A wireless navigation and healthcare system for Group Recreational Cycling

Kun-Ming Yu
Department of Computer Science and Information Engineering, Chung Hua University, No. 707, Sec.2, WuFu Rd., Hsinchu 30012, Taiwan
E-mail: yu@chu.edu.tw

Chi-Chung Lee
Department of Information Management, Chung Hua University, No. 707, Sec.2, WuFu Rd., Hsinchu 30012, Taiwan
E-mail: leecc@chu.edu.tw

Hung-Nien Hsieh
Department of Architecture and Urban Planning, Chung Hua University, No. 707, Sec.2, WuFu Rd., Hsinchu 30012, Taiwan
E-mail: planhsieh@gmail.com

Hsin-Wen Chang
Department of Leisure and Recreation Management, Chung Hua University, No. 707, Sec.2, WuFu Rd., Hsinchu 30012, Taiwan
E-mail: hwchang@chu.edu.tw

Jiayi Zhou
Institute of Engineering and Science, Chung Hua University, No. 707, Sec.2, WuFu Rd., Hsinchu 30012, Taiwan
E-mail: mail4jiayi@gmail.com

Cheng-Yan Yu and Jian-Yuan Liu
Department of Computer Science and Information Engineering, Chung Hua University, No. 707, Sec.2, WuFu Rd., Hsinchu 30012, Taiwan
E-mail: ian@pdlab.csie.chu.edu.tw
E-mail: elendil@pdlab.csie.chu.edu.tw

Ming-Gong Lee*
Department of Leisure and Recreation Management, Chung Hua University, No. 707, Sec.2, WuFu Rd., Hsinchu 30012, Taiwan
E-mail: mglee@chu.edu.tw
*Corresponding author

Abstract: Group Recreational Cycling (GRC) is a new kind of tourism activity involving a courier and a number of tourists. In addition to cyclists’ safety and comfort, tracking their position, monitoring their health condition in terms of heart rate, guiding and warning along the way if necessary, are important in GRC. Information exchange among cyclists is essential to achieve above goals. In this paper, an event-based wireless navigation and healthcare system (EWS) for GRC using an Ad Hoc network with multi-hop protocol to transmit data among
devices is proposed. EWS can be implemented to design suitable routes, to warn about bad road conditions, to play multimedia attractions for guiding, track cyclists’ position and to monitor members’ heart rate. System structure and design for EWS are given. Two scenarios are shown to demonstrate and to show the feasibility of EWS.

**Keywords:** GRC; group recreational cycling; ad hoc network; multi-hop; event-based wireless navigation and healthcare system; route planning; healthcare.


**Biographical notes:**

Kun-Ming Yu received the BS in Chemical Engineering from National Taiwan University in 1981, and MS, PhD in Computer Science from the University of Texas at Dallas in 1988 and 1990, respectively. From August 1993 to July 1996, he was the Head and an Associate Professor in the Department of Information Management, Chung-Hua Polytechnic Institute. From 1996 to 2000, he was the Chair of the Department of Computer Science and Information Engineering, Chung-Hua University. He is currently the Dean of the College of Computer Science and Informatics, Chung-Hua University. His research interests include load balancing, distributed and parallel computing, high performance computing, ad hoc network and computer algorithms.

Chi-Chung Lee received his BS in Industrial Engineering from Chung Yuan Christian University, Taoyuan, Taiwan, in 1991. He received his MBA and PhD in Information Management from National Taiwan University of Science and Technology, Taipei, Taiwan, in 1993 and 2004, respectively. His research interests include database systems, data management for mobile computing and RFID systems. He is currently an Assistant Professor of the Department of Information Management, Chung Hwa University, Hsinchu, Taiwan.

Hung-Nien Hsieh received his MS in Department of Urban Planning from National Cheng Kung University in 1990 and PhD in College of Architecture and Urban Planning from Tongji University in 2008. Since 1996 until now, he is an Associate Professor in the Department of Architecture and Urban Planning, Chung-Hua University. From January 2007 to December 2010, he was the President of the Taiwan Institute of Glocalization Development. From 2007 until now, he is the Dean of the Continuing Education Center, Chung-Hua University and Director of the Innovation and Incubation Center. His research interests include urban planning, intelligent city strategies, community planning, environmental planning and design and urban renewal.

