Smart Playing Cards – Enhancing the Gaming Experience with RFID

Christian Floerkemeier and Friedemann Mattern

Institute for Pervasive Computing, Department of Computer Science,
ETH Zurich, 8092 Zurich, Switzerland
{floerkem,mattern}@inf.ethz.ch

Abstract. The idea of pervasive gaming, where traditional, tabletop games are enhanced with wireless computing devices, has recently received increased attention. In this paper, we present a card game that is augmented with information technology to advise novice players and to relieve the players of mundane tasks, such as score keeping. The paper outlines in particular our efforts to build a system that preserves the assets of conventional card games. The paper shows how appropriate RFID system design results in a portable solution which requires minimal changes and disruptions to the conventional game flow and which works reliably. We also illustrate how the players' mobile phones can be used as user interfaces, thus reducing the overall system costs.

1 Introduction

In his seminal article Mark Weiser imagined information technology that vanishes in the background and seamlessly integrates into the world of physical objects [13]. The notion of computer-augmented tabletop games [1, 8] embodies this vision by providing the best of both worlds – the dynamics and rich social interactions of traditional tabletop games and the computing support that can relieve the players of mundane tasks, such as score keeping, and can enhance the game with visual and audio effects. Sensing technology is used to unobtrusively detect human-to-physical-world and human-to-human interaction, while mobile devices and large displays are used to interface with the players.

In this paper, we present a computer-augmented card game. In such a smart card game, the embedded information technology can provide a number of useful services to the players. These include automated score keeping, advice to novice players, and alerts of wrong moves. Our work builds on earlier work by Römer et al. [10], who initially proposed the idea of a smart card game and also built an early prototype that uses radiofrequency identification (RFID) to capture the game state. We focus in this paper in particular on the development of a smart card game that addresses the limitations of the early work by Römer et al. The main contribution of our paper is thus an implementation of a smart card game that does not disrupt or modify the game flow of a conventional card game, is portable and low-cost, and works reliably. The paper also presents the results of user testing.

(a) Overview of Smart Card Game

(b) Playing Cards and Mobile Phone

(c) Display of Score on Mobile Phone

(d) Unobtrusive Integration of RFID Tags

Fig. 1. Smart Card Game.

The paper is organized as follows. In Section 2, we discuss usage scenarios and requirements. Section 3 features a detailed description of the system design. We focus in particular on the design of the sensing and the user interface component. In Section 4, we present the results of user testing and outline future work. Before we conclude in Section 6, we present related work in Section 5.

2 Usage Scenarios and Requirements

A card game augmented with information technology removes some of the annoying tasks required during a gaming session. It eliminates the mental arithmetic at the end of each game, when the individual value of each card won needs to be added up to determine the winner and the exact score. Such a smart card game can also relieve players of bookkeeping the overall score throughout the gaming session (cf. Figure 1). For novice players, who are quickly confused by the variety of game rules, it provides an additional benefit, since the system can advise the player on the moves allowed and the (presumably) best action to take. This will make the game more enjoyable for both beginners and experts. While these use cases apply in principle to any card game, those that feature a rich set of game and scoring rules will benefit the most from the computer support.

The added value of the automatic scoring and advice functionality should not come at the expense of the characteristic values of a card game, though. These include the dynamic nature of the game, the rich social interactions, the fact that it takes almost no effort to set up a game of cards, and its low cost nature. A computer-augmented card game that requires significant changes to the normal run of events, that slows down the card game, or that requires a significant set-up time will thus not be accepted by the players even if it provides additional functionality. This has been confirmed by previous work [10], where the initial part of the card game is modified to suit the limitations of the sensing technology. The interactive nature of the card game thus mandates a sensing technology that detects the movements of playing cards nearly instantly and reliably. The entire solution including sensing technology and user interface also needs to be portable, easy to set-up, and low cost. In the remainder of this paper we discuss the system we developed and show the extent to which we were able to satisfy these requirements.

