Department of Electronic Engineering

FINAL YEAR PROJECT REPORT

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<PDA Application for Museum>

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Assessor: Dr. Anthony Fong

Bachelor of Engineering (Honours) in
Computer Engineering
Student Final Year Project Declaration

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Project Title:
PDA Application for Museum

Student Name: Yung Wing Chi, Pauline          Student ID:              
Signature                                      Date: 25 April, 2006

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# Table of Content

Acknowledgement 8
Abstract 9
1. Introduction 10

2. Background Studies 12
  2.1 Related Work 12
  2.2 Comparison between different exhibit information presented materials
    2.2.1 Text description under exhibit vs. PDA 13
    2.2.2 Tour Guide Expositors vs. PDA 13
    2.2.3 Cassette Tape Players vs. PDA 14
  2.3 Choosing PDA as presented device 14
    2.3.1 PDA vs. Tablet PC 15
    2.3.2 Smartphone vs. PDA 17
  2.4 Comparison of using Pocket PC and Palm 19
  2.5 Positioning Technique 20
    2.5.1 Infrared vs. Bluetooth and IEEE 802.11 series 21
    2.5.2 Infrared vs. GPS 22
    2.5.3 Infrared vs. Radio Frequency Identification 24
    2.5.4 Conclusion on choosing positioning technique 25
  2.6 IrDA Overview 25
    2.6.1 IrDA Stack Architecture 25
    2.6.2 IrDA Application Developments
      2.6.2.1 IrDA Programming with Raw IR 28
      2.6.2.2 IrDA programming with IrComm 28
      2.6.2.3 IrDA programming with IrSock 30
3. Methodology

3.1 Infrared Programming Interface

3.2 How does IrSock work?

3.3 Communication Approaches between exhibit and PDA

3.3.1 Active Substation and Passive PDA (ASPP)

3.3.2 Passive Substation and Active PDA (PSAP)

3.3.3 Compare ASPP and PSAP

3.3.4 Conclusion

3.4 Ways of retrieving information

3.4.1 Compare the advantages and disadvantages of the ways of retrieving information

3.4.2 Conclusion

3.5 Using Internet Explorer to display information

4. Result

4.1 Program Flow Chart

4.2 Program Interfaces

4.3 How does it work?

4.4 What will happen when two or more users come to the exhibit at the same time?

4.5 What will happen when the IrDA communication link between PDA and substation is broken?

4.6 Comment Page Management

5. Further Development

5.1 Develop an embedded IrDA transmitter device

5.2 Mobility Management
<table>
<thead>
<tr>
<th>Section</th>
<th>Page</th>
</tr>
</thead>
<tbody>
<tr>
<td>6. Conclusion</td>
<td>65</td>
</tr>
<tr>
<td>Reference</td>
<td>66</td>
</tr>
</tbody>
</table>
List of Figures

Fig. 2.3 Real user accessing the Questionnaire inside the Museum 15
Fig. 2.5.1 Case of visitor standing in the region between two exhibit items 22
Fig. 2.6.1a IrDA protocol layers 26
Fig 2.6.1b The way application communicates with IR port 27
Fig 3.2 IrDA Communication process between Server and Client 34
Fig 3.3.1 ASPP 36
Fig 3.3.2 PSAP 39
Fig 4.1a Client Side Program Flow Chart 46
Fig 4.1b Server Side Program Flow Chart 47
Fig 4.2a Museum Tour Guide Server Program Interface 49
Fig 4.2b Museum Tour Guide Server Program Interface – Open Socket 50
Fig 4.2c Museum Tour Guide Server Program Interface – Identified user and sent data 51
Fig 4.2d Museum Tour Guide Client Program Interface 51
Fig. 4.4 Server program showing when two users are discovered. 58
Fig 4.5a Server programming showing the status of retrying sending the information link 59
Fig 4.5b Server program showing three retrials failed 60
List of Tables

Table 2.2 Comparison between different exhibit information presented materials 13

Table 2.3.1 Comparison between PDA and Tablet PC 17

Table 2.3.2 Comparison between Smartphone and PDA 19

Table 2.4 Comparison between Pocket PC and Palm 20

Table 2.5.1 Comparing Infrared, Bluetooth and IEEE 802.11 series on positioning techniques 21

Table 2.5.2 Comparing Infrared with GPS on positioning techniques 23

Table 2.5.3 Comparison between Infrared and RFID tag on position technology 24

Table 3.1 Comparison on different infrared programming interface 31

Table 3.3.4 Summary on the advantages and disadvantages of ASPP and PAPP 43

Table 3.4.2 Comparing different information storing method 45

Table 4.3 How does the Museum Tour Guide Client program work? 57

Table 4.6 Managing the comment webpage 62
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I am in debt to my classmates and the technicians of Digital Signal Processing Laboratory the support, discussions as well as sharing of the application experience in carrying out the work successfully.
Abstract

The idea of my Final Year Project is to develop a flexible, interactive and multimedia museum tour guide system on Personal Digital Assistant, PDA for providing map information, user comment area, special events announcement, assisting function and exhibit text, picture, audio and video description to visitors. Each substation identifies the visitors’ positions, when they travel throughout showpieces with PDAs, and the PDA downloads corresponding details from wireless network. Therefore visitors can get the relative multimedia information of the exhibit which they are gazing at automatically. It is in contrast with the conventional cassette audio tape exhibition tours. The project focuses on designing the ASPP communication protocol between PDA and exhibit substation, developing client and server programs, constructing information website for mobile devices and handling infrared communication.
1. Introduction

Educational activities were no longer limited to the traditional classroom. Visiting museum is one of the alternative choices [1]. People can go to museum with their relatives, friends or by their own.

When they get into the museum, they may follow the guidebook and the description under the exhibits, borrow cassette tape tour or join a tour group to enjoy their museum journey. However, they may find they cannot really enjoy themselves, for examples, they could not read the description under the exhibit from beginning to the end since there is a disturbing guy moving in front of them; they could never finish an interesting video as there is a child playing with it; they find the scheduled tour was full or they were late for the current one; they had waited until the next tour was scheduled, and then found themselves being hustled from one stop to the next; they want to ask more about the exhibit or they want to comment it but they find there is no place for them to do so.

To overcome the above problems, this project is developed to provide a smart learning environment for the visitor to learn individually or in a group. This museum guide application system is an active exhibit information teller which provides details information in visitors’ favours. The system is composed of a server with a wireless network, an IrDA substation and a Pocket PC [2].