Hsin-Wen Chang is an Associate Professor in College of Tourism, Chung-Hua University, Taiwan. She is also the Head of Department of Leisure and Recreation Planning and Management. With 20 years professional teaching experience, she has been engaged for many years in researching tourism development and especially in bicycles as a mean of transportation and tourism. She is invited as a member of the Committee on Bicycle Transportation of Transportation Research Board in the USA from 2009~2015. As a bicycle planner and researcher, she was invited as a keynote speaker in Velo City Global2012 in Vancouver, and 2013 in Wien.

Jiayi Zhou received his BS from the Department of Applied Mathematics and the MS from the Department of Computer Sciences and Information Engineering, Chung Hua University, Taiwan, in 2003 and 2005, respectively. He received the PhD in the Institute of Engineering and Science, Chung Hua University in 2010. His research interests included cloud computing, parallel and distributed computing, parallel algorithms and bioinformatics.

Cheng-Yan Yu received the MS in Computer Science and Information Engineering from Chung Hua University in 2010. His research interests include ad hoc network, advertisement recommendation system, and web applications.

Jian-Yuan Liu received the MS in Computer Science and Information Engineering from Chung Hua University in 2012. His research interests include context-aware systems, wireless networks, and RFID systems.

Ming-Gong Lee obtained his PhD in Applied Mathematics from the University of Iowa, USA. From August 2000 to July 2003, he was the Head of the Department of Applied mathematics, Chung-Hua University. He is currently a Professor at the Department of Leisure and Recreation Management/PhD Program in Engineering Science, Chung-Hua University. His research interest includes numerical solutions of partial differential equations, numerical solutions of differential algebraic equations, parallel computation and scientific education. He has published articles in
1 Introduction

In recent years, functioning of cycling has gradually been transformed from a simple transportation tool to recreation equipment. Recreational cycling is about a touring activity rather than racing, it makes safety and comfort as high priorities. The range of the cycling may vary for different purpose. It may be tour for intra-city, inter-city or inter-country. Although cycling often proceeds in groups, however, in strange or unfamiliar environment, riders can face unexpected safety issues, therefore safety and health are two major concerns when conduct the cycling tour. Safety entails both selecting a safe route (Aultman-Hall, 1996; Boarnet et al., 2005) and appropriate protection equipments (Cushman et al., 1990; Derhab and Badache, 2009; DiGuiseppi et al., 1989). Health also needs to be attended to, because discomfort and even injuries can be caused by unexpected conditions encountered along the road. As a result, effective mechanism for communication and monitoring of cyclists can improve both safety and comfort.

Telematics is made up by a computer for sending, receiving and storing information via telecommunication devices. Applications include vehicle tracking, satellite navigation, mobile data, mobile television, etc. Many telematics systems and architectures have been designed and are proposed to improve and facilitate driving (Lee et al., 2007; Mangharam et al., 2005; McCallum et al., 2004; Pias et al., 2009; Quddus et al., 2003; Ritchie, 1998; Reilly and Taleb-Bendiab, 2002). Various related applications and research also have been proposed, such as the speech recognition (McCallum et al., 2004), vehicle self-diagnostic (Breed, 2004), route planning (Quddus et al., 2003), multi-hop networking (Mangharam et al., 2005), etc. However, for many proposed applications, a powerful, expensive onboard device and high energy consumption are needed. Because car itself can provide necessary power, energy consumption is not an issue. In addition to the consideration about power supply, the on-board units for bicycles need to be at lower cost and less energy consumption. Therefore, a wireless Ad Hoc network is an alternative option for building an infrastructure with a less complicated network.

