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Tourism and the smartphone app: capabilities, emerging practice and scope in the travel domain

Abstract

Based on its advanced computing capabilities and ubiquity, the smartphone has rapidly been adopted as a tourism travel tool. With a growing number of users and a wide variety of applications emerging, the smartphone is fundamentally altering our current use and understanding of the transport network and tourism travel. Based on a review of smartphone apps, this paper evaluates the current functionalities used in the domestic tourism travel domain and highlights where the next major developments lie. Then, at a more conceptual level, the paper analyses how the smartphone mediates tourism travel and the role it might play in more collaborative and dynamic travel decisions to facilitate sustainable travel. Some emerging research challenges are discussed.

Keywords: smartphone; app; internet of things; transport; mobile media; sustainable travel

Introduction

As society has become networked, and networks have become ubiquitous through the use of mobile telephones, societal practices are undergoing a radical transformation, none more so than in the domain of travel. The rapid uptake of mobile technology (Ofcom, 2011) has enabled people to negotiate their day to day mobility with increasing fluidity (Ling, 2004) providing scope for adhoc decision making on the go based on networked connectivity between people. The contextual awareness capabilities of smartphone technology are enhancing this ability and the travel domain is proving to be a fertile ground for smartphone app development (Adobe Systems Incorporated, 2010). The smartphone is continually evolving but, at its core, combines a cellular telephone with built in applications and Internet access. Digital voice service is combined with text messaging, email, web browsing, portable media players, low-end compact digital cameras, pocket video cameras and GPS navigation.

At a time when pressing global environmental concerns are demanding a re-evaluation of travel solutions, changes in the digital landscape are revolutionising people's traditional relationship with time and place and evolving new travel patterns. The smartphone's ubiquitous capability to link people to remote information repositories, exchanging location based data and social information, has rapidly made it a powerful tool for tourists. Smartphones are therefore an inevitable partner for tourism and the tourism context has become a fertile ground for mobile computing (Cheverst, Davies, Mitchell,

Friday & Efstratiou, 2000). A plethora of novel approaches and mobile phone apps are emerging. This includes tourist specific apps, travel and transport related apps, social networking apps, and ultimately apps extending social networking to vehicles and the 'things' people need. With a growing number of users, apps are increasingly influential in tourism travel decisions and behaviour (Wang, Park & Fesenmaier, 2011) at all stages of tourism consumption (Höpken, Fuchs, Zanker & Beer, 2010; Frommer's Unlimited, 2011). This is especially so given the increasing number of independent tourists who are no longer reliant on packaged options (Buhalis & Law, 2008) and the marked shift from a "place-based connectivity to individual, person-to-person connectivity" (Schwanen & Kwan, 2008, p. 1365).

There has been a growing academic interest within the social sciences, especially sociology, geography and psychology, concerning the shift to digitally mediated activities loosening the traditionally close links between activity, place and time. This is manifest in the 'new mobilities paradigm' (Larsen, Urry & Axhausen, 2006) and recent work in time geography (Couclelis, 2009; Cresswell, 2006; Kwan, 2007; Middleton, 2009). Mobile use has softened the normal time-and-place related constraints and is allowing individuals a more spontaneous negotiation of their meetings with other people, places and the things they need during the course of tourism (Wang et al., 2011). Our understanding of time is increasingly less reliant on the clock and relationships with place are less rooted in the Cartesian tradition. Given tourism's place dependency, this raises questions about how place is embodied and the new affordances of a 'sense' of fluid time for movement and transport. This fundamentally alters our current use and understanding of the transport network and travel services.

Given the rapid uptake of smartphone technology and associated apps there is a need to evaluate the current and emerging state of the art and what this means for the tourist travel domain. While smartphones and their associated apps are useful in all forms of tourism travel arrangements, the focus of this paper is on domestic travel both to and around destination areas and visitor attractions. It is less concerned with the negotiation of international tourism travel, though there are a number of apps that focus on this market. The paper has three aims: to evaluate the current capabilities of smartphone apps within the tourism travel domain, to analyse how the smartphone app is evolving society's contemporary understandings of time and relationships with place and things in the tourism travel domain and to highlight where the next major developments could be. The paper's contribution to knowledge lies in adding to the understanding of how evolving mobile technology mediates travel decisions in the tourism domain.

