# CDMA VPDN-based Wireless Data Communication System for Mobile Pipeline Patrol

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***Abstract*—Communication is the basic method to guarantee oil transportation command and scheduling of mobile long-distance pipeline and is the nervous system of the mobile pipeline. Based on the characteristics such as varied topography of the region it extends, long distance between stations, large volume of data transmitted and high requirement for security and relying on the private network of Telecom CDMA VPDN, the wireless data communication system for pipeline patrol integrating task management, service filing, real-time communication and positioning & navigation is established. The experiment proves that the system establishes safe and reliable real-time communication and achieves desired effects and smooth high-efficient upstream & downstream data transmission. It is of significance to improve patrol efficiency and quality and to guarantee oil transportation security of the pipeline.**

***Keywords-mobile pipeline; CDMA VPDN; wireless communication; patrol***

## I. INTRODUCTION

As an effective method of long-distance large flow oil transportation in the emergency condition, mobile oil pipeline's patrol management is important to guarantee its safe operation[1]. The topography of the region where the mobile pipeline system extends is complex and varied and the transportation distance between stations generally is more than ten to tens of kilometers, which brings some difficulties in the patrol [2]. Therefore, wireless digital communication network becomes an inevitable choice of communication. With the current network coverage scope, flexibility, volume of data transmitted, security and convenience of the network taken into consideration, the private network of CDMA VPDN is preferredly adopted for communication network of the long-distance mobile pipeline patrol system.

## II. CDMA VPDN TECHNOLOGY

In virtue of wide signal coverage, large capacity, good security and low electromagnetic radiation, CDMA is identified as the first choice for 3G mobile communicating technology [3]. CDMA VPDN is a private network based on Telecom CDMA 1X/EVDO high-speed packet network, which is completely isolated from the public internet and is set up for the client via the layer 2 L2TP tunneling technology [4]. The user can use mobile terminals or PC to access securely the client network or the application system via wireless broadband VPDN network, consequently satisfying the needs of mobile data acquisition and wireless data transmission. It has advantages of low cost, rapid networking, easy extensibility and safe and reliable operation [5].

Standard CDMA VPDN network is composed of mobile terminals, packet data service nodes (PDSN), network server (LNS) supporting Layer 2 Tunneling Protocol and wireless broadband access authenticated AAA server. Its network topology is shown in Figure 1.

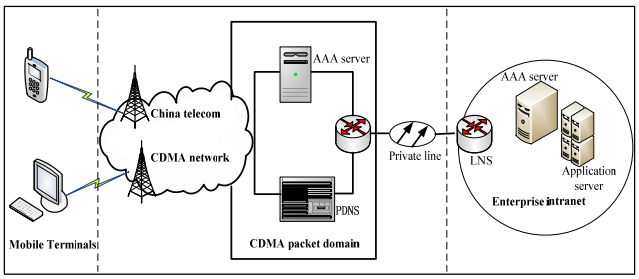


Figure 1. Network topology of CDMA VPDN

## III. COMPARISON BETWEEN VPDN AND INTERNET VPN

Internet VPN utilizes internet as the bearer network and sets up VPN channels to the enterprise internal network via IPSEC Protocol. This networking way has poor user data transparency and does not support mobile terminals such as mobile phone and PDA. Furthermore, it is not completely isolated from the internet and potential safety problems may exist. Different from internet VPN, VPDN is a virtual private network based on CDMA 1X/EVDO high-speed wireless data network, which is set up for the client by utilizing the L2TP tunneling technology and is completely isolated from the public internet. The comparison is given in TABLE I.

## IV. BUSINESS REQUIREMENT

Checkout and maintenance on mobile oil pipeline is performed by the patrollers assigned by the pumping station to see whether any leakage occurs in the pipeline, any fitting is damaged, the pipe sections in the complicated region and through the obstacle are firm or any potential hazard exists in the line. If any problem is found, the patrollers shall report to

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the pumping station immediately and take emergent measures to settle the problem. The distance between stations is about 12-15Km and reaches 60-80Km in the state of long distance mixed transportation. The communication nodes are chained distributed. Moreover, based on the requirement for data security, it is an inevitable choice to adopt the private network of CDMA VPDN for data transmission.