Visitors are supposed to rent a Pocket PC or use their own under the system. Once the visitor comes to an exhibit, his/her PDA will retrieve the related information of the exhibition automatically from the internet through the wireless network in response to the received infrared signal from the exhibit. The information display is making use of the feature of Hyper Text Mark-up Language and Hypertext Pre-processor, HTML and PHP, which support texts, graphics, audios, videos and other learning hyperlinks together.
With the use of ad-hoc networks and handheld PDA devices, the exhibit information is interactively and flexibly presented to the visitors. With this manner, both the efficiency and the satisfaction dimensions of the system usability are increased. It can also provide the appropriate amount of impetus to foster visitors’ learning and self-development so as to create a richer and more meaningful experience.
2. Background Studies

2.1 Related Work

To provide an interactive, multimedia and tailor-made tour guide system, appropriate
devices, effective positioning technique and information retrieval method play an important
role. Currently, different kind of interactive tour guide ideas are introduced into museums;
their differences are mainly on choosing the devices and positioning protocols, like
museum tour guide system with tablet PC [3] or with the use of Palm and GPS [10].
In the following sections, various devices and positioning protocol would be discussed.

2.2 Comparison between different exhibit information presented materials

<table>
<thead>
<tr>
<th></th>
<th>Text descriptions</th>
<th>Tour Guide Expositors</th>
<th>Cassette Tape Players</th>
<th>PDA</th>
</tr>
</thead>
<tbody>
<tr>
<td>Initial Setup time</td>
<td>Long</td>
<td>Long</td>
<td>Short</td>
<td>Short</td>
</tr>
<tr>
<td>Implementation Cost</td>
<td>Low</td>
<td>High</td>
<td>Low</td>
<td>Medium</td>
</tr>
<tr>
<td>Long-term expenses</td>
<td>Low</td>
<td>High</td>
<td>Low</td>
<td>Low</td>
</tr>
<tr>
<td>Time spent on modifying the information content</td>
<td>High</td>
<td>High</td>
<td>High</td>
<td>Low</td>
</tr>
<tr>
<td>Costs spent on modifying the information content</td>
<td>High</td>
<td>High</td>
<td>Medium</td>
<td>Low</td>
</tr>
<tr>
<td>Content integrity</td>
<td>Low</td>
<td>High</td>
<td>Low</td>
<td>High</td>
</tr>
<tr>
<td>Available to blind</td>
<td>No</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
</tr>
<tr>
<td>Available to deaf</td>
<td>Yes</td>
<td>Not good</td>
<td>No</td>
<td>Yes</td>
</tr>
<tr>
<td>Multilingual</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
</tr>
<tr>
<td>Freedom of moving</td>
<td>No</td>
<td>Low</td>
<td>Low</td>
<td>High</td>
</tr>
</tbody>
</table>
2.2.1 Text description under exhibit vs. PDA

Once the information written under an exhibit was set up, it is difficult to be modified or updated. And the modification cost will be relatively high comparing with that of PDA. The amount of information shown will also be limited. The areas for placing the text descriptions are limited, not all the information can be written into it, therefore, the content integrity will be lower then that displayed in PDA.

Since the location of text description is fixed, if the exhibit is crowded of people, visitors may not able to read it. However, with the use of PDA, visitors can refer the description by retrieving information from network and they can read the information individually. It also takes an advantage in the case that when visitors want to refer or read again their previously seen exhibit information, there is no need to go back to the exhibit again.

2.2.2 Tour Guide Expositors vs. PDA

Tour Guide Expositors are museum touring service commonly provided. Expositors are good for the visitors to fully understand the exhibits by asking questions. It is more interactive than that presented in texts or audio players. In this area, PDA can also do this interactively by a visitors’ comment area. Visitors are allowed to post their comment or questions on the web and it would be answered or replied.
However, the costs of educating the skilled expositors and arranging the tour are high by comparing with the other systems (see Table 2.2). And it is not flexible enough for the visitors to join as the scheduled time may not be appropriate for the visitors. Even that the visitors join one, they may find themselves being hustled from one stop to the next. They cannot enjoy the tour flexibly.

With the use of PDA, they can plan their journey by their own. Since the information is retrieved according to their positions, they are not need to follow a fixed routine like joining the tour. And they can read or ask at any time they want with PDA. It provides a smart and flexible learning environment for the visitors.

### 2.2.3 Cassette Tape Players vs. PDA

The use of conventional cassette tape players seem to be cheaper in Table 2.2, but the storage capacity and the way information presented are limited. For the visitor to use, they may find the players are too big and too heavy to carry around. Not to mention that they are lack of interaction ability.

As a result, the above inconveniences bring about the motivation to develop a museum tour guide system based on handheld devices and wireless technologies.

By comparing different tour guide system in various areas, PDA is the most favourable choice to overcome the old-fashion side effects. The results are summarised in Table 2.2.

### 2.3 Choosing PDA as presented device

According to Canalys Consulting Limited report [5], the worldwide market labels smart mobile devices, including Palm, Pocket PC, wireless handhelds and Smartphones, grew by 55 per cent during the first quarter of 2006 compared to the same period a year ago. It is popular to use handheld device in our daily life as it is easy to carry, multifunctional and large
computation capability. Therefore, they are considered as the device presenting the exhibit information. Followings sections compares different handheld devices to find the best for implementing our system.

2.3.1 PDA vs. Tablet PC

Some papers and research [3][4] may suggest using Tablet PC as the mobile touring device since the size of screen is larger than that of PDA, more information can be shown in one page. However, as the size of Tablet PC screen is larger than that of PDA, the size and the weight of Tablet PC is also larger and heavier. It is not appropriate for visitors to carry from site to site (See Fig. 2.3).

Some may claim the computation power of Tablet PC is better than that of PDA. As the power of storage, computation, and display technologies grow rapidly nowadays, PDA became more functional and suitable to play the role of mobile platforms for multimedia applications. It can fully support flash, mp3, mpeg, wmv, avi, texts, graphics and so forth. It is enough for exhibit information to be well presented in PDA.

