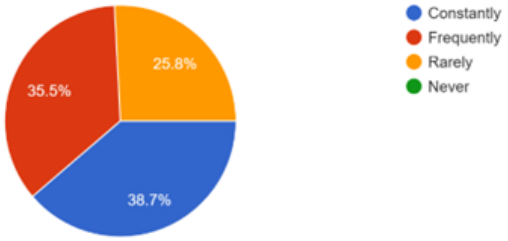

Fig. 5. Frequency of data transmission issues by pipeline industry experts.

3. Techniques and Methods

The most recent research has proposed Sky X Technology as a way of surpassing the limits of TCP (Transmission Control Protocol) performance [17,18]. This technology enhances the speed of IP (Internet Protocol) over satellite while remaining completely transparent to end users, achieved through a combination of protocol connection splitting, data compression, and Web pre-fetching. The Sky X gateway then takes over the TCP connections of the user and transforms the data into XTP (Xpress Transport Protocol) [19], a protocol that is optimized for satellite connections. In this way, Sky X Technology promises to be a powerful solution for those wishing to make use of the Internet via satellite.

3.1. Operation

The Sky X gateway serves as a bridge between the client and the server, catching the client's TCP data and converting it to XTP format before it is transmitted via satellite. On the other side of the satellite link, the Sky X gateway converts the data back to TCP, enabling it to reach the server. This process of conversion and transmission enhances performance, making it easier to adapt to existing internet infrastructure. As a result, applications can continue to function normally, as there is no need to modify either the client or the server. The architecture of the Sky X Gateway is depicted in Fig. 6.

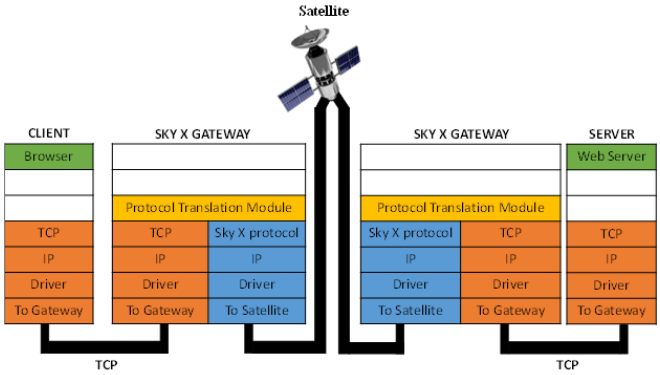

Fig. 6. Sky X Gateway Architecture.

The Sky X gateway divides the data connection into three distinct parts. Firstly, an XTP connection is used to transfer data between the two Sky X gateways. Secondly, a TCP connection is utilized to communicate between the Sky X gateway and the server. Finally, a TCP connection is also used to send and receive data between the client and the Sky X gateway [20]. This allows for a safe, reliable and secure connection between the Sky X gateway and the server, as well as the client.

The Sky X Client/Server structure is designed to optimize network access over satellite links by replacing the standard TCP protocol with XTP for the satellite phase of the connection. This increases the throughput and efficiency of the network connection, as well as provides maximum performance under extended delay, high loss, and asymmetric bandwidth conditions which are typical of satellite communications. Furthermore, Sky X incorporates data compression and Web-specific optimizations to further improve performance. By utilizing the Sky X Client/Server system, users can experience an optimized connection with improved speed, latency, and throughput.

The Sky X Client software program is directly installed on each individual PC within the Sky X Client/Server network, just as the Sky X gateway is. The Sky X protocol captures the data from the PCs and then transmits it across the satellite. From there, the Sky X provides a TCP connection to the destination server at the network hub. A visual representation of this Sky X network integration is shown in Fig. 7.