## V. DESIGN OF THE SYSTEM

### A. *Overall framework*

The pumping station issues patrol tasks by means of data messages via the CDMA VPDN wireless network. After receiving the task, the patrollers execute the task in the route and time specified for it. During the patrol, information about the GPS position is real-time transmitted. If any failure is found, the patrollers upload wirelessly the site conditions of the failure (position, type, time and live image etc. of the failure) via the terminal service system. The pumping station issues opinions about disposal to the patrol team. After disposing the failure, the patrollers make records on the condition of maintenance and upload them.

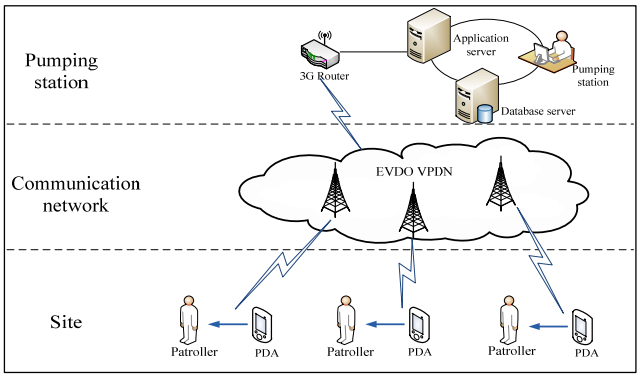


Figure 2. Architecture diagram of the system

### B. *Compositions and functions of the system*

The mobile pipeline patrol system is composed of two parts: patrol service digital processing terminal (PDA) and patrol service software. The patrol service digital processing terminal contains digital processing, GPS positioning, wireless communication and picture archiving modules. Patrol service software contains terminal embedded service system and background application system. Relying on terminal hardware and CDMA VPDN communication network, patrol service software achieves the functions of task receiving/management, filing/uploading of failure and maintenance records, GIS navigation and positioning, query statistics of work records, receiving and sending of universal messages, query of on-line services as well as issuing of tasks, commands and instructions of the background application system corresponding to the pumping station, receiving of site conditions and query of data and records.

### C. *Configuration of the devices*

The patrollers are allocated with patrol service digital processing PDA terminal. The server at pumping station side is provided with EVDO wireless router to perform information interaction with the PDA terminal of the patrollers (with built-in EVDO module). Its various service functions and accessory modules have been achieved by relying on this terminal. The patrol service processing terminal is integrated with high-performance processor, GPS module, CDMA EVDO wireless communication module, Bluetooth module, picture archiving module, audio module and input & output module. Meanwhile, it is provided with extended interfaces via which other service devices can be connected externally.

### D. *Software modules of the system*

Terminal embedded system software adopts modular design and mainly consists of task management module, GIS navigation module, work recording module, on-duty recording module, talking module on the telephone, information receiving and sending module, electronic handbook module, user login module and system service module. The functions of various modules are as follows:

- Task management: task receiving and viewing; the patrol service terminal inquires the background database every 30 seconds and downloads any new task or message;
- Data filing: service entry, image acquisition and data uploading; if any failure occurs in the pipeline during the patrol, file the failure conditions via failure recording of the patrol service terminal and file the failure disposal conditions via maintenance recording of the patrol service terminal. Site photos can be taken and wireless sent to the pumping station.
- Data transmission: perform patrol tasks, failure recording, maintenance recording and data interaction of other universal messages via EVDO wireless network;
- Query of records: perform query and browse respectively based on time, record types, work status (all, not uploaded, uploaded);
- Positioning and navigation: patrol area, failure positioning and route navigation; achieved via GPS and mobile GIS built in the service terminal;
- Information receiving and sending: universal message interaction; communication can be achieved by exchanging short messages between the patrollers and between the patroller and the pumping station in order to achieve prompt coordination and scheduling;
- User management: user login and authority control; verify whether the login user is valid and control the authority;
- System management: perform basic data management, network setting, parameter setting of the service terminal etc.

The background application system of the pumping station mainly consists of task assignment, record query, information receiving & sending and system management

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modules, and mainly performs the functions to assign tasks, commands and instructions, receive site conditions and inquire data and records, providing background support to the patrol embedded service system.