3 System Design

In this section, we outline some of the detailed design decisions we made regarding the system components that are responsible for sensing the card game state and communicating the computed results to the players (cf. Figure 2 for the architecture of the smart card game). We begin by illustrating how RFID technology and the appropriate system design can satisfy the requirements presented in the previous section, and continue by outlining the value of mobile phones with short range communication capabilities as user interfaces.

3.1 Capturing the Game State

The identification of the cards belonging to each player and of the cards placed in the current trick requires a fast, short range automatic identification technology. Common identification techniques, such as vision systems or contact-based systems, which require either line of sight or physical contact to the object, are not well suited to the application domain because the cards are often placed partly overlapping in a heap. Vision systems also require a configuration of a camera that limits the portability of the system [12]. Passive RFID solutions are a much better alternative, since they require neither line of sight nor bulky components on the cards. The limited positioning precision of RF solutions is not an issue here because the system only has to distinguish between a few different locations – the space immediately in front of each player and the trick in the middle of the table (cf. Figure 1). Since card decks typically feature up to 60 individual cards, the required address space poses a challenge for low-cost chipless RFID solutions. Instead, we chose to use chip-based RFID technology operating at 13.56 MHz,

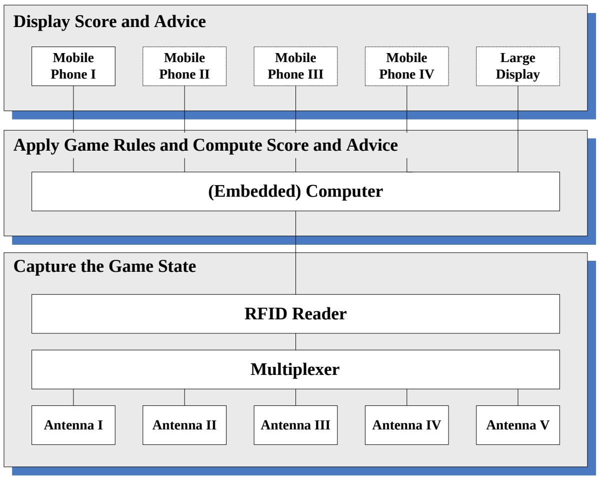
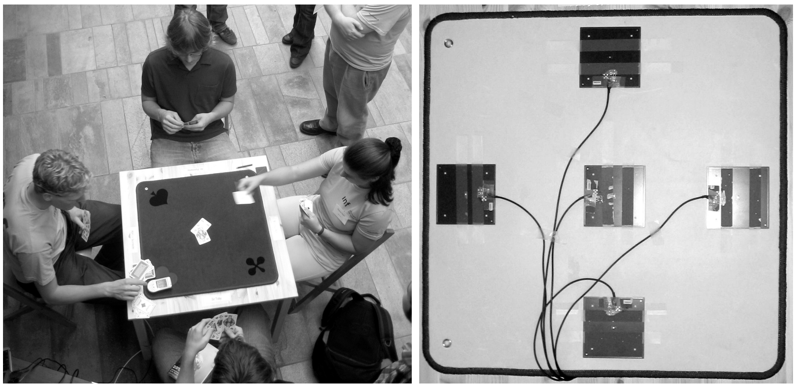


Fig. 2. Architecture of the Smart Card Game. The figure shows the different components and their corresponding roles.

which permits the unobtrusive integration of the RFID labels in each playing card (cf. Figure 1(d)). RFID technology operating in this HF-band also features a well-defined read range due to the operation in the near-field of the reader antenna. The technology is thus ideally suited to distinguish between different locations in close proximity. The limited range and small reader antenna size imply that we are operating well within the radio regulations in the HF-band. This allows us to improve the identification speed by choosing a reader-to-tag data coding scheme with increased sideband signalling.