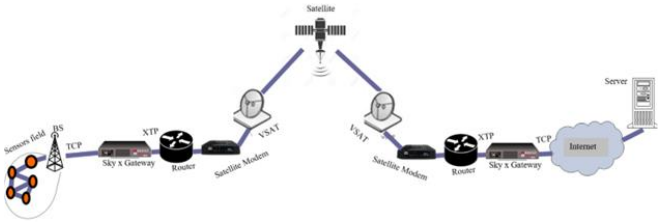

Fig. 7. Sky X Network Integration.

XTP is a reliable transport-layer protocol that has been developed to operate at maximum efficiency on high-speed networks, with a degree of performance that is unachievable when using TCP [21]. Not only does XTP provide all the traditional services of TCP, UDP, and TP4, but it also features an array of additional features, such as selectable error and flow control mechanisms, multicast group management, transport multicast, traffic descriptions for quality-of-service negotiation, transport layer priorities, and rate and burst control. Table 1 demonstrates the differences between the traditional TCP protocol and the new XTP protocol.

The Protocol	Operation Over Other Protocols	Priority Support	Transmission Scheme	Rate Control	Connection Control	Selectable Flow Control	Selective Acknowledgment
XTP	-operates over IP and CLNP -operates directly over the MAC or LLC of any LAN - operates directly over the adaptation layer of ATM	Yes	Multicast	Yes	3 control packets	Yes	Yes
TCP	operates side-by-side above IP	NO	Unicast	No	6 control packets	No	No

Traditional methods of data transfer in computer networking require considerable time and bandwidth [22]. However, with the introduction of multicast technology, many users can now access a single data stream, making data transfer much more efficient. Sky X Multicast Fan-Out is an easy-to-implement solution for delivering dependable multicast over wide-area networks [23]. The Sky X Gateway facilitates quick, effective, and reliable multicast file transfers by utilizing the reliable multicast capability found in XTP, the open-standard transport-layer protocol that the Sky X Gateway uses over the WAN link. Additionally, utilizing the Sky X Gateway eliminates the requirement for special Forward Error Correction (FEC) software, as data is sent and resent to ensure transmission reliability.

The Sky X gateway is an incredible tool, incorporating a number of powerful components, including a revolutionary Sky X multicast fanout. This unique feature allows TCP unicast connections to be seamlessly converted into dependable multicast transfers, allowing for the use of standard TCP-based applications such as FTP, to send files to any remote site across a vast area network with just a single multicast transfer. The market-leading Sky X gateway IP utilises satellite performance optimisation technology, allowing the Sky X multicast fanout mechanism to remain completely invisible to the end devices, regardless of their operating system, allowing for easy initiation and reception of multicast transfers without the need for specialised software.

Figure 8 demonstrates how Sky X Accelerator efficiently utilizes networks and maintains a steady data flow, even in the presence of TCP protocol design constraints, high latency, and lost packets which can impede application connection speed. This technology helps to ensure that applications are able to run at optimal speeds and users can enjoy a seamless connection experience.

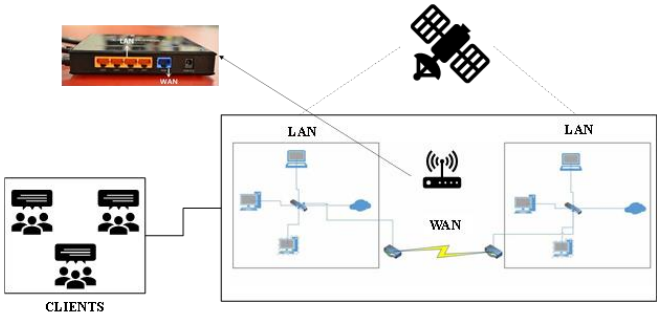

Fig. 8. Sky X Accelerator.

The Sky X Accelerator technology is revolutionizing the way we transfer data across large networks. Eliminating the delay effect on TCP over high-bandwidth links, it is enabling data to transfer quickly and efficiently. Not only does it make use of the available bandwidth, but it also drastically improves the replication performance of data centers connected. Additionally, the technology is designed to be resistant to packet loss, which could otherwise lead to delays and session dropouts. As a result, data transfer is now up to 100 times faster than before.