### *E. Wireless networking scheme of VPDN*

#### *1) Structure of the network*

The region where the mobile oil pipeline extends is uncertain, the distance between stations is long, the volume of data transmitted is large and the requirement for data security is high. All the above problems can be settled by adopting CDMA VPDN network. The network structure of the whole system is shown in Figure 5. The system network contains CDMA VPDN network and internal local area network. The background application server of the system is provided with dual network cards which cross two networks and two network segments. Patrol terminals and the background application server form VPDN network. The background application server, the database server and the client side of the background application system of the pumping station are arranged within a local area network.

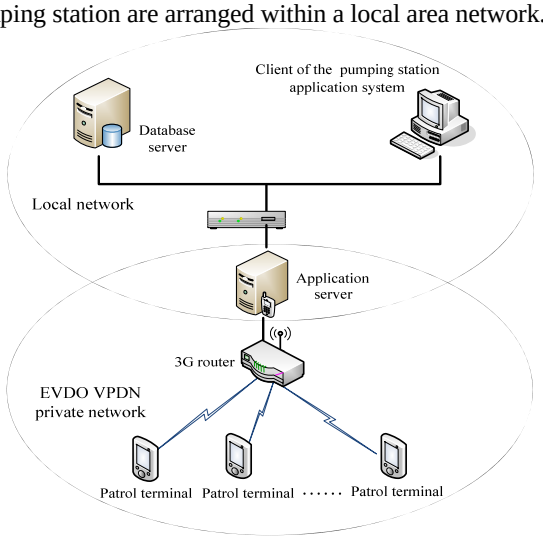


Figure 3. Network structure

#### *2) VPDN network building*

VPND network access has two ways: Telecom LNS access and user LNS access. Telecom provides LNS and does not share with the user; Telecom provides authentication and assigns IP addresses; for user LNS access, the user provides authentication and IP address assignment. Therefore, from aspects of data security, service stability and management convenience, we adopt private network user LNS access. Cable line is established between Telecom and the data center of our institute. The data center is equipped with network LNS server and user network authentication AAA server which support Layer 2 Tunneling Protocol. The terminal and the background application server establish PPP connection respectively via PDSN of the telecom packet network and LNS of the intranet of the data center. Data stream from the patrol terminal and the background server are transmitted via the tunnel which is broken through.

The dialing flow of the terminals (PDA, mobile PC etc.) is shown below:

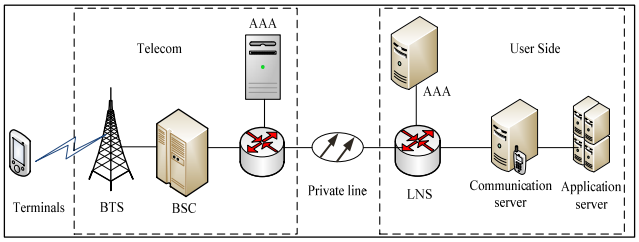


Figure 4. VPDN access flow chart

*a) At the terminal, use the user name to dial and make connection requests to Telecom PDSN via the devices in the base station and at wireless side BSC/PCF.*

*b) Telecom PDSN forwards the access request to the Telecom AAA server which judges whether the user is VPDN user based on the user domain and has the access authority, and then returns VPDN attributes to PDSN after AAA authentication.*

*c) Telecom PDSN sets up the L2TP tunnel based on VPDN attributes returned by AAA (including LNS address, tunnel type and L2TP tunnel key etc.) and user LNS.*

*d) The terminal user and the LNS device at user side negotiate and make a request to establish PPP connection and transmit user name, password, authentication method etc. to LNS.*

*e) LNS sends user name, password, authentication method etc. transmitted to AAA at user side for second authentication to authenticate whether the terminal user can access the user network.*

*f) After AAA authentication at user side, LNS assigns the preset static IP address to the terminal user which then sets up PPP connection with LNS.*

*g) Complete the connection of the terminal to the user intranet, that is, to set up data channels between the terminal and the user server.*

The patrol service terminal and the background application server perform communication interaction via data link channels set up as above.

