# Chapter 14
# The Design and Realization of Online Land Patrol System Based on CORS

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**Abstract** Land patrol is very crucial to land resource management, land resource management not only face to huge amount of data, but also requires a concurrent and high accuracy data. The most popular technology for land resource management is remote sensing, but it constrained by the spatial and temporal resolution, lacking the ability to detect the illegal incidences occurred in particular, dispersed region, which is go against the land planning, utilizing, protection and management. GNSS based patrol technology can make up the shortage of remote sensing land monitoring technology. On another hand, continuous operational reference system (CORS) are widely used in many provinces and cities as urban infrastructure. Low-cost receiver can meet the requirement of land patrol with CORS aided. This paper presented the design and realization methods of a land patrol and monitoring service platform. In this system, low-cost GIS data collectors are applied to collect the spatial information, properties and even multi-media information of a land parcel, all these data are sent back to data centre according to the mobile network. Data centre can monitoring the status of data collectors, acquiring data. These data are processed, edited and checked, and then stored in the database or used to provide information service to the public. The system combined CORS positioning technology, GIS data management and wireless communication technology, allocated different authority to different role. This design makes managers can monitoring the fieldwork progress, fieldworkers can acquire the information of land parcel, and the public can access the information of their concern. The whole land patrol and data collecting, data processing procedures are paper-free, real-time, intelligence. The efficiency of fieldwork is improved, and the work strength is cut down and less professional skills are required for surveyors with this system.

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## 14.1 Introduction

Land patrol is very critical to land management. Land management need to deal with huge amount of data and have a high demand of uptodate situation and accuracy. Land management involves managing cultivated land, state owned land storage, sold land and other types of monitored land, preventing spare land and illegal land, achieving the aim of rational land utilization. Land patrol is the most directive and effective way to manage land for base land management departments and its efficiency may influence the management and utilization of land. Currently, remote sense (RS) is the most popular technique for land management, however, it restrict to its spatial resolution and temporal resolution. Especially remote sense is insensitive to sparse distributed and small scale illegal land utilization events, which is not good enough for land planning, utilization, protection and management. Global navigation satellite system (GNSS) positioning technique can make up the shortage of RS and provide precise coordinates and shape of interested land parcel. Hence, GNSS positioning technique play an important role in land patrol as well.

Wu et al. investigated vehicle-based land patrol system and proposed vehicle based 'moving-platform' relative positioning scheme to solve patrolling vehicle positioning problem [1]. The advantage of this method is that it applicable for large scale and multi-vehicle cooperative mission without base station. However, the coordinate of moving-platform is very difficult to precisely determine in real-time. Coordinate of vehicles subject to different moving-platform may existing systematic bias. Xi et al. studied PDA based land patrol technique [2], but the study focused on processing properties information and multi-media display. As developing of GNSS technique, RS technique geo-information system (GIS) technique and communication technique, the land patrol technique changed dramatically as well. This paper presents a multi-propose land patrol service system with continuous operation reference system (CORS) [3] aided positioning technique, which assembles RS, GIS and communication technique. The system utilize inverse network real-time differential (RTD) technique for positioning, utilize remote sense image for land utilization change analysis, and utilize GIS technique for land information management. The system provides evidence for decision making and enforcing the land law, which improves land management efficiency.

## 14.2 System Design and Implement

The land patrol system is an enhancement of GPSNet software. The basic idea of the system is adding a patrol server between field user and GPSNet server. The patrol server acts as a middle server who connects field user, Web browser and

GPSNet server. Field users can upload raw GNSS observations to the patrol server, the patrol server processes these observations and output inverse RTD solution, after transform field user coordinate to local coordinate system, the final solution was broadcast to user via wireless network. The scheme encrypts local coordinate system transformation parameters, and simplifies field user devices. Meanwhile, administrator of the system can assign new patrol mission to field users via browser, monitor field user status and analyze field data. Field worker can connect to patrol server to download new mission via field terminal. The whole system ensures the land patrol process efficient.