The smartphone, apps and tourism mobility

UK figures at the start of 2011 indicate 27 percent of adults own smartphones and there is growing interest in mobile Internet access for functions such as social networking (57% of mobile Internet users), sending/receiving emails (53%) and information search (42%) (Ofcom, 2011). The market is expected to grow, especially as mid-range and low-end

smartphones target the mass market. Campbell and Kwak (2011) categorise smartphone use into three patterns: logistical, for example, organisational use related to travel, household management and meetings; relational, for example, keeping in touch with friends; and informational, for example, accessing news up dates. All of which are applicable to tourism travel contexts. In addition, smartphones are emerging as mobile entertainment devices with the capacity to supplant other portable devices such as gaming consoles and DVD players during leisure travel. Most importantly, drawing on logistical, relational and informational functions, smartphones have quickly been adopted as a travel tool with a 2010 US user survey revealing accessing maps and directions as the number one mobile activity (Adobe Systems Incorporated, 2010).

An important feature of smartphones is the ability to download and install mobile applications, otherwise known as apps. Apps refer to software, tailor made for mobile devices which improve the delivery of mobile services. Since individuals and organisations beyond the relatively closed mobile phone market place can develop apps, this has provided a revolutionary opportunity to exploit the mobile computing capabilities of the smartphone. This has resulted in the rapid development of commercial and non-commercial apps for a variety of purposes. Globally, over 300,000 apps have been developed and apps have been downloaded 10.9 billion times (mobiThinking, 2012), however, Localytics (2011) estimate that around a quarter of apps are used only once. Around half of UK smartphone users have downloaded an app (47%) (Ofcom, 2011), this in part reflects some mobile user preference for mobile web (mobiThinking, 2012).

Mobile media is evolving new understandings of what it means to travel. In simple terms, '*travel*' means to move through space, to move from place to place or to go on a journey. The related term, 'transport' generally refers to how people or things are moved and transport research in the tourism field typically focuses on the spatial problem of movement of people or objects from one place to another (Dickinson & Lumsdon, 2010). Travel, however, is imbued with other meanings. Travel can also be virtual using the Internet or mobile media. A phone call transports you to another place, even when conducted in a very public place. The 'new mobilities paradigm' (Sheller, 2006) places social networks and the movement of people, objects, ideas and information centre stage. Larsen et al. (2006, p4) describe five interdependent mobilities: physical travel of people; physical movement of objects; imaginative travel; virtual travel; and communicative travel. As Lemos (2010 p404) suggests "now we have the possibility to move physically/spatially and vitual/informational at the same time".

It is interconnections between people, be that for work, education or maintenance of friendship, and the interconnections between people and the objects we need that cause us to travel. These interrelationships are typically maintained by copresence, but are increasingly managed through communicative travel, due to increasingly globalised networks which in turn yield physical travel to maintain close ties. Social networks can also emerge purely in the virtual world linking communities which are no longer place related (Bradshaw, 2008) and where individual members may never physically meet. Relevant to this is the emergence of mobile social networking which has shifted from

desktop computers to mobile computing platforms (Frommer's Unlimited, 2011) and offers new sharing capabilities beyond hubs for chat and repositories for photographs. Apps are now available to distribute users' diaries and map users' locations in real-time. This brings an opportunity to more actively co-ordinate activities, including travel, in which users can specify the degree of information sharing and with whom they share (Wang et al., 2011). In an analysis of smartphones and their apps, it is therefore impossible to ignore the wider, and more abstract, interpretations of travel.

'Space' and 'place' are terms that are regularly used interchangeable. Space generally has a more abstract quality (Cresswell, 2003), we can talk of physical space, abstract space and virtual space (Couclelis, 2009). Place, on the other hand, has a more every day life, lived in quality (Cresswell, 2003). Wilkin (2008) describes two conflicting strands of research about place. One interpretation centres on place being derived from social and human-environment interactions, or as Bærenholdt, Haldrup, Larsen and Urry (2004, p. 10) explain, "tourist places are produced spaces and tourists are co-producers of such places." The second interpretation focuses on place as a relatively fixed physical entity that structures the possibility of human experience. Until recently, tourism studies were predominantly in the second camp and made a clear distinction between place, as in destinations that pull in visitors, and tourists travelling to destinations (Hannam, Sheller & Urry, 2006). The emergence of mobile media has added a further dimension to the problematisation of place. Given their ubiquity, that is the ability to be in connection with everyone all of the time, and the capacity of smartphones to transport people to other social settings (Humphreys, 2010), at an abstract level it is now less clear which place people are in. Thus, the analysis here takes a more relational view in which smartphones, as socio-technical devices, are transforming how we engage with place (Wilkin, 2008).