#### *3) Data upload and download*

*a）Data download*

After data assignment, any new task or message added in the client side of the background application system of the pumping station is saved in the background database. The data scanning thread at the service terminal of the site patroller sends a data scanning request every 30 seconds to the background application which responds to the request and retrieves whether the background database has any data to be downloaded by this terminal. If none, return null. If any, return the data for terminal analysis and saving in the terminal database. After the data are saved, feedback results are uploaded to the background application of the pumping station which will upgrade the zone bits in the data table accordingly based on the results.

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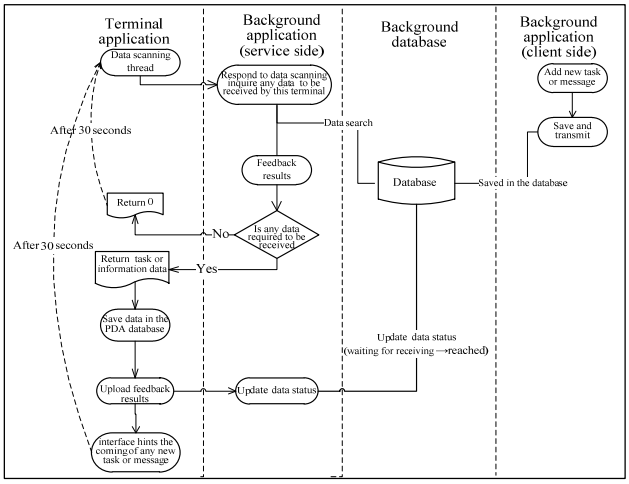


Figure 5. Data upload chart

*b） Data upload*

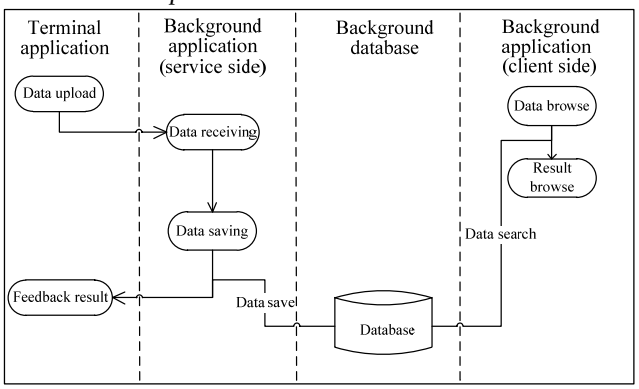


Figure 6. Data download chart

The terminal uploads data. The background application listens to the terminal request and performs data transmission after which the data are saved in the background database. Feedback whether the results are uploaded successfully to the terminal. At the client side of the background application system of the pumping station, data browse and inquiry can be performed.

## VI. CONCLUSION

After successful research and development, the service experiment was conducted on this system. During the experiment, real-time information interaction between the patrollers and the pumping station was realized, filling/uploading of failure and maintenance records, work route navigation and information pass back during the patrol is realized, improving the working efficiency of various links from the administer to the patroller and from work assignment to task return. Results show that the pipeline patrol system based on the private network of CDMA VPDN has complete functions with convenient, safe and reliable operation and smooth high-efficient upstream and downstream information transmission. It can improve the working efficiency of the pipeline patrollers and the patrol quality and guarantees reliable operation of the pipeline system.

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TABLE I. COMPARISON BETWEEN VPDN L2TP PROTOCOL AND VPN IPSEC PROTOCOL [3]

| | ***L2TP*** | ***IPSEC*** |
|---|---|---|
| **OSI levels** | Level two, with strong user data transparency | Level three, with slightly poor user data transparency |
| **Encryption** | IPSEC encryption as needed | IPSEC encryption |
| **Bearer network** | Telecommunication network, completely isolated from the internet | Internet |
| **Requirement for front-end devices** | Low requirement for front-end devices, with various user terminals supportive, for example, mobile phone, PDA and notebook etc. | Encrypted front-end devices, with high requirement for the processing ability, not applicable for user terminals such as PDA |
| **Maintainability** | Key devices maintained by China Telecom, with high reliability and low maintenance work for the user | Devices maintained by the user entirely with high maintenance work |
| **Authentication Method** | Double AAA authentication, terminal legitimacy mutually authenticated by the operator and the customer | AAA authentication by the customer |
| **UIM card binding** | With binding of user name, password and UIM card No. supportive | Non-supportive |
| **Qualification** | Certified by the National Research Center for Information Technology Security | None |