Mobile Ad Hoc Network (MANET) is a self-configuring network for mobile devices connected by wireless links. Routing protocols can be roughly classified into proactive and reactive. Both of these protocols can allow a node to join and leave an Ad Hoc network without having a base station. Types of MANET include Vehicular Ad Hoc Network (VANET), Intelligent Vehicular Ad Hoc Network (InVANET) and Internet-Based Mobile Ad Hoc Network (iMANET). The related research for MANET includes distance measurement (Hummel et al., 2007), routing protocols (Perkins and Royer, 1999), and energy consumption, etc. Esbjörnsson et al. (2002) developed a Hocman protocol which applied a peer-to-peer application for a motorcycle. For group cycling, the wireless Ad Hoc network is more suitable as the basis for communication because of the shorter distance between cyclists. However, compared with cars or motorcycle tours, the success of group cycling is more dependent on good route planning, safety monitoring, road condition precaution and sceneries guiding. Overview of a group recreation cycling environment with Ad Hoc, 3G and GPS support systems is illustrated in Figure 1.

In this paper, an event-based wireless navigation and healthcare system (EWS) is proposed, it can provide functions meeting the following features:

- safety route planning
- real time warning
- multimedia attraction guides
- cyclist communication
- cyclist tracking
- cyclist health monitoring.
Members involved in a recreational cycling group are either couriers or tourists.

To achieve objectives defined above, 802.11 wireless Ad Hoc networks are designed as the point-to-point transmission facility. A 3G network module is also attached to the courier’s device to facilitate communication with the server. Information exchange between the courier and the tourists applies the Ad Hoc module so that onboard devices can reduce the energy consumption and satisfy low energy requirement. For safety, health-related aspects such as heart pulse monitoring module is used to read the cyclist’s heart rate. Any irregular rate will be reported through the monitor module. A GPS is also included in the cyclist’s onboard device, so that information about attractions and road conditions can be provided according to the current location of the cyclist. The module can also provide exact location of the cyclists to the courier to prevent accident happen when the cyclists are not in the same area. On the other hand, the server provides the route planning, emergency notification and other computing-intensive works. With this planning, the cost of onboard equipment on bicycles can be lowered.

To achieve these objectives, three subsystems are designed, namely Bicycle Onboard Subsystem (BOS), Courier Subsystem (CS) and GPS and Health Subsystem (GHS). Instructions on how to operate the subsystems will be demonstrated and design of the system will be explained in the following sections. Two scenarios are also used to illustrate the feasibility of the proposed EWS system architecture. This paper is organised as follows: Related works are described in Section 2. Section 3 illustrates the system architecture and modules of the proposed EWS. Two scenarios are given in Section 4. Finally, the conclusion is given in Section 5.

2 Related works

2.1 Bicycle-related research

Bicycle-related research basically can be divided into few areas, including bicycle commuting, bicycle tourism and recreational cycling. In all activities, safety and health are two critical issues. In Ritchie (1998), Ritchie defined recreational cycling as the occasional riding of a bicycle during their holidays, with the bicycle considered as an alternative and enjoyable mode of transportation when exploring a destination. Route planning is important for cycling, therefore many methods and research topics have been proposed (Betz et al., 1993; Ehlers et al., 2002; Stinson and Bhat, 2003a, 2003b). Ehlers et al. designed and implemented a Geographic Information System (GIS)-based cycling routing system. The system designs a route and uses the GIS to announce the route though the WWW. However, this is a pre-planning mechanism, and cannot provide real-time information while riding is actually happening, so that some alternative mechanisms should be considered, and an infrastructure-less network should be given instead. A multi-hop Wireless Networks (MHWNs) is defined as a collection of nodes that communicate with each other wirelessly by using radio signals with a shared common channel. It was also named as Ad Hoc network, mobile network or packet radio network (Mshari, 2011).

2.2 Ad hoc network

An MANET is a self-configuring infrastructure-less network of mobile devices connected by wireless communication medium (Sarkar et al., 2013). The self-configuring and infrastructure-less characteristics make users easily deploy MANET in a hostile environment such as military intervention or disaster rescues missions. To realise the characteristics, many scholars have been exploring issues of MANET, such as admission control (Hanzo and Tafazolli, 2009), routing protocol (Abusalah et al., 2008), system security (Zhao et al., 2012) and data replication (Derhab and Badache, 2009). While there are already many excellent results, most of them focus on the general-purpose MANET (Conti and Giordano, 2007), i.e., it is completely the infrastructure-less network model. From the viewpoint of academic, the exploration of the ‘pure’ general-purpose MANET is interesting, but it also ‘complicates’ the architectures and protocols and causes no successful products on the market yet (Conti and Giordano, 2007).