Another feature of PDA is more favourable to be adopted in the tour guide system is that, no matter when the visitors shut down their PDAs, the programs and pages which are

Fig. 2.3 Real user accessing the Questionnaire inside the Museum [3]
previously opened will stay until the next time the visitors switch on the PDA. It is more easy and convenient for the visitors to use the touring guide system.
<table>
<thead>
<tr>
<th>Comparison</th>
<th>PDA</th>
<th>Tablet PC</th>
</tr>
</thead>
<tbody>
<tr>
<td>Size</td>
<td>Handheld size</td>
<td>Large for mobile carrying</td>
</tr>
<tr>
<td>Weight</td>
<td>Light</td>
<td>Heavy</td>
</tr>
<tr>
<td>Size of screen</td>
<td>Small</td>
<td>Large</td>
</tr>
<tr>
<td>Computation power</td>
<td>Medium</td>
<td>High</td>
</tr>
<tr>
<td>Cost</td>
<td>Medium</td>
<td>High</td>
</tr>
<tr>
<td>Popularity</td>
<td>High</td>
<td>Low</td>
</tr>
<tr>
<td>Convenience</td>
<td>1. Time is required to start-up</td>
<td>1. Once PDA is powered on, it can be used</td>
</tr>
<tr>
<td></td>
<td>2. Programs are closed once tablet PC is shut down</td>
<td>2. Status is not changed whenever the PDA is shut down</td>
</tr>
<tr>
<td></td>
<td>3. Not all the visitors can hold it by one hand</td>
<td>3. Visitors are able to hold by one hand</td>
</tr>
</tbody>
</table>

Table 2.3.1 Comparison between PDA and Tablet PC

### 2.3.2 Smartphone vs. PDA

Implementing the tour guide system in Smartphone is an alternative choice. Currently some Smartphone with Wi-Fi function are introduced. However, their prices are much higher and it is not common in use and if it is introduce in our system, most of the visitors have to borrow it from the counter.
Alternatively, Smartphone can retrieve the information through GPRS and 3G. For those using GPRS, since the bandwidth is not broad enough to transmit pictures or even video smoothly, it is not recommended to be used in this system. For those using 3G, multimedia performance would be better with 3G communication, however, the cost of this protocol is relatively high. It is not appropriate to be implemented in this system.

Besides, this system supports visitors to leave their questions or message in the visitors’ comment area; it is more convenient for them to input their message with PDA rather than Smartphone. (See Table 2.3.2)

<table>
<thead>
<tr>
<th></th>
<th>Smartphone</th>
<th>PDA</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Processing Speed</strong></td>
<td>Slow</td>
<td>Fast</td>
</tr>
<tr>
<td><strong>Size of Memory</strong></td>
<td>Small but some are extensible</td>
<td>Large and most are extensible</td>
</tr>
<tr>
<td><strong>Size of Screen</strong></td>
<td>Small; Number of lines has to be displayed more than one screen</td>
<td>Medium; Number of lines can be displayed with one screen</td>
</tr>
<tr>
<td><strong>Touch Screen</strong></td>
<td>Rare</td>
<td>Majority</td>
</tr>
<tr>
<td><strong>Convenient of data entry</strong></td>
<td>Low ( Input device is limited on Num-pad)</td>
<td>Medium ( Input device can be writing recognition, screen keyboard and peripheral keyboard device )</td>
</tr>
<tr>
<td><strong>Interface</strong></td>
<td>Vertical scroll menu is used to control all items</td>
<td>Buttons, scroll bars, list boxes, check boxes and</td>
</tr>
</tbody>
</table>
various GUI components are available

<table>
<thead>
<tr>
<th>Support</th>
<th>Smartphone</th>
<th>PDA</th>
</tr>
</thead>
<tbody>
<tr>
<td>IrDA</td>
<td>Most</td>
<td>Most</td>
</tr>
<tr>
<td>Bluetooth</td>
<td>Some</td>
<td>Most</td>
</tr>
<tr>
<td>Wi-Fi</td>
<td>Rare</td>
<td>Most</td>
</tr>
<tr>
<td>GPRS</td>
<td>Most</td>
<td>Rare</td>
</tr>
<tr>
<td>3G</td>
<td>Some</td>
<td>Rare</td>
</tr>
</tbody>
</table>

Table 2.3.2 Comparison between Smartphone and PDA

### 2.4 Comparison of using Pocket PC and Palm

In the PDA market, it is mainly occupied by Palm and Pocket PC. The most significant difference between Pocket PC and Palm is Palm use Palm OS as operating system while Pocket PC use Microsoft Windows Mobile or named as Microsoft Windows CE operating system. With the comparison of Pocket PC and Palm in Table 2.4 below, Pocket PC would be the best device for this tour guide system.

Firstly, since the operating system used in Pocket PC is Windows series, the platform and the interface is similar to that commonly used in PC, most of the people are familiar and easier to cope with it.

Secondary, it is very important to prevent data loss in the PDA when battery power is low or running out. There is a low battery warning only with the Pocket PC, that is highly reduced the chance of losing data. Furthermore, Pocket PC is fully backup the utilities into a backup file which can be used to recover a crashed Pocket PC.

Last but not least, Pocket PC supports multitasking which Palm does not support. It is an essential criterion in this tour guide system, as the tour guide system is running with web
browser to display relevant information. And visitors should be allowed to leave their message when the tour guide client program is running at the background.

<table>
<thead>
<tr>
<th>Feature</th>
<th>Pocket PC</th>
<th>Palm</th>
</tr>
</thead>
<tbody>
<tr>
<td>Back-up battery</td>
<td>Yes</td>
<td>No</td>
</tr>
<tr>
<td>Memory card slot</td>
<td>Yes</td>
<td>Yes for some</td>
</tr>
<tr>
<td>Support IrDA</td>
<td>Yes</td>
<td>Yes</td>
</tr>
<tr>
<td>Support Bluetooth</td>
<td>Most</td>
<td>Some</td>
</tr>
<tr>
<td>Support Wi-Fi</td>
<td>Yes for some</td>
<td>Yes for some</td>
</tr>
<tr>
<td>Multitasking</td>
<td>Yes</td>
<td>No</td>
</tr>
</tbody>
</table>

Table 2.4 Comparison between Pocket PC and Palm

2.5 Positioning Technique

The automatic exhibit details display is the important part of the museum guiding application. The point of this service is to tell visitor automatically where they are and what they are gazing at. To do this, the PDA requires knowing where it is and the application should involve an accurate positioning mechanism.