There are various conceptions of 'time' and much variability in how individuals view time (Middleton, 2009), some of which is culturally specific. The clock-time, that governs Western industrial society, is just one conceptualisation, albeit one that is dominant and hard to ignore. However, mobile media are loosening the grip of clock-time on a variety of travel accomplishments, thus this paper examines a more relative view of time. In geography, space and time are often researched together (Merriman, 2012) and concepts such as space-time (see for example, Southerton, Shove & Warde, 2001) and timespace (see for example, Hannam et al., 2006; Stein, 2001) are used. As with the ideas of space and place, there are theoretically multiple spaces and times (Thrift, 2000) and Schwanen and Kwan (2008) discuss the idea of 'other' mobile mediated space-times.

New technologies and emerging socio-technological configurations will shape the future as systems of provision are intrinsically enmeshed with what we do and how we do it (Shove, 2010; Wajcman, 2008). Within tourism, as with other areas of life, smartphone apps have the capacity to reshape dimensions of social life including travel. Wajcman (2008, p. 66) describes this as a process of 'mutual shaping'. Smartphones are just one of the many material things we interact with that tourism research often overlooks, yet the tourism transport system depends on the use of objects and technology such as cars and

phones (Haldrup & Larsen, 2006; Van der Duim, 2007). As such, tourism can be seen as a network of people, things and places. Smartphones are increasingly playing a role in this 'hybridized mobility' (Haldrup & Larsen, 2006, p. 284) as they guide people both to and around destinations and attractions, reveal new experiential opportunities, make connections with other people, enable fluid temporal arrangements and negotiate immediate tourist needs.

Research methodology

Smartphone apps can be categorised by end use application or by technical functionalities. Wang et al. (2011) grouped tourism travel related apps into 12 application categories based on the information services provided, for example, destination guides, food finder and local transportation. As a first step in analysing how smartphone apps conceptually alter our understanding of tourism travel practice, this paper explores the technical functions embedded in apps. This focus on functionality is adopted in order to understand how the smartphone alters human interactions with other people, places, objects and information. The ubiquity of mobile media changes the traditional understanding of a transport system connecting a relatively static network of fixed physical entities and requires development of new conceptual understandings. Given the diversity of functions, tourists currently use a combination of different apps for different travel purposes. For example, you might use a map app to work out how to reach a destination, a branded app, such as 'Starbucks UK', to find a favourite café, and share your location with a friend using 'Glympse' (a map tool that briefly reveals your whereabouts to others) in order to meet up. At a conceptual level these apps reveal real-time spatial relationships and can provide estimates of arrival times to allow journey planning. In another example, you might use a social network tool, such as 'Facebook', to update your status to geographically and temporally dispersed friends, here conceptually 'travelling' to another space-time.

In order to evaluate current app functionalities in the tourism travel domain a selection of tourism, map and travel apps were purposefully selected. First, the apps used by top UK visitor attractions were identified. A sample of top attractions (n=164) were identified from the Association of Leading Visitor Attractions and Visit England. Of these, 73 had an app (Table 1). The final list yielded a total of 22 attraction apps since many of the attractions were National Trust or English Heritage owned and respectively share generic apps.

[Table 1 about here]

To augment this list a broad search for Apple and Android apps with functionality related to the tourism travel domain was conducted online and using the iPhone 'app store' (Apple and Android provide smartphone operating systems). Given the thousands of apps available and the many apps specific to tourism destinations and transport providers, that are essentially variations on the same capabilities, this is not an exhaustive list and apps

with a range of features and functionalities were selected. From this review, 49 destination based apps, including 14 from National Parks and 7 apps with a tourism related search function (for example, 'beach finder') were selected. In addition, a range of generic travel and map apps were explored. Analysis explored app functions and contextualised their use in the tourism travel domain. Apps embed varying degrees of sophistication from those that are compact versions of web sites ('light' web sites), to those which embed higher levels of mobile computing capabilities. Through an iterative review process, a series of broad technical app functions emerged (see Table 2).