The system makes up by three modules.

The first module is an extension of CORS server. This module is a client/server scheme, each field user own a unique connection to the server for GNSS observation and multimedia data delivery. This CORS extension server can decode received data. Extracted GNSS observation was combined with information from CORS system to generate final positioning solution and Extracted multimedia information was saved in the database. Then, the module broadcast the final positioning solution to field users again via wireless network.

The second module is the major part of the system, which is a web server called patrol server. The patrol server supports all web services including administrator's interface and field user's interface. Meanwhile, the patrol server shares database with CORS extension module, which enables administrators monitor field work status.

The third module is embedded into handheld devices. The function of embedded module is fourfold: the first function is that the module can setup a wireless connection to CORS extension server to deliver GNSS observation and multimedia data. Furthermore, the module can receive the final positioning results and display them on the map. The third function of the module is updating land parcel information and synchronizing information with the database. Finally, the handheld device can browse webpage and download new mission from patrol server.

The structure of the system can be shown as Fig. 14.1.

### *14.2.1 The System Layer Scheme*

In order to make the system stable, extendable and efficient, the system is divided into three layers: display layer, logical layer and data layer. The triple layer scheme is demonstrated in Fig. 14.2. Function of each layer can be described as follows:

Presentation layer: the presentation layer includes administrator's interface and field user's interface. This layer supported by web server and embedded module. The function of this layer includes system configuration, coordinate display, mission distribution et al.

Logical layer: the logical layer responds requests from both administrators and field users. Function of logical layer includes wireless communication with field