Wireless signal could help in defining the coordination of the PDA’s location, the name and the number representing the exhibit. There are several wireless positioning techniques could be chosen including infrared transmission, Bluetooth, IEEE 802.11 series, RFID and Global Position System (GPS). A comparison tables are done based on the needs of the automatic tour guide system that is shown from Table 2.5.1 to Table 2.5.3 below.
### 2.5.1 Infrared vs. Bluetooth and IEEE 802.11 series

<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Best apply to</strong></td>
<td>Pico area</td>
<td>Micro area</td>
<td>Micro area</td>
</tr>
<tr>
<td><strong>Effective Range</strong></td>
<td>Around 1 meter, Max. 30 degree</td>
<td>Around 10 meter</td>
<td>Around 83 to 132 meter</td>
</tr>
<tr>
<td><strong>Indoor Location Identification</strong></td>
<td>High</td>
<td>Low</td>
<td>Low</td>
</tr>
<tr>
<td><strong>Directional Signalling</strong></td>
<td>Yes</td>
<td>No</td>
<td>No</td>
</tr>
<tr>
<td><strong>Transfer Data Rate</strong></td>
<td>Up to 4Mbps</td>
<td>Up to 2.1 Mbps</td>
<td>Around 10 Mbps under ideal conditions</td>
</tr>
<tr>
<td><strong>Power consuming in user-end</strong></td>
<td>Low</td>
<td>High</td>
<td>High</td>
</tr>
<tr>
<td><strong>Implementation cost</strong></td>
<td>Low</td>
<td>Medium</td>
<td>High</td>
</tr>
<tr>
<td><strong>Practical utilization</strong></td>
<td>High</td>
<td>Low</td>
<td>Low</td>
</tr>
</tbody>
</table>

Table 2.5.1 Comparing Infrared, Bluetooth and IEEE 802.11 series on positioning techniques

In this application, accuracy plays an important role. Exhibits in most of the museum are put close to each other. In the case of using Bluetooth and IEEE 802.11 series technology, a great risk on long error distance on positioning would be suffered. Since both of the
technologies have wide signalling emitting range properties, if they are applied to the touring guide system, the page on the PDA will swap between two adjacent exhibits (See Fig. 2.5.1).

When visitor x comes in between the region of item 1 and 2, both of the items will identify it as in their region and ready to send their information to it. In the case in Fig. 2.5.1, if the visitor is gazing at item 2 and its ID name is detected and is put into item both 1 and 2’s ready to send device lists, according to the lists, visitor x will initially receive item 2’s information and then it will receive a new information sent by item 1 in a short period. The new loaded page will be a wrong one for the visitor. In the second round of detection, if item 2 finds the information page shown in visitor x’s PDA is not the correct one, it will send its information to visitor again, and the location detection and information retrieval will repeat again and again in case of visitor x is still staying there.
With the use of Infrared, due to its short range transmission, probability of forming overlap region is relatively low.

Furthermore, the management and maintenance of the system should be kept simple, so that the special training or requirement of manager’s background knowledge is excluded and minimized. In this area, infrared protocol would be the best choice. While implementing the infrared protocol to position the manager, the manager is only need to mark each exhibit with a unique identifier. However, if Bluetooth or IEEE 802.11 series is implemented, the manager has to find out the unique number embedded in every access points, AP, since AP must be set at every exhibit for the PDA to recognize them. It is not only brings up the cost on planting APs to every exhibit but also makes the job complicated. Therefore Bluetooth and IEEE 802.11 series are not good for this guiding system.

2.5.2 Infrared vs. GPS

<table>
<thead>
<tr>
<th></th>
<th>Infrared [12][13]</th>
<th>GPS</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Best apply to</strong></td>
<td>Pico area</td>
<td>Wide area</td>
</tr>
<tr>
<td><strong>Effective Range</strong></td>
<td>Around 1 meter, Max. 30 degree</td>
<td>Up to 6 miles</td>
</tr>
<tr>
<td><strong>Indoor Location Identification</strong></td>
<td>High</td>
<td>Low</td>
</tr>
<tr>
<td><strong>Directional Signalling</strong></td>
<td>Yes</td>
<td>Yes</td>
</tr>
<tr>
<td><strong>Transfer Data Rate</strong></td>
<td>Up to 4Mbps</td>
<td>Up to 400 Mbps</td>
</tr>
<tr>
<td><strong>Power consuming in user-end</strong></td>
<td>Low</td>
<td>High</td>
</tr>
<tr>
<td><strong>Implementation cost</strong></td>
<td>Low</td>
<td>High</td>
</tr>
<tr>
<td><strong>Practical utilization</strong></td>
<td>High</td>
<td>Low</td>
</tr>
</tbody>
</table>

Table 2.5.2 Comparing Infrared with GPS on positioning techniques
GPS is widely employed in locating one’s location on the world. And some of the Pocket PC is implemented with this function. However, it was also not good to be introduced to the system as it has great error probability especially implemented in indoor.

On the positioning accuracy issue, infrared transmission technology shows its virtues. The benefits of infrared are not only the short error probability, but also the controllable emitting direction as it is a wireless point-to-point networking.

2.5.3 Infrared vs. Radio Frequency Identification

<table>
<thead>
<tr>
<th></th>
<th>Infrared</th>
<th>RFID tag</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>[12][13]</td>
<td>[7]</td>
</tr>
<tr>
<td>Best apply to</td>
<td>Pico area</td>
<td>Micro area</td>
</tr>
<tr>
<td>Effective Range</td>
<td>Around 1 meter, Max. 30 degree</td>
<td>Up to 1 meter</td>
</tr>
<tr>
<td>Indoor Location Identification</td>
<td>High</td>
<td>High</td>
</tr>
<tr>
<td>Directional Signalling</td>
<td>Yes</td>
<td>No</td>
</tr>
<tr>
<td>Transfer Data Rate</td>
<td>Up to 4Mbps</td>
<td>Up to 100Kbps</td>
</tr>
<tr>
<td>Power consuming in user-end</td>
<td>Low</td>
<td>Low</td>
</tr>
<tr>
<td>Implementation cost</td>
<td>Low</td>
<td>Medium</td>
</tr>
<tr>
<td>Practical utilization</td>
<td>High</td>
<td>Low</td>
</tr>
</tbody>
</table>

Table 2.5.3 Comparison between Infrared and RFID tag on position technology

RFID technology becomes more popular and imperative to be used in positioning. However, the majority of PDA does not include this technology. Using RFID would be quite expensive indeed if specified devices are introduced.

However, the infrared devices are commonly found from some desktop computers and many portable devices, for example, PDAs and mobile phones. And the costs of setting up
the infrared network are low. Therefore, the implementation of the whole museum guiding system can be minimized.

2.5.4 Conclusion on choosing positioning technique

To sum up, infrared transmission protocol is good fit in this system comes to several primary specialties it owns. The first reason is its short error probability and its controllable emitting direction. The second one is the low long term used cost to make every exhibit be locatable. The final one is it is simple to maintain.

2.6 IrDA Overview

Many infrared devices have an infrared port compliant with the Infrared Data Association (IrDA). The IrDA specifies standards for hardware specifications and software protocols. Many Windows CE-based infrared devices support IrDA-compliant stack that enables two IR devices to communicate with each other [14].

