Lessons Learned from Developing a Bluetooth Multiplayer-Game

Matthias Handy, Frank Golatowski, and Dirk Timmermann

Institute of Applied Microelectronics and Computer Science
University of Rostock
matthias.handy@etechnik.uni-rostock.de

Abstract. Gaming applications in ubiquitous computing environments will be in need of wireless communication facilities. In this paper, we outline advantages and drawbacks of Bluetooth. As a first step, we examine general issues of gaming applications in ubiquitous computing environments. Afterwards, we show how Bluetooth can cope with these issues. Furthermore, we describe two prototype applications: a Bluetooth-based multiplayer card game and a Bluetooth advertising pillar.

1 Introduction

In the 1997's motion picture "The Game", a wealthy financier gets a strange birthday present from his brother: a life-action game. All kinds of bad things happen to the man after the game has started and he never knows who and what is part of the game until the separation of real life and game blurs completely. Many of the game elements in this movie seem to be visionary and far away from reality, but with ubiquitous computing in mind, the vision moves a lot closer.

Life-action games where reality and game get mixed are only one but maybe the most challenging and ambitious manifestation of gaming applications in ubiquitous computing environments. However, there are more. Imagine a restricted area as playground, e.g. an abandoned factory, fortress, or even a whole island where only the players have access to. In these locations, invisible communication and computation infrastructure could exist enhancing the game. In contrast to life-action games, non-players will not be involved in such a *playground-based game*[1]. Additionally, another type of ubiquitous computing games can be outlined. They mostly take place indoors at a game board that is equipped with communication and computation components and/or with smart objects as pieces. We will refer to this type as *smart game board applications.*

We could arrange these types of ubiquitous computing games on a timeline with the smart game board applications in the present or near future, playground-based games a bit further away, and life-action games as vision. But we would not do justice to the matter. We should rather look at them as parallel threads of the evolution of ubiquitous computing games. In a world where communication and computation technology is ubiquitous, board-games will not be

[1] In [1] the term *game arena* is used for playground-based games

threatened with extinction, just as computer games did not replace traditional board-games. Moreover, playground-based games will not become stale when life-action games will become feasible.

Common to all types of gaming applications in ubiquitous computing environments are the possible relations between the components of a game. We could classify game components at least into players, (smart) objects, and the gaming infrastructure. Players communicate with each other using speech or gestures or can exchange all kind of digital data in an imperceptible manner using a wireless communication technology. Additionally, players can communicate with smart objects or artifacts that are part of the game, e.g. by reading out an RFID-tag[2]. Smart objects can communicate with each other, e.g. if some properties of a smart object change if it passes by another smart object. In many cases, a ubiquitous computing game needs a kind of infrastructure to coordinate player's actions and to allow a bird's-eye view on the game. Players or smart objects have to communicate with the infrastructure from time to time, e.g. to synchronize or to update position information. This can be done using cellular phones or a local access points that are connected to a central game server.

In Section 2, we investigate issues of ubiquitous computing games in order to expose requirements on a wireless communication technology used for such games. In Section 3, we describe possible candidates for such a technology. In particular, Bluetooth is examined in Subsection 3.2. Two prototype applications are presented in Section 4, a Bluetooth-multiplayer card game in subsection 4.2 and the Bluetooth advertising pillar in subsection 4.3.

2 Issues of Ubiquitous Computing Games

In recent years, a couple of papers were published dealing with issues of ubiquitous computing games [1][2][3][4]. Many of the issues can be subsumed under the term *context awareness* [5]. Ubiquitous computing games use context information as input to decide about the further course of the game. Location is such a context information. For a certain situation in a game, it could be important to know the position of participants and smart objects. At least two types of location can be distinguished: absolute and relative location [6]. Absolute location refers to a shared reference grid for all objects, e.g. the GPS-system uses latitude, longitude and altitude. Relative location allows different reference grids for different objects. In a game it could be interesting to know how close two smart objects or participants are to each other or if a smart object is inside another one. This information can be obtained using a relative location system.

Context information other than location could be integrated into Ubiquitous Computing games. Participants or smart objects could be equipped with sensors to record *real-world phenomena* such as temperature, humidity, acceleration, mechanical stress, etc.

If there are different teams in a game, *team members* have to recognize each other even if they did not see before. Team members could wear a special sign,

[2] RFID = radio frequency identification

a piece of jewelry or an RFID-tag to accomplish this. In case of an RFID-tag, participants have to use RFID-readers to acquire information from tags.

Besides peer-to-peer communication between players, there must be a possibility to communicate with more than one player at the same time. A kind of *broadcast- or multicast mechanism* could allow this, e.g. if a player wants to post a message to all other team members or players in transmission range.

Furthermore a *service discovery* mechanism could be used by a player to learn something about a certain smart object. This issue is well known from computer games where players often wonder what to do with a thing they found. Service discovery could also be used to learn something about the skills of another player.