Findings and analysis

Overview of current app functions

A primary function of most tourist apps is *information* delivery at various levels of sophistication (Table 2). This largely replicates other information sources (travel guides, Internet), however, the ubiquity provides immediacy to the information. Real-time and place specific updates are especially valuable to the mobile tourist who can adjust travel plans accordingly. An evaluation study of a mobile tourism guide, myMytileneCity (Kenteris, Gavalas & Economou, 2009), revealed that users liked the way information was adapted to their personal needs and preferences. However, no location capabilities were embedded in the system with users noting its absence and seeking improved digital mapping tools and more personalised itineraries. Users therefore recognise the higher level capabilities of their smartphones and desire increasingly spatially and temporally relevant tourist information.

With *two-way sharing capabilities* user data can be shared with the app provider and between users. For instance, in explicit sharing, people give away personal information to businesses in exchange for better services (see for example, Buhalis & Law, 2008), in exchange for travel deals (Frommer's Unlimited, 2011) or to share location based data with other users (for example, using Facebook). Whilst ethical and legal messages warn users of the capacity for their devices to be transmitting personal data to the Internet, our curiosity and desire to connect to people, places and things often encourages us to agree to the terms of conditions of any new app without reading about its implications. Users may therefore be unaware that they are sharing information with a provider (implicit sharing). This enables mining of crowd sourced data and can include information about app use characteristics and also temporal and spatial data about a user's travel.

Typical smartphones include more than eight sensors providing opportunities for *context awareness* (Dey, 2001). Beyond the microphone and camera, that became standard equipment on early mobile phones, accelerometers, gyroscopes, GPS, digital compasses and proximity sensors have become standard issue with contemporary smartphones:

- Accelerometers are able to detect the magnitude and direction of a device as it moves. By measuring acceleration across single or multiple axis, many smartphones use accelerometers to simply understand which way the user is

holding up their phone. Sensing tilt and orientation have subsequently been useful to support game play, sport and photography applications.

- Gyroscopes are used to detect rotational movement. Although the same data maybe derived from accelerometers, gyroscopes offer smartphones a far higher precision reading of the orientation of a phone.
- GPS, short for Global Positioning System, is one of several sensors (others include wifi and mobile cell towers) that correlate signals to establish the receiver position according to longitude, latitude and elevation. Offering a high-level of accuracy in open spaces (around 10m), these sensors are less accurate within dense urban spaces as buildings obscure access to satellites, however the technology is rapidly improving.
- Digital Compasses were introduced as GPS became standard in smartphones to further aid navigation. Able to sense magnetic fields, the electronic sensor tends to be specifically applied to mapping applications to simply allow an onscreen map to be orientated toward the North.
- Proximity Sensors are used to detect when smartphones become close to objects. The most common use is when the phone is used to make a call. The sensor detects when the user moves the phone close to their ear, and the software turns down the brightness of the screen and disables touch functions so that the owner's ear does not press unwanted keys. 'Near-field' communication using radio-frequency identification (RFID) is another example popular in transport systems to make payments.

Installed on each phone as discrete technologies, software is able to access a single or multiple sensors at any time to support functions for specific applications. Often it is the combination of sensors that makes a piece of software innovative as different data is used in correlation to establish information about where someone is, who or what they are close to, what they are doing and which way are they facing. Data from an individual's smartphone can be shared with information on the web and used to further extend a sense of context and opportunity. The range of sensors has increased with every development of the smartphone with new sensor types or better quality sensing being offered as a novel feature to promote particular models. These sensors allow the development of adaptive systems that effectively operate as a mobile personal assistant (Höpken et al., 2010) extending the smartphone's space-time capabilities in response to individualised user needs.

While mobile social networking is relatively well established, sharing capabilities are also extending to 'things', with transport among the first systems to be linked to the Internet with GPS. This is evolving a vision described as an '*Internet of things*', which refers to the technical and cultural shift that is anticipated as society moves to a ubiquitous form of computing in which everyday objects, such as buildings, vehicles, clothing and packages are connected to the Internet and have the "ability to sense, communicate, network and produce new information" (Technology Strategy Board, 2011). This radically alters the current humanistic emphasis on communicative travel and

provides opportunities to data mine inanimate objects to better understand the transport network potential.