2.6.1 IrDA Stack Architecture

IrDA communications protocols deal with many issues, and so are generally divided into several layers [16], each of which handles with a manageable set of responsibilities and supplies needed capabilities to the layers above and below. When the layers are placed on top of each other, a protocol stack is got. An IrDA protocol stack is the layered set of protocols particularly aimed at point-to-point infrared communications and the applications needed in that environment. The IrDA protocol layers structure is shown in Fig 2.6.1a.
From the Fig 2.6.1a, different layers support different functions as follow [15]:

- **Physical Layer**: Specifies optical characteristics, encoding of data, and framing for various speeds.
- **IrLAP**: Link Access Protocol which establishes the basic reliable connection.
- **IrLMP**: Link Management Protocol which supports multiplexes services and applications on the LAP connection.
- **IAS**: Information Access Service which provides a “yellow pages” of services on a device.
- **TinyTP**: Tiny Transport Protocol which adds per-channel flow control to keep things moving smoothly. This is a very important function and is required in many cases.
- **IrOBEX**: The Object Exchange protocol. Easy transfer of files and other data objects
- **IrCOMM**: Serial and Parallel Port emulation, enabling existing applications that use serial and parallel communications to use IR without change.
- **IrLAN**: Local Area Network access which enables walk-up IR LAN access for laptops and other devices.

When the stack layers are integrated, the application communicates with an IR port in the
following manner which shown in Fig.2.6.1b.

![Diagram showing the way application communicates with IR port]

**Fig 2.6.1b** The way application communicates with IR port

### 2.6.2 IrDA Application Developments

Microsoft Windows CE or above operating system supports an Infrared Data Association (IrDA)-compliant stack that enables two IR devices to communicate with each other. The IrDA specifies standards for hardware specifications and software protocols.

There are three options for implementing IR communications [14][17]:

- Raw infrared (raw IR)
- IrCOMM
- Infrared Sockets (IrSock)
3.4.1.1 IrDA Programming with Raw IR

Raw IR access is only available on devices that expose the IR hardware as a serial port. Using raw IR, the IR adapter is connected to a COM port such as COM1 or COM2 and these ports can be accessed as usual using serial communication APIs [15].

By using this non-IrDA-compliant method, which does not use the Microsoft Windows CE-provided IrDA stack, programmer can control the entire sequence of the data flow. However, the application cannot benefit from the functionality provided by the stack. For example, it is possible for signal collisions to occur between devices during a data exchange. Also, it is possible to lose data when the infrared beam is broken, such as when someone walks between the two devices. Moreover, no handshaking and discovery are provided during the communication. Extra care should be taken on detecting and handling these error conditions. [17]
2.6.2.2 IrDA programming with IrComm

IrComm programming interface works with the IrCOMM layer, which is at the top of the IrDA protocol stack and provides an emulation of a device connected via a serial or parallel port [17]. Legacy applications proceed to work the same way in communicating with the devices through the same APIs without knowing that it is actually the IrDA protocol stack that is put to operation. By this way, older applications are made to make use of the latest and efficient means of communications available.

The IrComm emulates the RS-232 serial ports and the Centronics parallel interface port [17]. When an application writes to a COM port, IrComm stands midway and uses the services of the IrDA protocol stack to perform the required communication with the IR device. The state changes occurring at the serial port are converted into messages suitable to the underlying protocol and transmitted to the other device connected to it through IR. The IrDA protocols provide full flow control between the two devices in action.

However, since IrComm runs on top of a reliable protocol layer and the session establishment and release services are not exposed through the serial API, IrDA connection would be broken and re-established without the event being communicated to the application through serial API.

Another limitation of IrComm is that multiple servers cannot concurrently listen for incoming connections, which means only two devices can be connected simultaneously using IrComm.
2.6.2.3 IrDA programming with IrSock

IrSock is an extension of Winsock. It is essentially a socket-like API built over the top of the IrDA stack used for infrared communication. IrSock is the only high-level programming interface to the IrDA stack.

The usage of IrSock is similar to that of Winsock. The major differences are IrSock does not support datagram [16], it does not support security, and the method used for addressing it is completely different from that used for WinSock. Besides, IrSock does provide method to query the devices which are ready to talk across the infrared port, as well as arbitration and collision detection and control [17].
3. Methodology

3.1 Infrared Programming Interface

To implement infrared programming interface, Raw IR, IrComm and IrSock can be taken into consideration.

<table>
<thead>
<tr>
<th></th>
<th>Raw IR</th>
<th>IrComm</th>
<th>IrSock</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Platform</strong></td>
<td>Support only Windows CE</td>
<td>Support Windows CE or above, but Not</td>
<td>Support Windows CE, Windows 98 or</td>
</tr>
<tr>
<td></td>
<td>series</td>
<td>support Windows 2000 or above</td>
<td>above in Programming Model</td>
</tr>
<tr>
<td></td>
<td></td>
<td>IrComm programming Model</td>
<td></td>
</tr>
<tr>
<td><strong>Collision Handling</strong></td>
<td>No</td>
<td>Yes</td>
<td>Yes</td>
</tr>
<tr>
<td><strong>Signal interrupt</strong></td>
<td>No</td>
<td>Yes</td>
<td>Yes</td>
</tr>
<tr>
<td><strong>Handling</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Detect remote devices</strong></td>
<td>No</td>
<td>Yes</td>
<td>Yes</td>
</tr>
<tr>
<td><strong>Support multiple</strong></td>
<td>No</td>
<td>No</td>
<td>Yes</td>
</tr>
<tr>
<td><strong>programs simultaneously</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Table 3.1 Comparison on different infrared programming interface
By comparing the differences between the three programming interfaces (See Table 3.1), IrSock must be the most suitable one for this tour guide system.

In the tour guide system, infrared plays the role of identifying visitors’ location and transferring data. There may be more than one visitor staying in front of the infrared transmitter. The infrared transmitter must be able to detect more than one remote device.

Besides, Raw IR does not deal with data collision and signal interrupt, problems will be raised in some cases, for example, when visitor A is suddenly blocked by visitor B, the connection between visitor A and the exhibit infrared device is broken and no re-establishment will be made. The unreliable connection will dissatisfy visitors.

Therefore, Raw IR is not suitable for this system.

Regarding IrComm, it runs on top of a reliable protocol layer, but session establishment and release services are not exposed through the serial API. Also, since the underlying IrDA connection can be broken and re-established without the event being communicated to the application through the serial API, IrComm is not a reliable protocol in this system use.

Also, the virtual serial port provide by IrComm cannot be shared by multiple applications. This condition is particularly troublesome in many situations. For example, if a visitor use his/her own PDA with an IrComm-based application which opens the single virtual serial port and holds it open until system shutdown, the virtual serial port is unavailable for the data transmission from the exhibit infrared device.

