Paper Gaming: Creating IoT paper interactions with conductive inks and web-connectivity through EKKO

Abstract
Paper is ubiquitous. It forms a substantial part of our everyday activities and interactions; ranging from our take-away coffee cups - to wallpaper - to rail tickets - to board and card games. Imagine if you could connect paper to the Internet, interact with and update it with additional data but without recourse to reprinting or using e-ink alternatives. This paper explores work examining conductive inks and web-connectivity of printed objects, which form part of an emergent sub-field within the Internet of Things (IoT) and paper. Our research is starting to explore a range of media uses, such as interactive newspapers, books, beer mats and now gaming environments through prototype IoT device named EKKO; a clip that allows conductive ink frameworks to detect human touch interaction revealing rich media content through a mobile application as the ‘second screen’.

Author Keywords
Internet of Things, Board Games, Physical & Digital, Paper, Conductive Ink, Interactive Media, Printed Electronics

ACM Classification Keywords
Hardware~Hardware-software codesign
**Introduction**

Over the last few years we have witnessed the rise in; the maker community [18], affordable off the shelf pieces of hardware designed to be hacked, mobile device ownership and social media [16]. Conductive inks is one of many prime examples of increasingly affordable open source technology that combined with the processing powers and connectability of recent releases of Raspberry Pis, Arduino and Electric Imps etc. are currently being explored in a number of research contexts [10]. These span media and newsprint, packaging, music, paper sensors and the book publishing industry, for example, between 2011 and 2013 the EPSRC project Interactive Newsprint [9] sought to explore conductive inks via a news and information context, and the book publishing industry has also engaged with initial prototyping work [17]. Affordable technology is also offering a scalable solution, as companies such as Bare Conductive¹ and MakeyMakey² are finding success in numerous sectors such as crowdfunding platforms to work with the craft and maker communities [3, 6]. Viewed through the frame of the IoT, these innovations are creating a range of new interactions and user scenarios that span a multitude of industries and sectors. Beyond these projects, a range of new hardware solutions developed by the craft and printing industry have begun to create reliable and robust paper interfaces that allow the detection of human touch and related responses (such as data transfer both to and from the paper, and audio activation). Paper is all around us, when we purchase a train ticket, visit a restaurant (menu), read a movie poster, play a board/card game etc. Paper enables the masses to retrieve a piece of information with low barriers to entry, which are further lowered when iconography and images are used to communicate where literacy may present itself as a barrier to understanding. The print industry, in Europe alone, is a sector worth €30bn [19] and we interact with paper in a range of ways throughout the course of our daily lives. To varying degrees, paper spans all socio-economic stratas and is present across the developed and developing world. When viewed as a ‘platform’, it has global reach beyond digital devices or operating systems. There are also a number of key and unique affordances that paper offers that are either absent from a virtual or digital space, or manifest themselves differently, or with a different degree of emphasis. These affordances - such as touch, tactility, texture and smell appeal to the senses in a uniquely tangible way. They offer a sense of physicality that a virtual space cannot recreate. Tactility presents games designers with options that are not possible in digital and virtual gaming environments. These include, potentially, a sense of permanence, physical interaction in three dimensions and a playful element in how digitally-conveyed data can surprise or delight users with an unexpected interaction or in-game event.

**Background**

Researchers and the industry have also, in recent years, sought to explore the interplay and potential links between the physical and digital worlds. Augmented reality products [1, 6, 11, 13], while not ubiquitous have been produced across a range of sectors to bridge a gap between physical and digital. In the gaming sector, products such as Livegameboard [11] demonstrate a market-ready offering that seeks to overlay digital data over the physical reality captured

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¹ http://www.bareconductive.com/
² http://www.makeymakey.com/
**What is EKKO?**

Over the last year, design research was conducted around an Internet-connected paperweight that pushes analytics data, and plays audio stored locally on an IoT object. During initial alpha testing the paper clip prototype presented in this paper has been collaboratively designed with our partners and gone through numerous rounds of alpha testing. EKKÖ as it is named, is split into three components; the clip, mobile app and Content Management System (CMS) analytics suite. The clip is known as an IoT device comprising off the shelf open technology; an Electric Imp combined with a capacitance sensor to measure the ink button presses, a small rechargeable Li-Po battery and an LED for user feedback. Its purpose is to be situated at the edge of a piece of print clipping itself to apply pressure to the conductive ink to enable a connection to the circuit.

by a smart device camera. Similar solutions include the current Kickstarter project Darkling Plain [6] and OUTLIVE [1].

Over the last decade, the exponential rise of mobile device ownership, the creation of the ‘app store’ and lower barriers to entry has propelled mobile gaming to be the leading entertainment factor amongst mobile device usage [5]. However due to the nature of said personal devices they tend to isolate its users, whereas console and board games promotes social interactions via online play functionalities (i.e. XBOX Live) or through the inclusion of people sat around a table (board games). The solution to this is to bridge the gap between the physical and digital, leveraging the social play characteristics of board games with the interactions and capabilities of mobile devices. Board games have been at the forefront of home entertainment for centuries, first dating back to 3300–2700 BC; Senet is reportedly the oldest board game to date [15]. Many of the characteristics that makes a board game enjoyable are through it ability to facilitate interactions between players, ability to be played around a table/floor, nomadic, have set rules but also ‘house’ interpretations of these rules (i.e. no computer algorithm to say which is right or wrong).

