Abstract. Handheld devices have become so commonplace now-a-days that in future these will get mixed with our day to day life seamlessly. To communicate between these devices a number of protocols have been developed – Bluetooth and IEEE 802.11 being two dominating protocols. For developing applications on these mobile devices, we need good support for device discovery and at the same time protocol independent consistent application programming interface (API) which will make the job of application developers easier. Keeping application developers free from worrying about underlying communication protocols and at the same time ensuring application portability across protocols is a major design issue in current generation middleware for ubiquitous computing. In this paper, we present a device discovery service in the middleware for ubiquitous computing – MARKS, that also provides a consistent API for application development hiding the underlying communication protocols from application developers.

Keywords: Device discovery API for ubiquitous applications, MARKS, Interoperability, Middleware for Ubiquitous computing, IEEE 802.11, Bluetooth and middleware services.

1 Introduction

With the mass availability and popularity of handheld devices, wireless technologies, and the Internet, ubiquitous computing [1, 2] has evolved as an emerging and highly challenging area in computer science. It is envisioned that future computing will be full of tiny sensors and mobile handheld devices thus bringing computing to everywhere we go. To communicate between these handheld devices, a number of communication technologies have been evolved of which IEEE 802.11 and Bluetooth are predominant. Due to lack of consistent API and good support for protocol independent device discovery models, applications developed on these devices need to take into consideration the underlying communication protocols. As a result, application developed using services/API to access 802.11 devices become unusable
when ported to devices with Bluetooth interface and vice versa. If application developers have to make their applications independent of underlying protocols, they have to provide ad-hoc solution for device discovery into their applications. This makes the life of application developers tiresome and at the same time the developed applications more complicated. To overcome these deficiencies we have developed our own lightweight device discovery model and incorporated it in Ahamed et al.’s middleware for ubiquitous computing – MARKS. Our model, in addition to device discovery, provides a consistent API for application developers to make the developed applications independent across underlying communication protocols. A number of frameworks [4-12] have been developed to facilitate interoperability across heterogeneous protocols. But they suffer from many limitations that make them unsuitable as middleware service in ubiquitous computing. Some of these approaches are too heavyweight to be deployable in ubiquitous computing environment. Also, others are hardware oriented approaches that make them unsuitable for ubiquitous computing due to its ad-hoc nature and lack of fixed infrastructure.

In this paper, we present our device discovery model to integrate heterogeneous devices using 802.11 and Bluetooth, which we have developed as part of core device discovery feature of Ahamed et al.’s middleware – MARKS. We call our approach TLDDM (Transparent Lightweight Device Discovery Model). Our approach in addition to discovering devices in protocol independent ways, provide one consistent API for application developers making applications portable across Bluetooth and 802.11 communication protocols. Also, its lightweight enough to be implemented as a middleware service.

In section 2 we present architecture of MARKS which has TLDDM as a service. In section 3, we present how we evaluated our approach. Finally in section 4, we summarize the contributions made by our approach.

2 Our Model Architecture

MARKS (Middleware Adaptability for Resource Discovery, Knowledge Usability, and Self Healing) [3] is a middleware, which provides the core communication facilities along with other services TLDDM has been added as a service to MARKS. For device discovery we use a simple periodic broadcasting technique with specific timestamp. Each device broadcast their presence with its address and host name. After getting these signals each device updates their valid neighbor list. If a device fails to broadcast its presence notifying packet for two consecutive rounds, it will be discarded from the device list of other nodes of the network. We need to be careful in choosing the time delay between two broadcasts. If this value is chosen to be too small, traffic in the network will grow up. On the other hand, if we choose a greater value it will reduce the accuracy of the current device list. This algorithm is implemented in TLDDM module along with other necessary functionalities. TLDDM has been incorporated in MARKS. It communicated with the Core services of MARKS, which in turns communicate with other ubiquitous computing devices such as PDAs, Pocket PCs, Smart phones etc. Other ubiquitous computing devices have to run the MARKS and TLDDM. Since MARKS is an open source research project, it is fine to assume that other devices will run MARKS and TLDDM. Ahamed et al.[3]
have put sample programs to show how MARKS can be used on their website, it is easy to include TLDDM.

3 Evaluation

We have designed and implemented the prototype of TLDDM. We have used Windows CE as the operating system, Dell Axim X50v as PDA hardware platform, VC#.Net Compact Framework as programming language. We have developed a sample chat application on top of the MARKS middleware using TLDDM service. The application uses TLDDM service to establish communication with other devices seamlessly using appropriate communication protocol available on the PDA used.

We have followed the cognitive walkthrough strategy on our prototype of TLDDM using our chat application. We collected the feedback from the users by giving a questionnaire. Figure 1 shows the users’ overall rating. It also shows usefulness, simplicity of use, and ease with which it is possible to perform chat using the application. Our findings are presented in Figure 4, 5, and 6 (where 5=highest, 0=lowest on Y-axis).

Due to limitation in battery power of PDAs, power consumption has become one of the most important issues to be considered in ubiquitous computing applications. Our TLDDM consumes minimal power which is supported by the graph shown in Figure 2. Here we have shown two cases for PDA: the idle case (when the PDA is ON but not doing anything) and the active case (when the chat application is running on the PDA).

4 Conclusions

In this paper, we have presented a transparent light weight model for device discovery with a common consistent API to overcome the heterogeneity of underlying communication protocols. Our model is especially suitable for ubiquitous computing
environment where we have low-power handheld devices with limited infrastructure support. Our device discovery approach is really lightweight which we have demonstrated by deploying it as a service in the MARKS middleware[3]. Its low power consumption makes it suitable for ubiquitous computing. It is also protocol independent and application transparent. As a result, applications don’t have to take into consideration the underlying communication protocols whether it is Bluetooth or 802.11. This makes applications protocol independent and hence, portable across Bluetooth and 802.11 protocols. Since our approach provides a common consistent API which is independent of the underlying communication protocols, it makes the application developers’ life easier.

References