To advance MANET application in our daily life, four pragmatic extensions have been derived from the pure general-purpose MANET (Conti and Giordano, 2007). They are mesh networks (Benyamina et al., 2012), opportunistic networks (Pelusi et al., 2006), VANET (Eichler et al., 2005; Kosch et al., 2006; Schroth et al., 2005) and Wireless Sensor Networks (WSN) (Yick et al., 2008). Mesh networks introduce fixed routers to simplify the network design. Opportunistic networks provide connectivity opportunities to pervasive devices when these devices cannot direct access to the data source. VANET provides communication between vehicles that are near each other on the roads. WSN collected data from the sensor nodes in multi-hop Ad Hoc networks on a specific application. VANET is a form of MANET. Each vehicle equipped with a VANET device will be a node in the Ad Hoc network and can exchange information within the network. The objectives can be divided into two parts, namely, comfort and safety. Research in VANET includes traffic model and mobility mode (Ritchie, 1998), scalability problem (Kosch et al., 2006), message exchanging (Eichler et al., 2005), etc. As VANET is mainly used in inter-car communications, it can provide communication between nodes in a high-speed driving environment. It should be possible to use the same system with bicycles. However, none of the existing VANET equipment takes energy consumption into consideration, because cars have the necessary power for these devices. Therefore, in this study, the energy consumption of each device on a tourists’ bicycle needs to be concerned.

Several works have been introduced in MANET to cycling in recent years. The most related work is in Chen et al. (2011), it proposed an augmented reality-based group communication system which is implemented on
smart phones for cyclists. To provide efficient group communications, the cyclists exchange their data through MANET if they are in the same group. The main function of the proposed system includes group member localisation, communication, emergency notification, leadership exchanging, speed racing and file sharing. However, navigation and healthcare are not considered in the system. The second related work is the BikeNet Mobile Sensing System (Eisenman et al., 2007, 2009), which deploy mesh network and WSN to explore cyclist, bicycle and environmental sensing in the cycling area. The BikeNet not only store and report the cyclist performance, but also collect environmental data when the cyclist engaged in cycling. To achieve this function, the BikeNet simultaneously employs WSN and mesh network to transmit the sensing data to the backend server. The BikeNet equips a WSN on the cyclist and her or his bicycle to sense cyclist performance and environmental data. The BikeNet also sets up a number of sensor access points that provide the uploading of the sensing data when the cyclists pass through the transmission range of the sensor access points. From the functionality standpoint, the sensor access points of the BikeNet can be regarded as the fixed routers of mesh networks. In Pias et al. (2009), a cyclist location tracking system, the Sentient City-Bike system, is built practically at Cambridge (UK). It collects the cyclist mobility data from the community bicycle system. These mobility data would be a valuable source for predicting the cyclist movement in opportunistic networks. The communication architecture of the Sentient City-Bike system comprises the WSN and the mesh network. The sensing mobility data are uploaded when the sensor node equipped on a bicycle is in the transmission range of a pre-setting access points. Another related work is the Hocman system (Esbjörnsson et al., 2004), it is a peer-to-peer application based on MANET for handheld computers. It can support traffic encounter report between motor cyclists during short moments of visual contact.

A navigation and healthcare system, namely EWS, is proposed for Group Recreational Cycling (GRC) in this paper. The goals of EWS are to provide a safe route planning, real time warning, multimedia attraction guides, cyclist communication, cyclist tracking and cyclist health monitoring. To achieve these goals, each bicycle was equipped with a Tourist’s Onboard Device (TOD) and Courier’s Onboard Device (COD). Both COD and TOD have a display panel, a GPS receiver, a heart rate sensor and an Ad Hoc network module, in addition, the COD has a 3G network module (see also Figure 1). Since all communication between server and cyclists is transferred via the COD, communication between cyclists only requires an Ad Hoc network. Therefore, this design reduces the energy consumption and lowers the cost of the TOD. A system diagram for EWS is shown in Figure 2.