Previous work has been identified in this area exploring the use of the ‘magic lens’ to digitally recreate the game world on the players’ mobile device modelling buildings and people from a flat printed board [12]. Whereas Regan et al explored a hybrid approach to leveraging the advantages of physical mediums with digital media, through False Prophets, a game which integrates the strengths of traditional physical and virtual play in a hybrid physical/electronic game environment [16]. Xu et al studied the potential of digital tabletops through a handheld augmented reality game to understand how social play unfolds in board games [20]. In terms of objects and connectable objects Bakker et al and Coulton have studied the interactions of tangible objects and their connection to digital games. This closely resembles the types of physical objects traditionally found in board games, such as character pieces [2, 4]. The majority of research in this area has studied the use of technology as a counterpart to play or a lens into a digital world using the board as a marker. Connecting the physical game world (board) to the Internet via physical interactions from players, adopting to use the technology (mobile) as a second screen to play, permits for harnessing those playful characteristics synonymous within board games whilst combining the use of dynamic data and rich media from mobile technology.

The purpose of this paper is to explore the use of EKKO (see sidebar) in a different environment, studying a novel context with an alternative and unique digital solution. This paper is a follow on from the prototyping EKKO for Trinity Mirror’s local newspaper, the Liverpool Echo and collaborations with Haymarket Media’s Stuff magazine.

**Paper Gaming**

The research team’s initial thinking around paper-based digital interactions, developed with gaming and paper-gaming digital concepts at their core. We will discuss preliminary work to develop paper games controllers in tandem with a national magazine, and articulate a range of development pathways that encompass a range of user scenarios and products spanning board
games imbued with capacitive touch and the ability to transfer live data and other media directly to and from printed matter.

Initially, it was proposed to utilise EKKO and conductive print as a method of controlling a vide game. Working alongside Stuff magazine\(^3\), the authors designed a front cover, which could connect to EKKO and provide some basic game controller interactions for a one-button/two-button game (Fig. 1). The initial research and testing highlighted numerous technological and social factors that had to be considered, such as latency, physicality and feedback. This led onto other ideas exploring the use of EKKO with other playful forms of interaction. In particular board games, at the basis of any board game is a printed piece of artwork, which is situated flat on a floor or table. They come with a set of rules and usually have one approach to play (other than house rules). The notion of connecting a static piece of game area (board) to the Internet was found to be of interest to the researchers and partners to explore further. The research began exploring the potential for multiple purposes using a basic schematic of conductive ink and ‘reskinning’ its printed touched sensitive surface with different artworks.

In the first instance adopting an existing board game was preferred prior to designing our own. Combining the play characteristics of board games [16] with mobile technology and IoT [4] unlocks potential to allow games designers to adapt the game over time, change the style of play within the game, combine real time data with printed graphical information increasing the level of interactivity.

\(^3\) http://www.stuff.tv/

Monopoly was the chosen game as it has many elements that could be altered with the use of the IoT, enabling greater interactions, such as the chance/community chest cards, dice and of course the house prices and train stations. Adapting Monopoly has been studied in many contexts from utilising the mechanics of Monopoly in a Location Based Game [8], augmented reality [13] but also using open data to create a new board based on data gathered from real world demographics [7]. The moment you open the Monopoly board you can see the house prices, but what if these prices were calculated to the location context you were playing the game? What if the prices were obtained for an existing data source (rightmove.com, the news etc.), What if the train stations had some waiting element depending on the location context it was played and what if the number of people playing the game simultaneously had an effect on the outcome of the game? These were all questions that were proposed when designing an IoT enabled board game. As previously mentioned the clip would be situated on the edge of the board, connect button presses to the Internet and fed back to the user via the mobile application. As you can see from Fig. 2, the board has been designed to so that the conductive ink sits behind the artwork of the board game. This allows users to interact with certain areas of the board to reveal further information. In this example, users can tap the house they wish to purchase to find out how much it costs (this data can change over time similarly to real house markets fluctuation and by location for instance the data can be pulled from online estate agents) additionally there are no cards provided with the board game, instead users press the card and a virtual card is displayed on screen, akin to the rolling of the dice.
Further Work & Conclusion

The ecosystem of EKKO is simple, and similar to the mobile ‘app store’ ecosystem. The clip is where the interactions are made possible, similar to a mobile device and the ‘apps’ are the print that it can connect to. As this research is still in its infancy, there are a number of technical and social challenges to overcome, which is why delivering workshops and playtesting sessions are required to further the research into a longitudinal study to explore the concept of connecting board games to the Internet increases engagement and interactivity from a players and designers perspective. Furthermore it is hoped that with the inclusion of the Internet in board games, designers have more possibilities when designing game mechanics, novel ways of interaction and to create a new forms of play within traditional board games, whilst at the same time incorporating those characteristics that make board games enjoyable and sticky [21]. Furthermore, the research team intends to carry out a number of co-design sessions with professional games designers, gamers and non-gamers to begin to refine and prototype a range of IoT board games and paper-based games experiences. Beyond this immediate co-design approach, researchers will look forwards deployments within live home environments to further refine and iterate both the EKKO platform and the paper-based interactions, and continue to explore novel game mechanics and digitally connected features via EKKO or related iterations of this prototype-stage platform.

References