3 Communication Technologies for Ubiquitous Computing Games

3.1 Wireless Communication Standards

Wireless communication usually comprises at least optical and RF-based technologies. Both have advantages and drawbacks. As an example, infrared communication such as IrDA needs line-of-sight conditions to work properly. RF-based communication, however, can easier be eavesdropped since radio waves propagate in any direction.

For RF-based communication, properties such as transmission range, reliance on infrastructure, or frequency are qualifying or disqualifying factors. For short range, RFID-systems can be used. Passive RFID-tags do not need an energy source, are cheap, small and can be read out imperceptibly. For wide range communication, cellular phones (GSM[3], UMTS[4]) are applicable. In [2] the authors describe a game where team members use their cell phones to communicate over long distances. For the medium range, Bluetooth and WLAN seem to be the most promising candidates since both are relatively mature technologies and hardware costs are moderate. Younger technologies such as ZigBee or UWB[5] look promising for the future.

3.2 Bluetooth as Wireless Communication Technology in Ubiquitous Computing Games

Bluetooth is a radio standard operating in the ISM-band at 2.4 GHz. It was originally intended as cable replacement for peripherals of personal computers and uses a spread-spectrum-radio. A communication channel between two devices changes its frequency every 625 μs.

Bluetooth technology differentiates, among others, between *inquiry* substate and *page* substate. The *inquiry* substate is used by a unit that wants to discover

[3] GSM = Global Standard for Mobile Communications
[4] UMTS = Universal Mobile Telecommunications System
[5] UWB = Ultra Wide Band

new devices. During inquiry, the searching device periodically broadcasts ID-packets on changing frequencies (two packets in each 625 μs TX-slot). Discovered devices respond to an inquiry by the transmission of a FHS-packet (Frequency Hopping Synchronization). A FHS-packet contains the Bluetooth device address and the clock of the sender. The receipt of a FHS-packet is not acknowledged.

A Bluetooth device switches to *page* substate in order to create a connection to another device. Again, the paging device (the master) periodically transmits ID-packets on changing frequencies containing a Device Access Code (DAC). The DAC contains the lower address part (LAP) of the target device. Notice that all statements about Bluetooth refer to release 1.1 of the Bluetooth specification [7].

Context Awareness If a connection is established between two Bluetooth devices, each of them can measure a RSSI-value[6] of the connection. RSSI measures the signal strength of a received signal. The shorter the distance between two Bluetooth devices, the larger the RSSI-value. Ubiquitous Computing games can use RSSI-measurements to roughly estimate distances e.g. between two players or a player and a smart object. Notice that many commercially available Bluetooth devices adapt output power automatically, not controllable by an application. However, a RSSI value is useless if we don't know the corresponding output power. Consequently, the output power of Bluetooth-based smart objects or player's handhelds must be controllable by the gaming application.

Grouping Functionality Bluetooth devices can form so-called piconets. Each piconet consists of one master and up to seven active slaves. The master coordinates piconet communication. Even two connected Bluetooth devices form a piconet, requiring a role assignment. One device becomes master, the other device acts as slave. Overlapping piconets form a so-called scatternet. Scatternets imply that some Bluetooth devices are member of more than one piconet and have been a theoretical construct for a long time, not supported by Bluetooth device vendors. Recently, Bluetooth devices are available with limited scatternet support.

Team members of a Ubiquitous Computing game could form a piconet for confidential data exchange if they are within transmission range. Due to the frequency hopping scheme, eavesdropping an existing piconet is complicated. Furthermore, team members could identify each other with their unique Bluetooth device addresses.

Broadcast Before two Bluetooth devices can exchange data, a connection has to be established. Thus, Bluetooth allows no pure broadcast where data is sent to all other devices in range. Bluetooth specification describes a kind of broadcast-scheme, however, this is limited to a piconet. The master of a piconet can send

[6] RSSI = Received Signal Strength Indicator

data to all slaves at the same time. Slaves do not acknowledge broadcast messages. Developers of Ubiquitous Computing games have to keep in mind these constraints.

Service Discovery Bluetooth specification defines a Service Discovery Protocol (SDP) that can be used by Bluetooth devices to acquire information about services available on other devices. SDP uses a client/server-architecture. SDP servers store information about available services, SDP clients can request this information. Service information is stored in service records. Each record holds the information of one service. Services can be grouped into service classes. SDP clients can directly request information on specific well-known services. If the service class is unknown, SDP clients can browse through all services offered by a SDP server.

Discovering services of multiple Bluetooth devices can be time consuming. However, we can use the inquiry procedure for a faster service discovery. As described above, discovered devices respond to an inquiry by the transmission of FHS packets. Each FHS-packet contains a 24-bit field *Class of Device*. This field may contain information about services offered by a Bluetooth device. Thus, information about available services can be obtained already during inquiry procedure.