In a tourism context, the smartphone, working with simple *tags* such as Quick Response (QR) codes, can greatly enrich the tourist experience at a destination or attraction. QR codes allow the operator of the attraction to post information about specific items, exhibits or locations directly to those locations which the tourist can then access via the smartphone by scanning the QR code. While conventional bar codes are capable of storing a maximum of approximately 20 digits, up to 7,089 characters can be encoded in one QR code symbol (QRme, 2011) enabling a host of static information to be stored such as mobile telephone numbers, contact cards (for example, VCards) and geographic information. Of interest in the tourism domain is the ability to link directly to a webpage (QRme, 2011) which allows graphic rich media, including videos, to be played directly on the smartphone. This enables the tourist to engage with a specific place or object in its own space, allowing it to effectively tell its 'story' via the smartphone and QR code link. 'Visit England' is currently experimenting with such an approach, tagging historic sites with stories via QR codes in Leicester, Shrewsbury, Chester, Rochester and Rutland (Visit England, 2012).

[Table 2 about here]

The trajectory of smartphone and app capabilities is always for more sensors and higher definition. Smartphone manufacturers have always been keen to converge their technology with other portable devices, from mp3 players to gaming consoles, finding ways of helping a user carry just one piece of equipment. In relation to tourism travel there are conceptually three important areas of development. First, improved contexual awareness is realising new space-time capabilities for users; significant given that space and time are core travel concepts. Second, improved sharing capabilities and the Internet of things have the capacity to revolutionise travel organisation within social networks which not only embed people but also objects. Third, data mining techniques are able to integrate data from individuals and objects to reveal new opporunities afforded by the array of travel resources available.

Space-time concepts in mobile mediated tourist travel

The most documented travel related capability of the mobile phone is its capacity to radically alter the temporal and spatial organization of social interactions and the scheduling of co-presence (see for example, Campbell & Kwak, 2011; Kwan, 2007; Line, Jain & Lyons, 2011; Ling, 2004; Neutens, Schwanen & Witloz, 2011). From a society previously rooted in clock-time we are now more able to negotiate meetings person-to-person rather than on the basis of specific places and times. This has enabled a negotiated scheduling around more personal needs and circumstances which is very valuable in a tourism context. Kwan (2007, p. 437) describes this as 'ex tempore lifestyles' in which the detail of meetings and places are spontaneously and continuously renegotiated

changing the start and end point of trips. This makes already complex tourism trips more so as options change en-route and is challenging the traditional understanding of a journey in transport models. This 'micro-coordination' 'softens' the fixed temporal and spatial contexts of meetings and travel organisation (Ling, 2004) and provides enhanced flexibility to tourists.

Already smartphone apps are moving beyond the coordination of people by assisting in the 'micro-moments' of the travel process (Wang et al., 2011, p. 6), for example, using near-field technology to find toilets, entrances to tube stations etc. Visitor attractions are also harnessing this power as push based mobile services can customise information delivery. For example, 'Secret London' and 'London for families' reveal unusual visitor attractions relative to the tourist temporal and spatial location and Flamingo Land reveals the proximity of its attractions and facilities to users, providing essential details such as animal feeding times. As the technology evolves, the context awareness of smartphones will automatically adjust the search radius relative to the speed of the user, that is, software will utilise the smartphone sensors to work out if the user is on foot, cycle or car (Chu, Kansal, Liu & Zhao, 2011). This radically alters the way people interact with destinations and find visitor attractions, substituting existing tools, such as guide books and tourism information centres.

In this area there are several emerging technical capabilities of note. Improved sensing capabilities linked to the availability of internal maps of buildings will improve indoor navigation and location. This will assist tourist mobility through large museums, sports stadia, shopping malls and other large indoor spaces, with improved altitude readings providing accurate data for tourists as they climb tall buildings and move through particularly hilly towns and cities. As smartphone apps have made use of onboard sensors to support sport and healthy living programmes, such as running, cycling and dieting, it is highly likely that medical and environmental sensors will become part of the smartphone. For example, humidity, temperature and pollution sensors will help inform tourists about local conditions. Pico projection, that is image projection built into a mobile device, will develop to enable the overlay of information onto objects improving the interpretative capabilities of smartphone apps and visitor interaction with destinations.