Unfortunately, the fundamental limitation of the IrCOMM protocol, which is that multiple servers cannot concurrently listen for incoming connections, is still exposed in this implementation. If one application is listening for incoming IrComm connections and another application, which is trying to do, will get an error from Windows Sockets.
To contrast the points discussed above, as IrSock can buffer the data and re-establish the link when interrupt occurs, detect the remote devices, handle data collision and allow multiple applications run at the same time in a device, it is appreciably to be used as location identification and data transmission.

3.2 How does IrSock work?

IrSock is socket-like API developed over the top of the IrDA stack. With the use of IrSock, IrDA devices can implement a Windows Sockets client, server, or both. The terms client and server refer only to the device that initiates the connection; once a connection is established, data can be reliably exchanged in both directions. Since server-side functionality requires a bit more functions of IrDA stack, it is anticipated that Windows will often host the server. The connection can be driven from a user-initiated action, or can be the result of discovering a device in a discovery polling loop. Applications are not constrained in their implementation of client or server roles, or in connection establishment. Both of the client and server sides can close a connection, although this is generally coordinated by application-level protocols. A receiver receives all data sent to Windows Sockets by the peer application before it receives notification of the peer connection closure. If the connection aborts, both sides of the connection receive an error through Windows Sockets. As such, it is always possible to differentiate between graceful and abortive closes. Multiple server applications can be waiting concurrently for incoming connections without interfering with one another.
From Fig 3.2, the connection is initiated by creating a raw socket, which is a socket that interacts with the IP layer of the TCP/IP protocol. It is used to send an echo request to other servers, in the process known as pinging.

On the server side, after the sockets are created, it will bind the socket to an address and then places the socket into listen mode, so that it will accept incoming communication attempts.

For the client, things are different. Instead of binding the address and being ready to accept the connection, the client simply connects to a known server.

Once both the server and client have socket handles, they are able to send or receive data. The Windows Sockets send and recv function calls translate into TinyTP send receive
functions. Even though IrLAP is half-duplex, the IrDA application is not aware of that limitation. The send and recv functions can be called at the same time, on the same connection on two different threads.

The IrDA stack manages TinyTP credits on behalf of the application. When the peer stops issuing the TinyTP credits, the sender would block with the send function. In a non-Windows device, it must issue TinyTP credits as it can consume new data. Windows stops issuing credits when the receiver stops calling the recv function to consume data.

An IrSock application can send a large buffer of data on a send function call and the IrDA stack will segment it when there is a need. Applications will get substantially higher performance if they pass in at least 8 kB of data on a single send function call. [14]

With the Winsock, IrDA supports data stream semantics, which means any notion of message boundaries is not preserved. Application usually adds a length field to the head of messages to pass message boundary information to a peer.

After everything is finished, both sides socket have to be closed to shut down the connection between them. On condition that the peer calls again the recv function when the other side socket is closed, it issues returns with a length of zero, indicating a normal socket close. Any error that prevents data from being correctly sent will result in a Windows Socket error. And that will return to the application.

### 3.3 Communication Approaches between exhibit and PDA

There are two approaches for the exhibit to communicate the PDA. The aims of these approaches are to identify the position of the PDA automatically and periodically. They are
called “Active Substation and Passive PDA” (ASPP) and “Passive Substation and Active PDA” (PSAP).

There are pre-defined conditions with these two approaches.

1. There will be a computer with an unique IrDA device in each exhibit. They are called substations.
2. IrDA is embedded in each PDA. Users brought along with the PDAs to retrieve information through Wi-Fi within the exhibition.

### 3.3.1 Active Substation and Passive PDA (ASPP)

In ASPP, the location identification is the responsibility of the substation. Once the system starts, each substation will search for those nearby detectable PDA. A device list is created by the substation. The device list is then stored in the substation for further use. It will send data packets, which contains the information about the exhibit, to the PDAs which are stored in the device list one by one.

When each PDA receives the data packets, it retrieves the corresponding information and displays it to the visitor.

After a short period of time, each substation will search again those nearby detectable PDAs. All the discovered PDAs are updated to the substation device list. By comparing the updated device list and the device list obtained in the previous round, the substations can easily find out those PDAs which are just arrived. The substations then send the data packets to the newly found PDAs one by one. The ASPP approach is illustrated with different scenarios in Fig 3.3.1
Scenario 1 – Only PDA Apple is walking from position 1 to 2.

When a substation searches for nearby PDAs, the device list with Apple’s device ID is created. Since the device list in the previous round does not contain Apple’s device ID, the substation notices that Apple has just entered region A. It sends the data packets to Apple. If the substation also finds other PDAs which are newly arrived, it will also send the data packets to them one by one. After Apple receives it, it retrieves and updates the information about exhibition A.

Scenario 2 – PDA Apple is already in region A and PDA Baby just enters the region A

(PDA Baby moves from position 1 to 2)
When a substation searches for nearby PDA in range, the device list with Apple’s and Baby’s device IDs is returned. Since the device list in the previous round contains Apple’s device ID, the substation will send the data packet to Apple again in the updated device list. Moreover, the substation notice that Baby is just enter region B. It then sends data packets to Apple like Scenario 1 does. The operation done by Baby is similar to the operation to Apple in Scenario 1. It will update the information of the exhibition A.

Scenario 3—PDA Apple moved from position 2 to 3 (Overlapped region)

On one hand, when substation A searches for PDA in range, a device list with Apple and Baby is returned. Since the device list in the previous round stored in substation A contains both Apple’s and Baby’s device ID, the substation will not send again to both of them in the update device list.

On the other hand, when substation B searches for PDA in range, a device list with Apple A is returned. Since the device list in the previous round stored in substation B does not contain Apple’s device ID, the substation will send the data packets to Apple like scenario 1. Apple will check and update the information of the exhibit like that in scenario 1.

After the above actions, Apple will show the information of showpiece B instead of showpiece A. In case that the user is still looking at showpiece A, the system has to provided a backward function so that the user can view the information of the showpiece A without any physical movement.

3.3.2 Passive Substation and Active PDA (PSAP)

In this approach, the location detection is the responsibility of the PDA instead of the substation. The PDA periodically checks for substations in range. If it finds any, it will
request the detected substation to send data packets containing the exhibit information. The device list is then stored at the PDA.

After that, it retrieves the information from the data packets. After a short period of time, it checks for those nearby substations. When the updated device list is returned, it will compare the updated list with the previous stored substation list and find out if there is any newly discovered substation. If it does, it will request the substation to send data packets. In cases of several substations are newly discovered, the PDA will request one of the stations to send the data packets. It may choose according to the order of the device list.