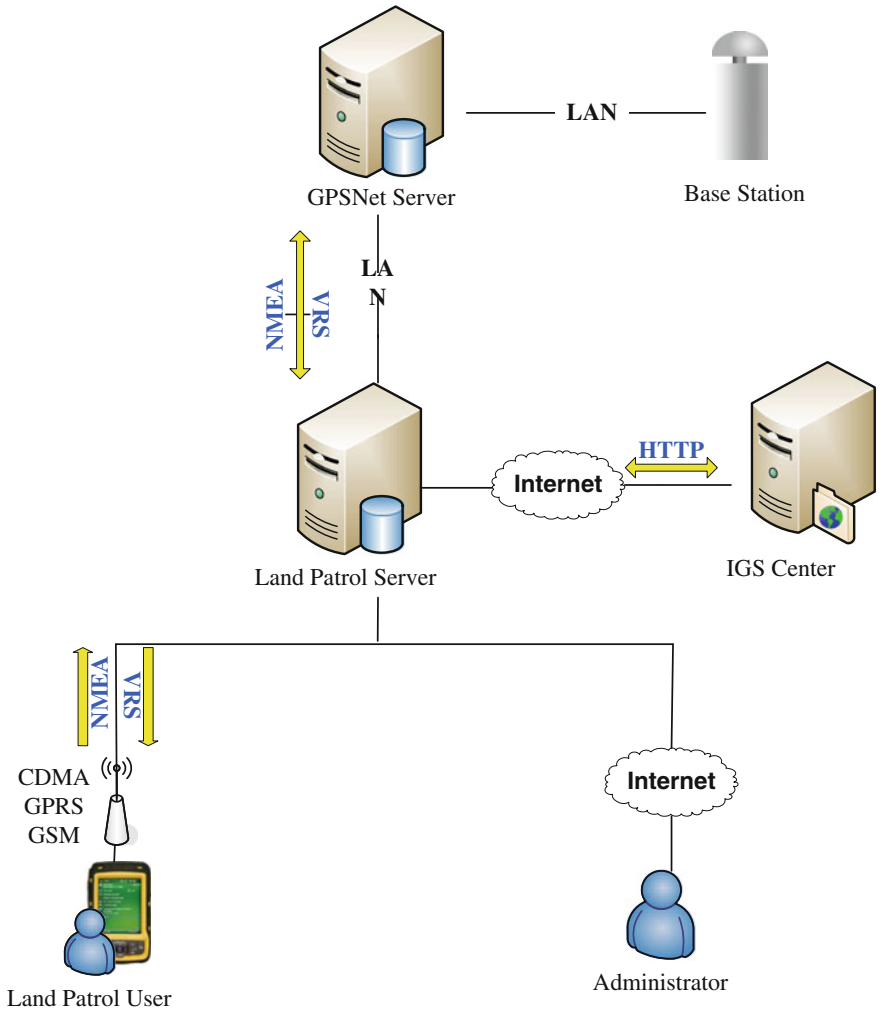


**Fig. 14.1** The logic structure of the online land patrol system

users, inverse RTD data process, database manipulation, system event logging and web requests responding.

Data layer: the data layer is used to define, maintain, access and update database to support logical layer and display layer. As patrol server and CORS extension server share the database, the data layer become extremely important to make system stable.

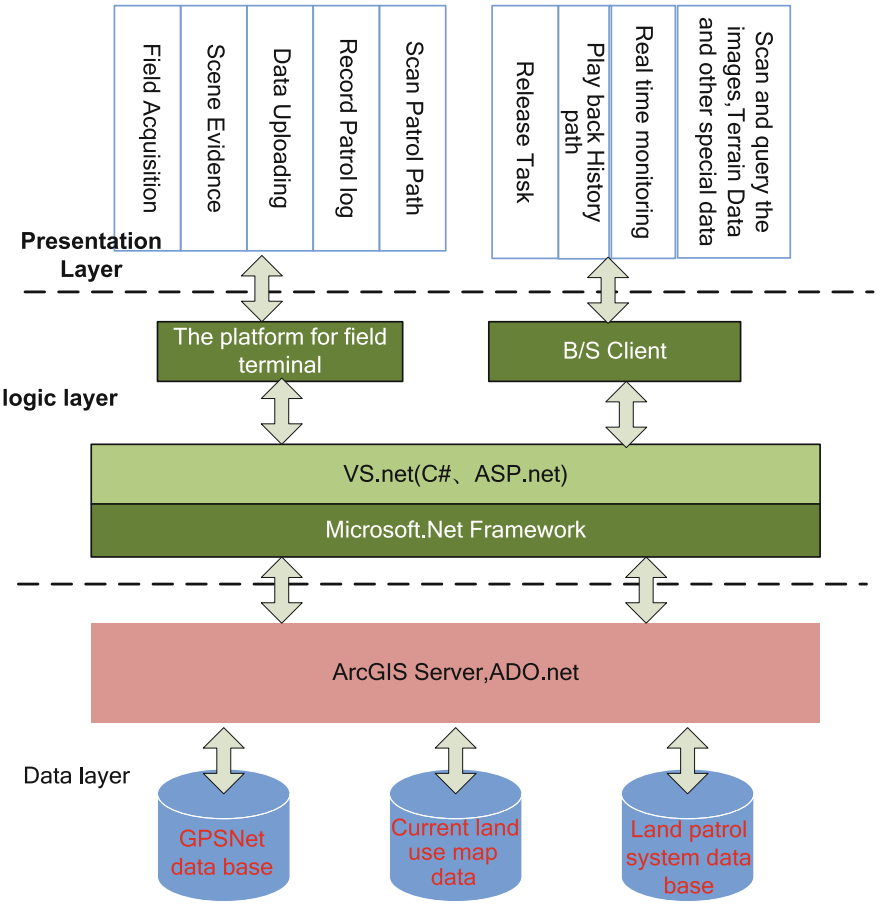


**Fig. 14.2** The layer scheme of the online land patrol system

### *14.2.2 Role Definition and Access Control*

According to user's mission type, two different role are designed in the system.

