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# Paper Gaming: Creating IoT Paper Interactions with Conductive Inks and Web-connectivity through EKKO

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**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 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**

H.5.m. Information interfaces and presentation

## Paper and Mobile Revolution

Paper has existed as a communications 'platform' for thousands of years. Its 'versioning history' spans papyrus, parchment and pulp, and when paper became a scalable and mass-production item, most famously via the Gutenberg press, it sparked unparalleled social and political change. It's a technology that's had 'impact'.

There are echoes here with mobile technology. Ownership has grown exponentially year on year, according to research from Nielson, which also highlights that more people now access the Internet through a mobile device than any other platform [14] and that devices are primarily used for activities such as playing games, voting and social media. With this growing trend unlikely to slow down, it emphasises the importance on bridging the gap between these platforms to create novel experiences.

## 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 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 scalable solutions, as companies such as Bare Conductive<sup>1</sup> and MakeyMakey<sup>2</sup> 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 offer 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).

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<sup>1</sup> <http://www.bareconductive.com/>

<sup>2</sup> <http://www.makeymakey.com/>

Paper is all around us, when we purchase a train ticket, visit a restaurant (menu), read a movie poster or play a board/card game. 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

### **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 prototype presented here has been collaboratively designed with our partners and gone through numerous rounds of alpha testing. EKKO as it is named, is split into three components; the clip, mobile app and Content Management System (CMS) and 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.

[11] demonstrate a market-ready offering that seeks to overlay digital data over the physical reality captured 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 its 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 follows on from the prototyping EKKO for Trinity Mirror's Liverpool Echo newspaper 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



**Figure 1.** Photograph of a prototype front cover game controller using EKKO.



**Figure 2.** Photograph of a prototype Monopoly board connected to EKKO.

range of user scenarios and products spanning board games imbued with capacitive touch and the ability to transfer live data and other media to and from print. Initially, it was proposed to utilise EKKO and conductive print as a method of controlling a video game. Working alongside Stuff<sup>3</sup>, the authors designed a front cover which could connect to EKKO and provide basic game controller interactions for a one-button/two-button game (Fig. 1). The research and testing highlighted numerous technological and social challenges such as latency, physicality and the need for feedback. This led onto ideas exploring the use of EKKO with other playful forms of interaction, particularly board games. At the basis of any board game is a printed piece of artwork 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 of interest to the researchers and partners, and the potential to create multiple purposes using a basic schematic of conductive ink and 'reskinning' its printed touched sensitive surface with different artworks.

Adopting an existing board game was initially preferred over 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, combine real time data with printed graphical information increasing the level of interactivity.

Monopoly was the chosen game as it has many elements that could be altered with the use of the IoT,

<sup>3</sup> <http://www.stuff.tv/>

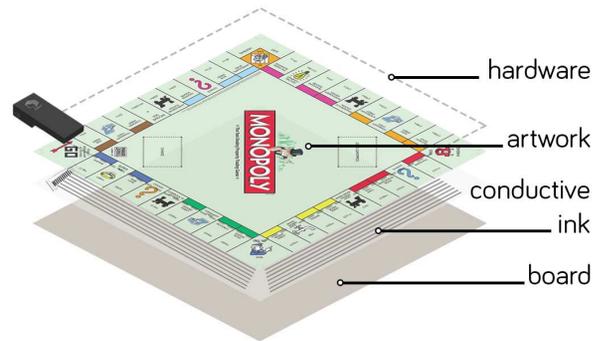
enabling greater interactions, such as the chance/community chest cards, dice and of course the house prices and train stations. Adapting Monopoly has been studied in many contexts from utilising the mechanics of Monopoly in a Location Based Game [8], augmented reality [13] but also using open data to 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 locations context where the game was played? What if the prices were obtained for an existing data source (rightmove.com or the Land Registry)? 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 Figs. 2 & 3, 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.

### EKKO Experience

The rich experiences are delivered to the user via a companion app installed on the user's mobile device. Pairing is achieved by specifying the friendly name or MAC Address of the clip with the mobile application; this allows multiple users to connect with the clip.

Currently the app is designed for iOS devices, having multiple purposes from playing audio and video to sending vibrations for extra feedback. The CMS and analytics suite, dubbed 'Interface', allows publishers to curate their own content for their publications. The CMS also comprises an analytics platform, to allow publisher to gain deeper insights into how users are interacting with their print products in much the same way that readers' interactions with web-based content can be recorded through analytics platforms.



**Figure 3.** IoT Monopoly layers diagram

### Further Work & Conclusion

The ecosystem of EKKO is simple and similar to the mobile 'app store'. 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 create a longitudinal study exploring the concept that connecting board games to the Internet increases engagement and interactivity from a player's and designer's perspective. Furthermore, it is hoped that Internet-enabled board games offer designers more possibilities when designing game mechanics, novel ways of interaction and creating 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, researchers deploy

iterations 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 iterations of this prototype-stage platform.

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