3.2. Sky X Technology Features

3.2.1. Efficient acknowledgment algorithm

The Sky X Protocol is a highly effective selective retransmission system for data acknowledgements. It is specifically designed to work in a single-channel satellite communication environment, where any gaps in the data sequence can only be attributed to data loss due to corruption and not to network congestion. If necessary, the outgoing Sky X gateway can quickly retransmit the data to the receiving Sky X gateway upon request. As opposed to the Transmission Control Protocol (TCP), which requires a reverse channel to broadcast a continuous stream of declarations, the Sky X Protocol only needs to confirm data arrival and empty buffers on rare occasions, leading to a 75% reduction in back-channel utilization when it comes to Web traffic and up to 95% for file transfers. This allows for much more optimized network performance, especially when back-channel bandwidth is a limiting factor.

3.2.2. Dynamic window sizing

The Sky X Protocol ensures that exceptional network performance can be achieved, regardless of the size of the Transmission Control Protocol (TCP) window on the end nodes. This is because the Sky X Protocol window is much larger, meaning the need for the bandwidth-delay product is eliminated. Furthermore, the Sky X Protocol window size is dynamically adjusted based on the link speed, latency, and the number of concurrent connections, allowing for optimal consumption of available bandwidth [24].

3.2.3. Rate control

The Transmission Control Protocol (TCP) uses Slow Start and Congestion Avoidance algorithms to determine a safe transmission rate. This is necessary because if the transmission rate is lower than the link's bandwidth, it wastes available bandwidth; and if it is sent at a pace more incredible than the link's capacity, it produces unnecessary retransmissions. In order to ensure the best throughput, the Sky X gateway utilizes a rate management mechanism that directly sets the transmission rate to the link's capacity. This allows for the most efficient communication between two devices, as well as the most effective use of available bandwidth.

3.2.4. Web prefetch

Sky X technology is an innovative solution that optimizes the performance of a web page over a satellite link. It works by first collecting all the web page's embedded elements as well as the requested HTML page, then transmitting these items to the user's device, so that they are accessible before the browser even requests them. This reduces the latency of the satellite link, allowing the browser to quickly access the web page and its elements without having to wait for them to be delivered over the satellite link. Ultimately, Sky X technology is an incredibly useful tool for enhancing the performance of web pages over satellite links.

3.2.5. Fast start web acceleration

Sky X solutions offer both HTTP-specific and TCP improvements to drastically increase web download speeds. Through Fast Start, which reduces the amount of handshaking necessary for each new HTTP connection, the total round-trip time of each new web connection is significantly reduced. This ensures that users can speedily access the content they need with the least amount of delay. It is an effective way to keep web pages loading quickly and efficiently.

4. Conclusions

The Sky X structure is built upon the Sky X protocol, which has combined protocol, application, and system-level advancements to maximize performance for the satellite network. By doing so, Sky X technology has provided a solution to the drawbacks associated with TCP/IP over satellite, making it a necessary and unavoidable method for accelerating the exchange of information. This has prompted further research into data communication optimization, intending to create frameworks for precise data transmissions and communication without interruption. The future of this research will be to develop optimization techniques that can eliminate the possibility of data transmission interruptions.

The future of data communication and data transmission optimization is wide and ever-changing. With the growing need for high-speed data transport, data communication networks must enhance their efficiency and speed. Some potential areas of development include 5G Technology (for rapid connectivity, low delay, and high capacity), the Internet of Things (an increase in the number of connected devices for enhanced data transmission and communication optimization), Cloud Computing (offering a fresh approach for storing and processing information to enable faster access), and Artificial Intelligence (transforming the way data is processed with artificial intelligence). Improving data connectivity and transmission optimization will allow AI-based applications to run more quickly and more efficiently).

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