![Figure 2 System diagram of EWS (see online version for colours)](image)

3.1 System modules of EWS

EWS constitutes three subsystems, namely Bicycle Onboard Subsystem (BOS), Courier Subsystem (CS) and GPS and Health Subsystem (GHS). Figure 3 illustrates the modules of each subsystem. Functionalities of each module are given as follows:

![Figure 3 EWS system modules](image)

3.1.1 Courier Subsystem (CS)

The CS is only mounted on the COD. It can communicate with the server, transfer the planned route and road conditions to tourists, track the tourists’ location and monitor their health conditions from heart rate data. It can also call the ambulance or other medical resources in case of emergency. Several modules and their functions in the CS subsystem are illustrated as follows.

3G Network Module provides the communication between COD and the back-end server.
**Location Monitor Module** continuously collects the tourists’ GPS data through the Ad Hoc network, and then displays it on the COD. This module notifies the courier if any tourist leaves the Ad Hoc network communication range. This information will be sent to the back-end server.

**Health Monitor Module** reads the heart rate of the cyclist by a heart monitor belt worn in each cyclist. To ensure receiving of the heart rate data correctly, traditionally radio frequency (RF) is abandon due to ease of loose-track signals, in turns, Bluetooth is replaced. The design of the Bluetooth is coded by Qt 4.6.2. It constitutes the Webkit 2.0 to enhance the usage of the advanced interfaces design tools such as XHTML and CSS3, and Map API by Google. It can warn the courier and send out the medical resource demand to the backend-server in case of an abnormal/irregular heart rate data is detected.

### 3.1.2 Bicycle Onboard Subsystem (BOS)

The BOS is installed on COD and TOD both, and it is the core subsystem of EWS. In addition, BOS stores data from CS and GHS; it also triggers the event according to the tourist’s demand or heart rate. The following are modules and their functionalities in the BOS subsystem.

- **Data Access Module** is the data storing and forwarding centre of BOS. It stores the GPS coordinates, heart rate, planned route, road condition and recorded images.
- **Ad Hoc Network Module** is responsible for data transmission of the onboard devices of cyclists. The presence of dynamic and adaptive routing protocol leads to the Ad Hoc network being configured quickly.
- **Event Notify Module** is used by the cyclist to notify the immediate road conditions, personal health concerns, etc. It can also send out an emergency notification to all cyclists and the back-end server.
- **Event Trigger Module** includes **Attraction Trigger Module (ATM)** and **Road Condition Trigger Module (RCTM)**. Attraction and road condition data are received from the COD and stored in **Data Access Module**. Attraction data include popular Positions of Interest (POI) and its coordinates of location. During the tour, ATM sends an event to BOS and plays the corresponding multimedia data while the present position matches the stored coordinate. By the same idea, RCTM plays the road condition warning when the present position of cyclist matches the designated coordinate.

### 3.1.3 GPS and Health Subsystem (GHS)

GHS is installed on COD and TOD, it can receive the present coordinate via GPS, to senses the heart rate of the cyclist, and to takes pictures. The following are modules and their functionalities in the GHS subsystem.

- **GPS Module** receives three-dimensional location (latitude, longitude and altitude) data and the time reaching the present position.
- **Heart Rate Sensing and Image Record Modules** read the pulse of cyclists and take images, respectively. These data are sent to the **Data Access Module** of BOS. The following Figure 4 illustrates the relationship between these modules in EWS, outline of functions of each subsystem will be given in the following paragraph.