As a new socio-technical substrate, the smartphone provides a tourist with an evolving 'local knowledge' that would otherwise take time, repeat visitation and extended familiarisation to achieve. This 'local knowledge' is multifaceted and multilayered, affording the tourist a new sense of security. There is potential to reveal localised opportunities, avoid unnecessary trips and reduce travel distances within the destination area, though enhanced local knowledge may also trigger new trips as opportunities are revealed. Combine this with the capacity to renegotiate meeting places and times, one of the suggested outcomes of widespread smartphone use is a higher degree of unplanned and opportunistic travel behaviour as choices are changed by apps (Wang et al., 2011) which facilitate increasing access to information on the move (Buhalis & Law, 2008; Frommer's Unlimited, 2011).

Improved awareness of potential opportunities has the capacity to develop new travel skills, or to re-skill people who have lost touch with the use of public transport in a car based society (Dickinson & Robbins, 2007). Tourists also lack the geographical knowledge to confidently execute walking trips. For instance, tourists regularly use the London Underground system to make a trip which would be quicker on foot, not being aware of the destination's proximity to their current position. New skills are also needed in rural tourist contexts. Dickinson and Robbins (2007) found that the car was used for 40% of trips less than 1km in a UK rural destination where tourists' lack the local knowledge to predict relative distance and travel time by foot. Map apps readily reveal such information and the manufacturers of bespoke GPS satellite navigation systems (for example, TomTom) are now producing their software specifically for smartphones to make wayfinding for the novice traveller easy. The widespread adoption of mobile media is therefore pivotal to a moment of transition that might be harnessed to reduce CO_2 consumption in travel.

The implications for the tourism sector are manifold: delivery of tourist information at attractions and destinations; improved visitor confidence through local knowledge and ease of navigation; more independent, opportunistic and unplanned behaviour; and new skills developed in relation to travel modes. A core opportunity is the potential for more efficient destination based travel. Working with an appropriate suite of apps, destination managers, attraction providers and tourists can avoid unnecessary car trips, reveal opportunities to substitute car trips with other modes and direct visitors to local leisure opportunities.

Social networking and the Internet of things

From a transport perspective, some of the most appealing opportunities lie in the capacity of apps to extend social networking principles not just to people on the move but also moving objects (vehicles, the things tourists need such as produce) and the networks on which people and objects move. Existing technology used in logistics can track objects in transit and public transport vehicles now use GPS. This reveals real-time locations as opposed to timetabled schedules (for example, London Bus Checker). It is feasible to provide users with information on exactly where the next bus is, how soon it will arrive in real-time rather than relative to the timetable and whether it has seats available. This removes temporal uncertainty and eliminates much of the waiting for public transport. Critically, for a tourism user, such systems also enhance user confidence as they reveal bus routes, places and alert users when to alight in an unfamiliar environment. By extending social networking principles to transport users, their individual and collective vehicles (cars, buses, trains, coaches) and objects, an 'Internet of things that move' emerges. This creates new opportunities for shared use of resources, collaboration and sustainable travel. For example, the car network is under utilised since average car occupancy is 1.58 (Parliament UK, 2010) and, until recently, it was difficult to spontaneously access this spare capacity. New apps, such as Avego Driver (http://www.avego.com), are changing this and allow car owners to distribute their routes

and real-time location to people who require a ride. The adoption of 'near-field' technologies using RFID will revolutionise this 'Internet of things' facilitating data exchange between people and objects as well as object to object.

A novel opportunity affoded by an 'Internet of things that move' is the application of tagging to mobile objects (including vehicles) as conduits to exchange information. Tourism research often overlooks the significance of 'things' and the agency of objects in determining mobility patterns. For instance, a forgotten item can generate an additional shopping trip by car. The transport network consists of many mobile objects that afford travel opportunities, such as cars and other vehicles. It is these 'things' that we need or utilise in the day to day tourist experience that are often ignored in tourism research (Van der Duim, 2007).

An aspect of social media, well documented in the tourism field, is the use of Web 2.0 for user generated content (Buhalis & Law, 2008). Smartphone apps can manage the upload of photos, blogs and recommendations to various social media sites while on the move. During travel crises, such as the volcanic ash cloud which grounded much European air traffic in 2010, media such as Facebook and Twitter provided an outlet for frustrated travellers and through user generated content these systems delivered real-time travel updates to other users. In this way word of mouth recommendations are generated on the move suggesting places to go and providing immediate feedback on attraction and travel conditions, such as crowding and congestion. This spontaneously alters trips as tourists visualise new opportunities and are made aware of transport problems and is increasingly difficult for attractions to manage. User generated content is already exerting a powerful influence in tourism marketing (Buhalis & Law, 2008) and will increasingly exert a powerful influence over travel and, if harnessed appropriately, could be an efficient transport management tool. For example, attraction managers could use this tool to reveal peak travel flows to potential visitors, identifying when capacity is exceeded and suggesting opportune times to visit. While information of this sort is currently delivered by other means, it lacks the capacity of user generated social media to respond to live updates, such as a road traffic accidents or unexpected weather conditions. One project developing such use of social media is 'Our Travel' (Our Travel 2011). This embeds users in a social network community to share live travel updates and enable more informed travel decisions.