4 Prototype Applications

4.1 General Remarks

During this year's lectures in hardware-oriented programming at the University of Rostock, each student of the course had to develop a distributed application using Bluetooth as communication standard. The main objective of the project was to familiarize students with concepts of wireless networks and Bluetooth technology. We will briefly describe two of the developed applications: BlueMauMau, a distributed version of the well-known card game MauMau[7] and the Bluetooth advertising pillar.

4.2 Bluetooth-based Card Game

BlueMauMau primarily consists of three components: a network component, a gaming component, and a graphical component. In general, one of the Bluetooth devices participating in the game has to act as game server coordinating communications among all players. The game server must be a Bluetooth master. If new players want to participate in the game they have to create a connection to the game server. Bluetooth specification postulates that the initiator of a Bluetooth connection always is the master. Thus, a role change is necessary in

[7] MauMau is a card game similar to Uno. For further information refer to: http://www.netsoc.ucd.ie/∼tadhg/main/maumau2.html

order to let the game server act as master again after a new connection has been established. The gaming component monitors all player's actions. It validates the legitimacy of player actions, e.g. taking up cards. For the mutual exclusion of player's actions, a token is used that is handed over between players.

4.3 Bluetooth Advertising Pillar

The Bluetooth Advertising Pillar can be used to transfer information onto mobile devices of people passing by a specific site such as a stand on a fair or a shop window. The application continuously searches for Bluetooth-devices in the vicinity. If one is detected, the Bluetooth Advertising Pillar tries to establish a connection and transfers some kind of data to the discovered device, e.g. a digital flyer or a business card. Meanwhile the Advertising Pillar continuously monitors the link quality. Thus, transmission can be terminated safely before the passer-by moves out of transmission range.

Originally developed as business application, the Bluetooth Advertising Pillar can also be used for gaming applications. Suppose a life-action game where some sites of the real world, such as a building or a square, bear information for players. Each player who passes by such a site receives information relevant to the course of the game.

5 Conclusion

In conclusion, we described how characteristics of Bluetooth technology can be utilized for gaming applications in ubiquitous computing environments. Furthermore, we showed what Bluetooth can *not* do. This paper can be regarded as decision guidance for developers of ubiquitous computing games.

Acknowledgment

This work is supported in part by the Gottlieb Daimler-and Karl Benz-Foundation, Ladenburg.

References

1. S. Björk, J. Falk, R. Hansson, and P. Ljungstrand, "Pirates! using the physical world as a game board," in *Proc. of Interact 2001, IFIP TC.13 Conference on Human-Computer Interaction*, Tokyo, Japan, 2001.
2. S. Björk, J. Holopainen, P. Ljungstrand, and K.-P. Åkesson, "Designing ubiquitous computing games - a report from a workshop exploring ubiquitous computing entertainment," in *Personal and Ubiquitous Computing.* Springer-Verlag, 2002, vol. 6, no. 5-6, pp. 443–458.
3. T. Starner, B. Leibe, B. Singletary, K. Lyons, M. Gandy, and J. Pair, "Towards augmented reality gaming," in *Proc. of IMAGINA*, 2000.

4. G. Iacucci, K. Kuutti, and M. Ranta, “On the move with a magic thing: Role playing in concept design of mobile services and devices,” in *Proc. of DIS2000 Designing Interactive Systems*. ACM Press, 2000, pp. 193–202.
5. G. Chen and D. Kotz, “A survey of context-aware mobile computing research,” Dartmouth College, Department of Computer Science, Tech. Rep. TR2000-381, 2000.
6. J. Hightower and G. Borriello, “Location systems for ubiquitous computing,” *IEEE Computer*, vol. 34, no. 8, pp. 57–66, August 2001.
7. *Specification of the Bluetooth System, Version 1.1*, February 2001.

Expectations Towards the Workshop

The workshop should bring together researchers from the wide field of Ubiquitous Computing and can be a panel to discuss the future of gaming. We think, this workshop should allow unprejudiced discussions about Ubiquitous Computing technologies in general. We should keep social implications in mind, however, should not overemphasize them.

Authors' Background

The authors are with the Institute of Applied Microelectronics and Computer Science at the University of Rostock. They work in the field of ubiquitous computing, reconfigurable computing, and real-time embedded systems. *Matthias Handy* is a Ph.D. student. One of his research projects deals with implications of Ubiquitous Computing. His other research interests comprise wireless ad-hoc and sensor networks. *Frank Golatowski* is a senior research fellow. His main research interests are in the area of service-oriented architectures and service-oriented programming paradigms for resource limited systems. *Dirk Timmermann* is professor for computer engineering. His research interests include digital CMOS design, low-power systems and wireless ad-hoc and sensor networks.