**Figure 4**

Objects in EWS and its control flow (see online version for colours)

### 4 Design of EWS

EWS basically is a device characterised by web service, Ad Hoc network and location sensing system. Its layer design relationship is shown in Figure 5. Given these characters, EWS is designed to provide a liberal, art and health-based cycling tour. In the web service, it can support the following functions: designing safety route for travelling, multimedia demonstration of POI, managing cyclist’s personal information and monitoring his (her) heart rate data. In order not to cause inconvenience and delay by the wireless transmission, necessary information regarding to the tour will be installed in the system when it is offline, such that the frequent access of the necessary data can be greatly reduced, as a result, it saves energy for operating the system during the tour. The system can also supply broadcasting to the cyclists by the courier, according to different POI, the courier can provide suitable music and stories about the POI, and at the same time, the courier has total control of the physical conditions of the cyclists by the heart rate data monitored from the system.

A web service is the main information management system, it include geographic location data, routes, POI and personal information. The data are massive and complicated to be accessed frequently during the trip. Thus, a compact version of the database is designed on each cyclists system, and the SQLite is the one installed in the cyclist’s system. The UTF-8 is the multi-languages support system to unify information transmission between each platform, it includes web and database access, Java script and some information exchanges mechanisms between systems.

A mobile device for cyclist digital system includes several functions such as using Google Map as the
geographical resources, using HTML as the access tool for
Google Map, using Qt4.6.2 to design GPS, multimedia, data
storage and communication network. All these functions
will be designed as an individual element and be exported to
the Webkit to be Java Script accessible resources.
Eventually, a unification of HTML, CSS and Java Script
functionalities is designed to be an Event-Based Navigation
and Healthcare System (EWS) as shown in Figure 5.

In Figure 5, we can see that EWS demonstrates a layer
structure mechanism. Design of EWS is based on Windows
XP, and Mobil devices by Qt. Several functions, including
Network, Data Storage, Media and Location sensing
systems are designed, and all these functions can be
exported to the WebKit. EWS provides mainly web service
and mobile devices. Web service is used to supply agents
and couriers to design tour and to manage members of the
tour. According to different purpose of the tour, either in
liberal visit or eco-environment observation, the planning of
routes, POI, multimedia service can all be exported to a tiny
data database and stored in the mobile device in each member
of the tour. In the following subsections, how to build up these
subsystems and their functionalities will be outlined.

4.1 System architecture of EWS
4.1.1 Environment of EWS
Development tool for web service: It is designed by ASP.net
and C# language is the tool to develop; Java Script and CSS
are used to do HTML information verification and
production.

Database for web service: MySQL is used as a back-end
database system to store important business management
material and necessary POI data. After the tour has been
decided, the necessary data will be accessed from MySQL
and saved in SQLite in each cyclists’ platform.

4.1.2 Platform of EWS
Development tool for Platform: Qt is a collection of
functions based on C++ language that contains the Webkit
for webpage analysis and perform system development by
Java Script.

Ad Hoc Network: Because 3G is not fully functioning yet,
an Ad Hoc network is used instead to supply cyclists
internet service; a heartbeat monitor belt is used to monitor
physical condition for cyclists; a broadcasting module for
courier is used to guide cyclists to travel on the right track.

4.1.3 Database of EWS
SQL schema: SQL schema is illustrated by the following
Figure 6. It includes title of the tour group, members, group
of the tour, participates information, position of interests,
routes, etc. At each field, some data definitions are defined
in the system, for example, in the field of ‘Recording’,
longitude (Long), latitude (LAT), height (High), date
(ParDate), time (ParTime), emergency (EmeEvent), video
logbook (VideoLog), music(Music), traffic monitor
condition (TMC), etc., are included.

SQLite schema: At each member of the tour, necessary data
from MySQL are downloaded to SQLite to reduce frequent
access information from main database, thus energy is
saved. A SQLite schema is given at Figure 7 for illustration.

4.2 System of EWS

Figure 5 Layer structure of EWS (see online version for colours)

Figure 6 SQL schema (see online version for colours)

Figure 7 A SQLite schema (see online version for colours)
In Figure 7, the field of ROAD\_TYPE is given for demonstration. It contains RSTN, TYPE and LEVEL, which are used to define and distinguish different road types, such as for sightseeing, recreation, mountain biking, speed tracking, etc. In addition, different level are marked by LEVEL, for the case when the road type is sightseeing, but if it is marked with ‘difficulty’ in LEVEL, that means the route for the sightseeing may be long and tough with several different elevation.

