This article investigates the use of the Internet as the communication link between the base and rover stations for the development of an Internet-based Real-Time Kinematic (RTK) system. An Internet-based RTK system has many advantages if compared to current radio-based RTK systems. To validate the concept, a prototype system has been developed and tested in both static and kinematic modes. The results indicated that the base differential data latency is in the range of about 1 second and the RTK positioning accuracy is at the centimeter level. © 2002 Wiley Periodicals, Inc.

1. INTRODUCTION

Real-Time Kinematic (RTK) is a satellite-based positioning and navigation technology developed in the early 1990s allowing the centimeter-level positioning of a stationary or moving platform in real time. Because RTK technology is able to provide the highest position accuracy possible from a satellite navigation system in real time, the technology has since then received a wide application in geodetic positioning and other areas.

Conventionally, RTK positioning employs a pair of navigation receivers and a pair of radios at each end of the baseline with one serving as the base station at a precisely known location and the other as the rover station with unknown coordinates. The data collected at the base station need to be transmitted via the radio to the rover station in order to derive centimeter-level position solutions in real time (Zhodzishsky, Vorobiev, Khvalkov, & Ashjaee, 1998).

Due to the fast advances in wireless communication technology, the Internet has become one of the most important communication methods today (Nguyen, 2001). Investigations are also under way to use the Internet for GPS applications. Muellerschon and colleagues (Muellerschon, Bertiger, & Trough, 2000; Muellerschon, Bar-Saver, Bertiger, & Stowers, 2001) and Hada, Yamaguchi, Kawaiita, and Murai (2000) have proposed that the Internet be used to distribute global GPS-based differential corrections. Lee et al. (2000) have investigated an Internet-based differential GPS system for mobile communication users. It is expected that the Internet will be increasingly used in the future as an efficient communication alternative to conventional radio-based methods.

This article investigates an Internet-based RTK system that uses the Internet as the communication link between the base and rover stations. Based on a prototype system developed at the University of Calgary, the performance of an Internet-based system was tested in both static and kinematic modes. In this article, the characteristics of radio-based and Internet-based RTK systems are first compared, followed by a discussion of an Internet-based RTK system based on currently available Internet access service. Numerical results and analysis are then provided to assess the operational performance of the system with respect to data transmission time delay and positional accuracy. The final section presents conclusions and recommendations.

2. COMPARISON OF RADIO-BASED AND INTERNET-BASED RTK SYSTEMS

2.1. Characteristics of Radio-Based RTK

A radio-data link is commonly used for communication between the base and rover stations in most RTK systems. Radio-based transmissions, however, have several significant disadvantages when used for RTK positioning and navigation. First, radio has a very short data transmission range because the data transmission range for VHF, UHF, and higher frequencies is limited to line-of-sight.
Between the base and rover radios (McLarnon, 1997; Pacific Crest, 1998). In addition, the radio communication range is affected by many other parameters including line loss, antenna configuration, path attenuation, and atmospheric conditions.

Second, RTK radio transmissions are prone to interference by other users in the frequency band because the radio waves in the band are crowded, and no effective frequency resource-sharing mechanisms are implemented to avoid frequency collision. For instance, the channel separation in the UHF commercial band is only 12.5 KHz, which makes it more likely to cause larger cross-channel interferences (Pacific Crest, 1998). The interferences will also deteriorate the communication quality and further reduce the effective radio transmission range. In urban areas where the radio wave environment is harsh, for instance, the effective radio transmission ranges are usually limited to a few kilometers (Liu, Gao, & Liu, 2001). Another complication with radio-based RTK is that radios must be licensed prior to use.

In the past several years, the Internet has evolved into an important communication and data distribution mechanism. An increasing number of applications utilize the Internet because it is widely accessible. The Internet has many advantages over conventional radio data transmission methods for RTK positioning and navigation.

First, the Internet is based on a global network and therefore is not limited by an effective data transmission range. In fact, the Internet theoretically can reach any corner of the world where there is an Internet node either in an office or in the field, and its transmission range is not constrained by physical factors such as line-of-sight requirements. Second, data transmission via the Internet is also considered more reliable due to less interference compared to the use of radio modems. Current Internet access services have been based on a dense network of transmission towers configured to maintain a constant signal power and avoid frequency collision by assigning different frequencies to neighboring towers. Moreover, its channel separation is much greater than that used by the commercial radio band and therefore the possibility of cross-channel interferences will be much smaller (Lin, 2001; Wong & Britland, 1995).

Another noticeable advantage is that the Internet keeps expanding daily in terms of its coverage, functionality, and number of users. Its accessibility will therefore be further enhanced in the future. In addition, the Internet-based RTK base station has the potential to serve as a virtual base station whose data can be accessed by a large number of rover users using different wireless Internet access approaches.

3. Implementation of an Internet-Based RTK System

In this section, an Internet-based RTK system developed at The University of Calgary is described. The system consists of two high-precision RTK receivers for position determination and wireless modems for real-time data transmission over the Internet. Equipped with a wireless modem, the base and the rover receivers are able to link to the Internet via a communication network. The system configuration of the Internet RTK system is depicted in Figure 1. The base station consists of a receiver capable of generating RTK differential corrections and a server PC.