Field users use handheld devices, their tasks are collecting spatial data and property data. They can download patrol mission from embedded web browser, and communicate with CORS extension server. Field user interest in their mission-related information, such as new patrol mission, mission related land parcel information and their own patrol trace et al. Administrator can configure the system, monitor field user [4], assign mission and analysis spatial data. Most administrative work can be finished via web server, and field users only access module embedded in handheld device. Different roles have different permission to access the system, which makes the system safe and extendable.

### *14.2.3 Technical Routine*

Download patrol mission: Land usage change can identified by various ways, such as enforcement department investigation, checking remote sense image, public report, transferred law case, leader specify et al. Administrators will publish the newest mission information on the website and assign these missions to field patroller. Each patrol can check the missions like checking email.

Investigation and taking evidence: patroller holds handheld devices to crime scene and record shape of land parcel and collecting multimedia information as evidence. Handheld devices can send back the spatial information and property information of certain land parcel to server, additional evidences such as photo, videos et al. will be send back as well [9].

Upload data and Monitoring: all GNSS position result, patrol trace and investigation data will be uploaded to the server and displayed on the handheld devices. Hence, administrator can monitor patrollers via the system, and the patrollers can enquire the current position, patrol trace, uploaded investigation data as well.

Data post-processing: After patrolling, collected spatial information, property information, multimedia information as well as other evidence will be organized and analyzed, the collected data will be compared with land usage planning, latest remote sensing image and relative policies to undertake qualitative and quantitative analyze. The final patrol report will be formed based on analyze results (Fig. 14.3).

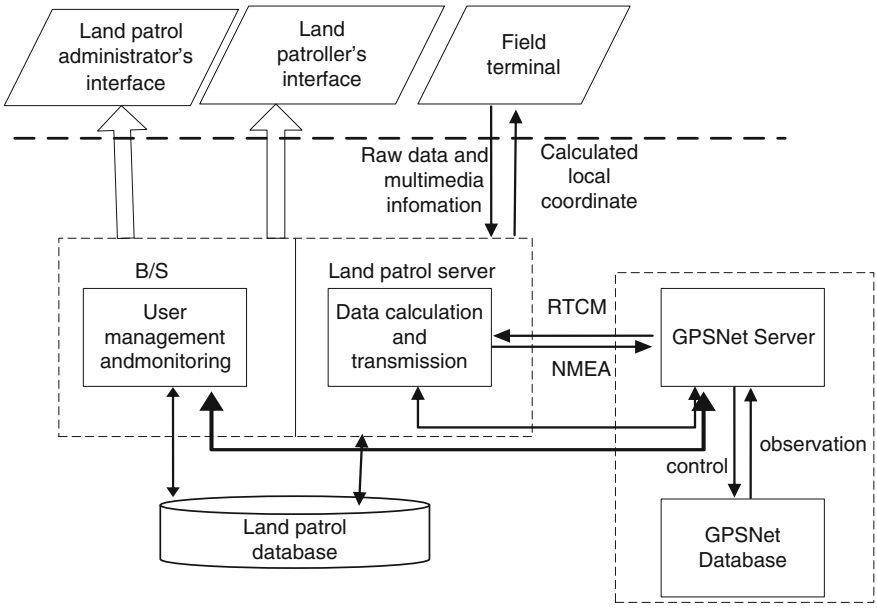


**Fig. 14.3** The dataflow diagram of the online land patrol system

### *14.2.4 System Implementation*

The system including three modules and it adopt a hybrid of B/S scheme and C/S scheme. All spatial data and property data are stored in SQL2008 database, and ArcSDE is adopted as spatial analysis engine. All geometry-related modification, analysis and enquiry are handled by the spatial analysis engine. As the system involves communication, web services and database manipulation, dot net framework is chosen, and C# is chosen as the developing language. Embedded module was a secondary development based on ArcPad package. ArcPad package can smoothly interactive with ArcSDE and help patrollers update land parcel informations. Zhonghaida Q5 GIS data collector was chosen as the handheld device, the GNSS observations was delivered back to server in raw OEM format, and the CORS extension module can decode the binary format and extract valid observations for coordinate calculation.