The approach is illustrated under different scenarios with the Fig 3.3.2

---

**Fig 3.3.2 PSAP**

Number 1 to 4: Movement of the PDA Cat

*Scenario 1 – PDA Cat move from position 1 to 2*

PDA Cat detects the nearby substations. An updated device list with substation C is returned. Cat checks if the device ID of substation C exists in the device list of the previous
round. If it does, it will request substation C to send the data packets with information about the exhibit to it.

Once received, it will retrieve the exhibit information from the data packets. If the substation is already displayed in the previous device list, it will not send to the substation again.

Scenario 2 – Cat move from position 2 to 3 (overlapped region)

After searching for the nearby substations, an updated device list with both substations C and D is returned to Cat. It then check with the previous device list, which already contains device ID of substation C. Cat discovers that it may move to location D. Thus, it request substation D to send data packets to update the information of the exhibit. Similar to ASPP, the program has to provide backward function so that the user can choose to view information of substation C if necessary.

Scenario 3 – Cat move from position 3 to 4 (exit overlapped region)

After searching for substations in range, an updated device list substations D is returned to Cat. The device list of previous round stored in Cat contains the device ID of both C and D. Comparing with the updated device list, Cat notices that it has completed entering the region of D, thus it request substation D to resend the data packets in order to prevent data inconsistency. Finally it retrieves the exhibit information from the data packets.

3.3.3 Compare ASPP and PSAP

ASPP and PSAP is compared in the following disciplines,

1. Complexity of location management of the PDA
2. Workload of PDA
3. Time delay

4. Complexity of device identification

1. Complexity of location management of the PDA

   The location management of ASPP is done by substations while that of PSAP is done by PDA. The substations in ASPP can connect together and share the device list. It is then easily to find out the instant location of the PDA and the majority movement of the PDA.

   As the device list is stored in the PDA in PSAP, it is difficult to share the device list. Although the substations can keep a history of the transmission so as to find out the current PDA position, it is not accurate since the data transmission is one time only.

   For example, PDA Cat has requested data packets from substation C, it may move to a position where no substations are detected. Based on the transmission log, the last time transmission between substations and Cat shows that the current position of Cat is at C. It gives a wrong result. On the other hand, ASPP keep tracks of the movement of Cat, it will report the loss of CAT immediately when CAT move to such position.

   As a result, ASPP is better for location management.

2. Workload of PDA

   In ASPP, the PDA will only monitor for any substations requesting its device ID during device list update. It is passive. It is contradictory for PSAP, each PDA actively update the device list itself. It has to compare with the old device list to check if new substation is detected. Its workload is thus higher than that of ASPP.
3. **Time delay**

   On one hand, the time delay of ASPP mainly depends on how many devices are connecting. When the substation detects several new PDAs, it will send the data packets to them one by one. Queuing method is used for the data transmission. The time delay is predictable.

   On the other hand, the connections between PSAP like WLAN protocols. If the substation is already sending data packets to particular PDA, other PDA may suffer from no response. It then has to compete for device list update in the next substation detection again. The time delay is not guarantee because the substation maybe sending data packets to another device in the next detection.

   Hence, the time delay in ASPP is more reliable than that of PSAP.

4. **Complexity of valid device identification**

   In real case, the physical location of the exhibit is assumed that they are not easy to detect each other. Hence, most device IDs in the device list are from PDA.

   In PSAP, the PDA easily detects other PDAs. Hence the retrieved device list may contain many PDA devices that are useless. It consumes time and power for the PDA to sort out those substation devices.

3.3.4 **Conclusion:**

<table>
<thead>
<tr>
<th>Complexity of location management of the PDA</th>
<th>ASPP</th>
<th>PAPP</th>
</tr>
</thead>
<tbody>
<tr>
<td>- Easy to share device list</td>
<td></td>
<td>- Difficult to share device list</td>
</tr>
</tbody>
</table>
Therefore, ASPP will be chosen for implementation in my project as it is easy to do further statistics about location management and common user movement.

### 3.4 Ways of retrieving information

PDA can retrieve information in three ways:

1. From the storage card in PDA
2. From server database through Wi-Fi
3. From substation through Infrared
3.4.1 Compare the advantages and disadvantages of the ways of retrieving information

**Information Retrieving Time**

Compare the three ways in information retrieving time, from the storage card in PDA would be the fastest one since data are directly retrieved. The second one would be through the Wi-Fi wireless connection to get the information from server database as the data transmitting speed of Wi-Fi is faster than that of infrared media.

**Implementation Cost**

Although the cost of storage card becomes more reasonable, in comparison with the others, when every visitor has to own one, the implementation cost is the highest among the three ways.

For the way retrieved from the database through infrared, memory storages should be embedded with the infrared devices. The cost of it would not be cheaper than storing the data in the central server database. Therefore, in the implementation cost session, retrieval of information from server database through Wi-Fi would be the cheapest one.

**Complexity of updating information**

As every visitor has to own at least one memory card for the information, when the information has to be modified or updated, a lot of work has to be done in modifying or updating in every memory card. It is very time and cost consuming.
The similar situation can be applied to the way of storing information in the embedded infrared device. When updated is needed, every embedded infrared device has to be modified individually. Time and cost is also consumed.

However, if the information is stored in the server database, when updated is needed, the museum staff can only modify the information in the central server database for one time. It also allows sudden change of information. It is good for news announcement as the information can be updated immediately to every visitor.

### 3.4.2 Conclusion

<table>
<thead>
<tr>
<th></th>
<th>Memory Card</th>
<th>Server Database</th>
<th>Embedded Infrared Device</th>
</tr>
</thead>
<tbody>
<tr>
<td>Information Retrieving Time</td>
<td>Fast</td>
<td>Medium</td>
<td>Slow</td>
</tr>
<tr>
<td>Estimated information retrieval delay</td>
<td>Yes</td>
<td>No</td>
<td>No</td>
</tr>
<tr>
<td>Implementation Cost</td>
<td>High</td>
<td>Low</td>
<td>Medium</td>
</tr>
<tr>
<td>Reliability</td>
<td>High</td>
<td>Medium</td>
<td>Low</td>
</tr>
<tr>
<td>Complexity of updating information</td>
<td>High</td>
<td>Low</td>
<td>High</td>
</tr>
</tbody>
</table>

Table 3.4.2 Comparing different information storing method

Although the delay time of getting information through the wireless communication is unestimated, by the rapid growth of wireless network technology and the overall performance of Wi-Fi communication protocol, retrieving information through Wi-Fi would be applied
to this tour guide system. Also, its simplicity and its lower cost would greatly appeal to the museum.