4.1.4 Software Objects

Application objects are the main body of EWS. They can provide operation and management for the application programmes in the system, which may include event notification, enlargement of the window and return to default values, and termination of the programme, etc.

Heart Object is the Bluetooth heart monitor belt, the communication pattern is by sequential transmission and data is organised by ASCII code. The Heart Object needs to be turn on and do data cutting procedure, eventually those observed data will be sent to Java Script handling procedure.

Database Object contains the final information about routes and POI, and will be exported to SQLite for cyclists. To let EWS can access and store the above information, ‘Database Object’ needs to do database assignment, opening, shutdown, and do SQL commands, etc.

Music Object is used to broadcast music to cyclists during the trip to relax and encourage cyclists’ emotion during the difficult part of the trip. ‘Music Object’ needs to have the functions of dynamic assigning music files and to initiate the music.

Camera Object is used to take photos or record video on any occasions during the trip.

GPS Object is designed to access correct geographical information, and need to calculate distance between any two positions.

Network Object is the information exchange system between courier and cyclists. It is operated by UDP and its purpose is to prevent any of the members depart from the group.

In the next section, we will outline how to operate these subsystems in the EWS in which functions defined in this subsection are contained.

5 Implementation of the EWS

5.1 Web service

In this section, we will describe the user interface of EWS and show how to operate the system. Because there is no simulation of the system yet, in the next section, two scenarios will be given for demonstration of EWS.

Assume the operation of EWS is managed and maintained by travel agents, the following Figure 8 illustrates the flow of web service of the travel agent, tour leader, tourists (cyclists) and their relations with EWS.

Figure 8 Operation flow of the web service (see online version for colours)

At first, the travel agent builds up the geographical area for the tours they mainly involve. They can design tour and routes they are interested and specialised according to the geographical area. On the basis of their specialty, they can maintain database of their customer and arrange their tour guilds according to different interest of the tourists. Design a few interesting routes for different kind of needs from tourists, and necessary information regarding to these routes can be saved in advance to the system. According to different tours they have managed before, customers and the routes arrangement involved in those tours can be saved in the system. Upon the selection of routes to fit for the current tourists’ needs is done, the system can export the history information to the EWS and can be taken as reference for better service. In Figure 9, a customers and route database is illustrated and some operations are demonstrated to operate the EWS.

Figure 9 Some user interface of the EWS (see online version for colours)
The operations of A, B and C stand for:
A  To modify the members’ information by pushing this button.
B  To show all the members in the window by pushing this button.
C  Information can be maintained in these columns.

5.2 Operation flow of EWS platform

According to Figure 5, the flow of operations for the mobile device EWS is illustrated, and is given in Figure 10.

**Figure 10** Operation flow for the EWS (see online version for colours)

The functionality of each operation shown in Figure 10 is described in the following:

**Step A:** It includes the operations of team member to record their GPS and heart rate data, the courier do the route planning and record GPS of POI along the route, at the same time, he/she also monitor team members’ physical situation by their heart rate record and geographically location by GPS.

**Step B:** The courier announces route information and export the route information obtained from the back-end server to his team members’ equipment.

**Step C:** In addition to the route information, some text explanation and pictures of POI are exported to team members’ equipment.

**Step D:** The courier will decide if the current position matches with GPS information of POI, and to decide to send correct text and pictures.

**Step E:** The courier can manually or automatically send pictures.

**Step F:** Every team member’s physical status, such as the heart rate will be exported to the courier equipment; at the same time, every member can also monitor the courier’s position from their equipment.

In the following paragraph, several figures of EWS are given for illustration of the operation of the system, they include the interfaces in the courier and the members’.

**For The Courier:** Figure 11 shows the EWS user interface for the courier. In Figure 12, the red line means the route planning for the tour shown in the courier’s interface. In Figure 13, ‘A’ includes items such as GPS information, elevation and satellite time, ‘B’ is the button to initiate GPS and ‘C’ is the button to tune off the GPS.