## 14.3 Key Technique

Developing a multi-propose platform requires multi-discipline knowledge. The system integrated GNSS positioning technique, GIS data management, Web service, wireless communication technique et al. The key techniques of implying the system are summarized in this section.

### *14.3.1 Inverse RTD Technique Based on CORS*

Land patrol is sparse distributed field measurement work. However, it doesn't require centimetre accuracy. In order to acquire decimetre positioning accuracy and encrypt local coordinate system parameter, the system adopts inverse network RTD technique. Single base RTD technique broadcasts code corrections to rover receiver, the longest distance between rover and base station can be several kilometres, which is too small for land patrol. Network based RTD technique is very similar to network RTK technique, but only code observation are transferred to rover station. Double differenced observations are formed with rover station code observation and virtual reference station (VRS) code observation, corresponding ultra rapid IGS precise ephemeris are downloaded to calculate rover coordinates. Another advantage of inverse network RTD technique is easily encrypt local coordinate parameters, as user coordinates will be transformed to local coordinate system in CORS extension module, the field users don't care the local coordinate system transformation parameters, they acquires local coordinates from server and display the coordinates in corresponding electronic map.

Comparing to single station RTD technique, Network RTD technique can share the coordinate easily, moreover, it suitable for low cost devices. Inverse network RTD technique enables server monitor multi rover users. Multi rovers cooperate more efficient under server's supervision. Network RTD technique require the same data flow as single station RTD technique, but network based RTD technique is suitable for lower cost hardware and cooperative field work. Inverse RTD handheld devices don't require high performance CPU to real-time GPS positioning calculation, which can cut off handheld device cost.

### *14.3.2 GIS Land Information Management Technique*

Land patrol data including vector geometry data, remote sense image from various sensors, hence, these spatial data need a unified spatial database engine to manage them. In order to support web application and spatial data management, ArcGIS server was chosen as the foundation of patrol server. ArcGIS server enables administrators analyzing spatial data via web browser and multi source spatial data management. Secondary development based on ArcGIS server makes patrol more suitable for land patrol application. Land utilization map, Land utilization planning map, remote sense images as well as vector geometries collected by GNSS positioning technique are transformed into a unified platform, which makes the system more efficient and extendable [5, 6].

### *14.3.3 Communication Technique*

Communication is extremely important in the land patrol system, especially with inverse RTD technique. Communication between handheld devices and CORS extension server are realized by mobile wireless network. Currently, code division multiple access (CDMA) [7] or general packet radio service (GPRS) [8] are available for long distance wireless communication. Handheld devices connect to server by specifying IP address and port of the CORS extension server. Handheld devices communication includes sending back GNSS observation to CORS extension server and hypertext transfer protocol (HTTP) request to the patrol server. The formal one was realized by TCP connection, handheld devices sending data to the specified port, server listening and decoding. The later one includes patrol mission download, and realized by standard browser/server communication. Communication between CORS extension server and patrol server was realized by sharing database. CORS extension server write new coordinate into database and patrol server read latest coordinates to monitor field users. AJAX technique was used to real-time update latest field user coordinate on the browser.

## 14.4 Concluding Remarks

The system integrated mobile devices developing, GIS developing, Web application developing and GNSS positioning. Three modules cooperate each other to make the whole process more efficient, the system can satisfy both administrators and field users demands in land patrol. Field user's work was cut off by handheld devices and wireless communication. Administrators can monitor fieldwork, encrypt coordinate system parameters and finish all work on the web application. Hopefully, the system can improve land patrol efficient, make effort on protect land resources and monitoring illegal land use. With the system, the quality of land enforcement services can be greatly improved.

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