To reduce the cost of the system, we use a single short range RFID reader (Feig ID ISC.MR100) together with a multiplexer (Feig ID ISC.ANT.MUX-A) that switches five different antennas (cf. Figure 2). The more expensive option would have been a design with five readers, each connected to one of the antennas. The antennas are integrated into a cover that is commonly used to facilitate the playing (cf. Figure 3). This cover can simply be rolled up to provide portability. We minimize the time it takes to detect card movements by dynamically eliminating antennas of no interest. Initially, we only poll the four "player" antennas because the central antenna is of no significance during card distribution. After the system has determined the owner of each card, the outer antennas are deselected and the multiplexer polls the central antenna only. This dynamic antenna multiplexing is facilitated by the RFIDStack [5], an RFID middleware platform that abstracts from the low-level details of the implementation and provides a convenient publish/subscribe interface.

The reliability of the identification process can suffer when RFID tags are placed in close proximity to each other [4]. This phenomenon – known as tag detuning – is due to the fact that the mutual inductance and parasitic capacitance



(a) Top View of Smart Card Game (b) Reverse Side of Cover

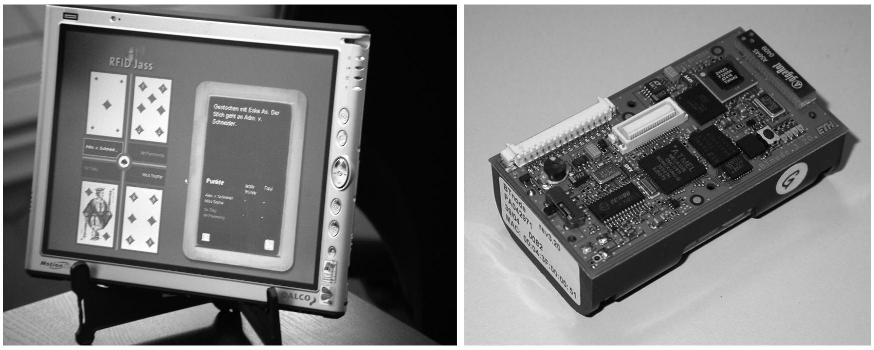
Fig. 3. RFID Reader Antenna Set-up. The five antennas are integrated into the cover that is placed on the table surface.

resulting from tags in close proximity change the resonance frequency of the tags. This means that the operation frequency of the carrier signal transmitted by the reader no longer coincides with the tag resonance frequency – effectively reducing the read range. In [4], it was shown that this makes the identification of cards placed in a stack a challenge. We address this problem by choosing tags that are tuned to a resonance frequency greater than the operating frequency. Placing them in close proximity will then reduce the resonance frequency to a value close to the operating frequency of 13.56 MHz.

One of the most difficult aspects of the system design is to capture the human-to-human interactions during the card game. This includes for example announcements during the bidding process and during the run of the game. While we have managed to build a system that requires no changes to the normal run of events to capture card movements, we do rely on explicit interaction with the computer system to replicate the verbal announcements. We facilitate this explicit interaction with the use of specialized tokens that feature an RFID tag. Placement of the corresponding token on the reader antenna indicates the appropriate announcement to the computer system.

3.2 Computing the Game Score and Advice

In the previous subsections, we discussed the design of a fast and reliable sensing system that captures the game state. This allows a computer attached to the reader to determine the current score, the subsequent player, and any wrong moves. It also enables services such as memory helpers, which inform the players of the cards remaining in the game and advise on the next move. We currently still rely on a Tablet PC to interpret the RFID data, to keep the game state, and to compute score and advice (cf. Figure 4(a)). The use of a Tablet PC also



(a) Tablet PC (b) BTnode

Fig. 4. Computing Platform. The game score and advice are today still computed on a Tablet PC. This provides a built-in display, but increases the cost of the system significantly. Future versions will be implemented on a Bluetooth enabled computing platform, such as the BTnodes [2].

provides us with an additional display, but increases the overall cost significantly. In the future, a simple Bluetooth computing platform, such as the BTnode [2], can provide the computing functionality to reduce overall system cost (cf. Figure 4(b)). The implementation currently supports a number of different trick taking card games, such as Jass and Doppelkopf.