3.5 Using Internet Explorer to display information

In this project, information is designed to be displayed in Internet Explorer browser. In the Internet Explorer under Windows CE or above, HTML and PHP language are supported. Therefore not only static information can be displayed, but also the dynamic or interactive one. On top of it, these two languages are easier to learn comparing with other programming languages and there are many high-level programs that helps user to compose a web page in simple way, the special background knowledge of staff is not required.

With the use of well developed web browser, visitors are provided to save or mark down their favourite information page or to go back the previous information page by just clicking on the backward button.

Besides, majority of the people has the experience using Internet Explorer [18], it would be more favourable to display the information in the way they are familiar with. That is why Internet Explorer is chosen to display the exhibit information.
4. Result

In this project, two programs and html with php web pages are constructed. The two programs are developed for the server and client sides and the web pages are the museum information page with a comment area which uses for the visitor to leave message immediately.

4.1 Program Flow Chart
Fig 4.1b Server Side Program Flow Chart
4.2 Program Interfaces

Server Side

In the Museum Tour Guide Server Program Interface (See Fig 4.2a), there is a text box that aims for entering the website link which is ready to send to visitors. When the “Start” button is clicked, the program will open the IrDA socket and start to search the nearby remote devices. (See Fig 4.2b)
Fig 4.2b Museum Tour Guide Server Program Interface – Open Socket

Once a user is detected and identified, the program will send the information website link to the user through IrDA (See Fig 4.2c).
Fig 4.2c Museum Tour Guide Server Program Interface – Identified user and sent data

**Client Side**

In the Museum Tour Guide Client Program Interface (See Fig 4.2d), users can choose their favourite language as the description language. And the text box below the language selected group box is used for showing the status of the program.
4.3 How does it work?

1. At start, user has to open the Museum Tour Guide Client Program and select the description language.

2. When the user stands in front of the exhibit, his/her Pocket PC would open the IrSocket, accept the connection and receive the link.
<p>| | |</p>
<table>
<thead>
<tr>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>3.</td>
<td>The corresponding information webpage is loaded with the Internet Explorer.</td>
</tr>
<tr>
<td>4.</td>
<td>At the bottom of every information webpage, there is a location indicator which tells the user where he/she is.</td>
</tr>
</tbody>
</table>
5. User can view the full map of the exhibition hall by clicking the graphic shown in 4.

6. When the user go to another exhibit and he/she choose the display language be Chinese, once he/she is discovered, information link of the new item is received.
7. A corresponding information webpage is loaded with the Internet Explorer. On the top right hand corner of the page, user can also switch to English language page with the highlighted hyperlink.

8. The same information but different language page is loaded. At the bottom of the screen, there is a link for watching a related video. User can click it and download the video through Wi-Fi to enjoy it.
9. If the user wants to leave a comment for the item, he/she can slide down the information page to find out the hyperlink of “Comment”.
10. User can enter his/her information and comment and then post it immediately.

11. Those posted message are immediately shown in the message board. Questions can be opened for discussion.

Table 4.3 How does the Museum Tour Guide Client program work?
4.4 What will happen when two or more users come to the exhibit at the same time?

For example, there are two users come in front of the exhibit at the same time, the server side program will discover them and put them into the device list. And then the server program will send the information link to them according to the order of device list. (See Fig. 4.4)

![Fig. 4.4 Server program showing when two users are discovered.](image-url)
4.5 What will happen when the IrDA communication link between PDA and substation is broken?

In the program design, when the IrDA communication linkage is suddenly broken, the server program will try to connect three more times.

On one hand, when the server program is trying to reconnect to the target client program, the status will be shown (See Fig 4.5a)

On the other hand, if the communication linkage cannot be recovered within the three retries, the device will be marked as an old device and postpone to send after finishing the current round. (See Fig. 4.5b)

Fig 4.5a Server programming showing the status of retrying sending the information link
4.6 Comment Page Management

The comment page is written with php language. All the smut or dirty language would be deleted automatically when the message is posted.

In this comment area, as every one can freely post their message in public, some impolite messages or dirty words would also be posted in the board. Therefore, management function has to be added on the comment page.

In the comment page, there is a login session for the administrator to logon and manage the page (See Table 4.6).
1. On the bottom left hand corner, there is a hyperlink which is linked to the administrator page.

2. After entering to the page, administrator has to input the password in order to logon.
3. After logon to the administrator management page, messages can be deleted or edited.

Table 4.6 Managing the comment webpage
5. Further Development

5.1 Develop an embedded IrDA transmitter device

In the current project, the IrDA transmitter works with a PC which helps to save the website link and device list, set up the connections and do some computations. In practice, if every exhibit has to reserve a computer with IrDA device, it would be quite expensive and the spaces could not be arranged for the set up. Therefore, an embedded IrDA transmitter device is suggested so that both of the size and the cost of the device set up can be reduced.

5.2 Mobility Management

Sometimes, visitors may find some of the exhibits are crowded of people but some are not. Since the IrDA transmitter can only send the information website link to one device at a time, if too many people staying at one exhibit, the information waiting time may be too long for them. On top of this, a database which counts the number of museum tour guide system users could overcome this disadvantage. Users can decide their own journey based on the updated statistic. With this database system, statistics can be made to find out the most attractive exhibit and can do any business study. To develop this database, the several ways of counting the number of tour guide system user can be applied.

Counted by the IP address

The number of tour guide system users can be counted by the IP address. Every time when a new information webpage is loaded, a counter in the webpage is updated and sent to the central database server.
The advantage of this method is the amount of update is small. It can minimise the loading on both sides. However, as it only updates when the new page is loaded, the database will not notice in the case of the user is off the region of detection. The data may not be correct all the time.

**Counted by the IrDA substation**

In the IrDA substation, the server side tour guide program will periodically detect the nearby remote devices and update its device list. The flow control statistic can make use of it by collecting the identified device IDs from each substation periodically.

Since only the detected users’ device ID are sent to the central server, the problem raised from counted by the IP address can be solved. And as it is updated periodically, the amount of updates can be estimated. The workload of this function can be controlled.

However, since the central server has to collect data from every substation, the substation should be connected to the central server through intranet or wireless network. The implementation cost and complexity will be increased.
6. Conclusion

In behalf of providing a smart environment to foster learning and self-development for every visitor, this project works out the idea of making PDA be an interactive and tailor-made tour guide and implements this system onto Pocket PC. Combining with the concise tour guide system interface and the educational exhibit information web pages, it makes every exhibit vivid through comprehensive descriptions and multimedia display. It is believed that the establishment of on-hand virtual museum would enhance visitors’ learning experiences.
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