**Figure 11** The interface of the courier and its functionality (see online version for colours)

**Figure 12** A route (plot in RED) is defined on the courier’s interface (see online version for colours)

**Figure 13** A GPS data on the courier’s interface (see online version for colours)
For the Members: Figure 14 shows the information of the tour, a sample (Chug Hua University) CHU Test Route is shown in the Tourist’s interface, at the same time, the route planning shown in Figure 11 will also be announced in the cyclist’s interface. Along the tour, pictures of POI are demonstrated and cyclist’s location is recorded in the GPS object, some illustrations are shown in Figure 15.

Figure 14 Cyclist’s system and route planning on the system (plot in RED) (see online version for colours)

Figure 15 Member’s GPS information and pictures along the position of interest (see online version for colours)

6 Scenarios using EWS

To verify the feasibility of EWS, two scenarios are designed to show activities between modules of EWS, ‘Scenario 1’ is to plan a route and ‘Scenario 2’ is to trigger an event, respectively.

6.1 Scenario 1: planning a route and transferring to tourists

In this scenario, a courier and two tourists are assumed to form a GRC. There is a back-end server stored geographic information, route planning programme, attractions media, road conditions data and emergent contacts information. First, the courier demands a safe route from the server, and then broadcasts the route and related information received from the server to the tourists using multi-hop routing protocol. During the tour, each TOD calculates its GPS data, senses the heart rate and records images, then sends its location and pulse to COD. Figure 16 is the sequence diagram of this scenario, and details at each step are given as follows:

1. Courier requests some route information from server via 3G network module.
2. Server responds with the planned route, attractions and road conditions to COD.
3. COD sends the received information to participating TOD in the same Ad Hoc network.
4. Since some TODs cannot connect directly with the COD, communications between TODs uses the multi-hop facility to forward the message.
5. TOD sends its location and heart rate to COD.
6. Although this message starts with Step 5, the transmission range is not long enough to be transferred directly to COD.
7. TOD1 forwards the message received from TOD2 to COD.

Figure 16 Sequence diagram of Scenario 1

6.2 Scenario 2: Receiving and broadcasting attraction and road condition events

This scenario assumes that the tourists come across attractions or adverse road conditions during the tour. The GHS continuously receives the GPS signals, therefore when the present position matches the coordinates in the stored database, TOD triggers an event and shows the related information. Figure 17 describes the data flow between modules for scenario 2, and details of each step are given as follows:

Step 1: Coordinates of attraction, its multimedia data, and road condition information stored in the data access module are received from COD after the route planning stage.
Step 2: GPS module constantly receives GPS location and sends those data to the data access module.

Step 3: Data access module sends the received GPS information to the event trigger module.

Step 4: If the present position matches the attraction coordinates, COD displays the relative multimedia attraction information.

Figure 17 Data flow of Scenario 2

7 Concluding remarks

GRC is a popular leisure activity, and participants’ safety and health are the main considerations while carrying out such activities. In addition, providing interactive information during the tour is also an essential factor to attract tourists. In this study, we propose an event-based wireless navigation and healthcare cycling system (EWCS) via Ad Hoc Networks for GRC. There are two types of devices, Courier Onboard Device (COD) and Tourist Onboard Device (TOD). Both COD and TOD contain BOS, GPS and health watching subsystem; in addition, COD also contains a courier subsystem providing 3G network connecting ability. With EWCS, cyclists could plan a safe route, be warned in real time, watch the multimedia attraction guiding, track locations, and monitor heart rate. Structure and design of EWCS are outlined and some of the operations of EWCS are also demonstrated and some figures are given for illustration. Two scenarios to verify the feasibilities of EWCS are outlined. One is planning a route by courier, broadcasting route to tourists, tracking the tourists’ location and monitoring tourists’ heart pulse. Another is an event-based scenario, which is triggering an attraction event and displays the related multimedia. In the future, some simulation of applying EWCS in different kinds of routes could be carried out to demonstrate its feasibility and to show its effectiveness.

References