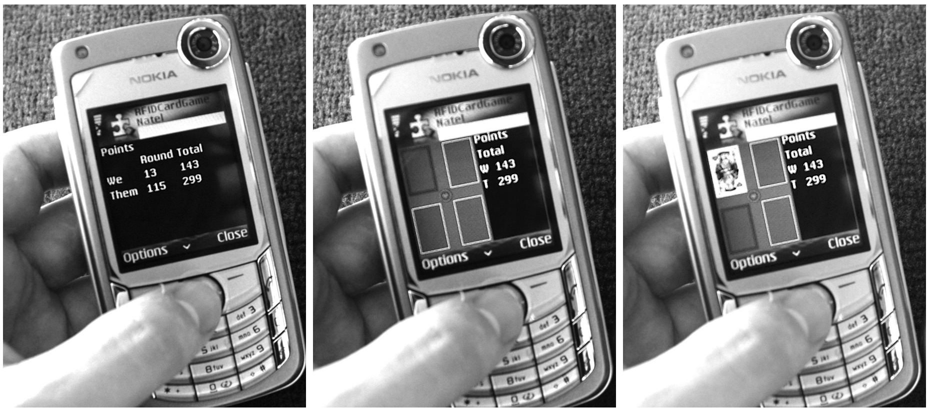
3.3 Interfacing with the players

To communicate information such as scores and advice, we chose to use the individual players' mobile phones. The main rationale for using the mobile phone was that it eliminates the need for a costly custom-built display. It also facilitates the set-up of the computer-augmented card game because no display needs to be installed. The use of the mobile phone displays also avoids the problem of making the game information available to all players without having multiple displays facing in different directions. Figure 5 shows the mobile phone display during various stages of the game.

Our solution relies on Bluetooth-enabled mobile phones that support the Java Mobile Information Device Profile [6] and JSR82 [7]. The mobile phones communicate with the computer, which keeps track of the game state, using the Bluetooth RFCOMM interface. The implementation on the mobile phones does not keep any state. This allows the players to connect to the "game server" with their mobile phones at any time during the game. The result is that a lost connection will not interrupt the current game.

4 Evaluation

The smart card game has been extensively tested on a number of occasions. This includes two days of user testing at an open day at the university. The tests



(a) Score (b) Trump/Turn (c) Card Detection

Fig. 5. Mobile Phone Display. The three figures show different use cases. In Figure (a), the total score and the winner of the last round is shown. In Figure (b), the display indicates the current trump and whose turn it is. In Figure (c), the first card placed in the trick is displayed.

illustrated the reliable and fast operation of the entire system. The evaluation showed that it takes only a fraction of a second before a card placed in the current trick also appears on the display of the mobile phone. The system also worked reliably over long periods of time. There were very few missed reads and most resulted from cards that were placed far away from the centre of the table. The central antenna which monitors the cards placed in the current trick was then not able to detect these cards. The Bluetooth communication and the software on the mobile phones also worked reliably and the delay the players experienced was minimal.

During the initial card distribution phase, the identification latency is increased, since the multiplexer polls one of the four "player" antennas at a time. This was intended during the design phase to alleviate the need for multiple readers. During this initial distribution phase, the identification rate occasionally suffered, when players placed the cards in a stack immediately after distribution. This happened although we use RFID tags that are deliberately detuned to enable stack reading. In such a case, the software would ask the player to briefly place his cards spread out on "his" antenna in order to identify the cards missed.

The user feedback also indicated a number of interesting observations and suggestions for future work:

Audio output. Some of the players that tested our system recommended using audio feedback as well. They mentioned that they were initially not convinced that the system would reliably detect card movement. As a consequence, they were distracted by watching the cell phone to verify that the system did pick up everything correctly. They recommended an option of using a short beep to indicate the successful detection of a trick. Some players also preferred an audio alert to indicate a wrong move.

LEDs in the cover. The tests also showed that some novice players would prefer LEDs integrated into the cover to indicate whose turn it is. They mentioned that a check on the mobile phone was inconvenient.

More variants. Card games, such as Skat, Doppelkopf, and Jass, allow for a number of variants and special game rules. Players commonly agree on a set of rules and sometimes even modify the rules during a game. Our solution currently supports only a single set of rules. The players that tested our system recommended that future versions should provide more flexibility by allowing the players to select their personal favourite rule set. Since it will be difficult to implement all variants, there should ideally be a simple way for players to program new rules or at least download rules from a repository. The creation of novel rules using the limited input capabilities of a mobile phone will remain cumbersome, however.

Availability of compatible mobile phones. While there are a number of mobile phones that support Java and Bluetooth, the number of mobile phones that support access to the Bluetooth stack via JSR82 is still limited. However, we believe that this will change in the foreseeable future with the proliferation of the Java platform on mobile devices.

5 Related Work

The work presented by Römer in [10] is closely related to the work in our paper. It presents the initial idea and an early prototype of an RFID enabled card game. The system relies on a single, large reader antenna to capture the game state. It uses handhelds that communicate over a wireless LAN access point with a central server. Our work differs from the early work by Römer because our design effort focuses on developing a portable, low-cost solution that minimizes the modification to the normal game flow and works unobtrusively. The prototype developed by Römer et al. relies for example on a special distribution procedure that allows the computer to determine the owner of each card with a single reader antenna. This not only requires the players to adapt their behaviour to the limited capabilities of the computer system, but also leads to unreliable operation as described in [10].

There are also computer-augmented card games that rely on a vision system to capture the game state. For example, the system described in [12] uses a set of cameras to sense the card movements during a game of Blackjack. Because of the significant infrastructure required, the applicability of this approach is limited to use within casinos. Due to the portability of our system, the card game can be played wherever there is enough space for the cover and there is a power connection.

The potential of RFID as a viable technology to bridge the gap between the physical and the virtual world has been demonstrated previously within the pervasive gaming research community [3, 9]. The STARS platform developed by

Magerkurth et al. [9] integrates a number of sensing technologies to capture the game state, such as vision, touch screens, but also RFID. This platform features an RFID antenna integrated into the table surface to detect the presence of physical tokens, which alleviate the need for a mouse or a keyboard. In [3], Bohn presents a smart Jigsaw Puzzle that also relies on RFID technology to provide a convenient method to interact with the computer. Players can place jigsaw pieces in front of a handheld RFID reader and the computer will provide some advice on a display. However, there is no use of RFID to automatically sense the current state of the game without explicit interaction from the players. The use of mobile phones as a viable technology to interface with users in ubiquitous computing applications has also been discussed in [11].

6 Conclusion

Computer-augmented tabletop games have recently received considerable attention. In contrast to the most common form of pervasive gaming, where computer games are mapped onto real-world settings, augmented tabletop games build on old-fashioned (board) games that are enriched with unobtrusive information technology. This paper presents a conventional card game that is augmented with information technology to automate score keeping and to advise novice players. We show how RFID and mobile phones can be used to combine the best of both worlds – the dynamics and rich social interaction of a conventional card game and the ease of score and advice computations that information technology provides. The paper outlines in particular our efforts to build a system that preserves the assets of card games. The paper shows how appropriate RFID system design results in a portable solution which requires minimal changes and disruptions to the conventional game flow and which works reliably. We also illustrate how the mobile phones of the players can be used as user interfaces, thus reducing the overall system costs. The results of an evaluation indicate that players appreciate the additional functionality especially because it does not come at the expense of the ordinary benefits of a card game. Future work should include audio alerts and the implementation of alternative gaming and scoring rules.

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