Data mining

The rate of development of the smartphone and its ubiquitous properties in many cases outstrips our ability to understand their potential as each new device moves further away from the capabilities of newspapers, books, televisions and even desktop computers. The potential for sharing information between the millions of networked devices, offers for many developers and organisations an exciting platform for reading, sharing and engaging with the environment. Correlating live data from people on the move or at rest, projects an image of the world in which data becomes more useful for navigating through

time and space than seeing the world with our own eyes. Centres such as MIT's Senseable City Lab invest heavily in developing projects that capitalise upon the rich and diverse data sets that are available across social and environmental systems to identity benefits for health, energy and economics. Consisting of a mixture of people carrying sensing devices, including mobile phones, to everyday 'things' that are able to transmit data about their condition, the production and consumption of the contemporary city is beginning to be manifested in real-time to allow connections to be made and opportunities realised. As the databases grow, information about how we move through places is becoming denser allowing analysts the opportunity to identify patterns, routines and future connections. The future of the 'Internet of things' suggests that every new object manufactured will be part of this extended Internet, because they will have been tagged and indexed by the manufacturer during production. It is also envisaged that consumers will have the ability to 'read' the tags through the use of mobile 'readers' and use the information connected to the object to inform their purchase, use and disposal of an object.

Beyond transport, artefacts such as buildings, packages in transit and consumer products, are all expected to be connected to the Interent in some form. From the provenance of items in the hospitality chain, where tags let consumers find out where their fish was caught, to projects such as Digital Interactive Graffiti that lets people leave messages on places for tourists, 'things' are becoming part of the Internet. At present the smartphone is critical at interfacing and linking up many of these 'things', such as scanning bus stop QR codes. The smartphone is the glue that connects many of the discrete networks and the creative use of apps and a constant link to the Internet is enabling companies to glean more and more information about social activity. As people, things and places become increasingly networked the visions offered by large corporations and small research centres promise new opportunities for correlation and connection.

One of the most exciting possibilities is the capability of remote systems to mine user data to both better understand existing travel patterns and to identify novel travel opportunities. Projects are emerging to consider the best use of these data on the trajectories of people, objects in transit and modes of transport (for example, All Hands, a UK Digital Economy project). Data of this sort can be compiled anonymously but could equally, subject to user agreement, be shared among a social network of users willing to provide social assistance. This raises various privacy, security and ethical issues that are currently subject to scrutany by both governments and developer communities. There are also other challenges. Several authors point out that new technology can have unintended consequences (Shove, 2010; Wajcman, 2008) as novel practices materialize and people use the emerging opportunities in "creative and often unexpected ways" (Couclelis, 2009, p. 1559).

One project exploring these opportunities is Sixth Sense Transport (www.sixthsensetransport.com). This provides a "glimpse of future mobility patterns" making collaborative travel and transport opportunities in the immediate future visible to users in order to reduce CO_2 emissions and improve quality of life measures (Davies et al

2012). Tourism is one of its experimental domains. From a theoretical perspective, the project poses a number of computing and social scientific challenges. Drawing on a variety of data sources, such as public transport travel feeds and data mining of individuals' travel 'traces' from smartphones, predictions can be made relative to the immediate future travel plans of users. For instance, one research challenge is predicting local traffic congestion conditions for users and visualising the time it will take to reach various local attractions under current weather conditions and by travel mode, based on date and time of day. While local people and repeat visitors gain such tacit knowledge through experience, tourists regularly encounter traffic congestion that is detrimental to the tourist experience and a significant tourism management problem (Dickinson, Calver, Watters & Wilkes, 2004; Mallet & McGuckin, 2000). Prediction may enable tourists to make more informed choices.

While it is relatively straightforward to make predicitons about aggregatge travel patterns, and this is a well established field of transport modelling, it is far from trivial to predict the individual patterns required to reveal collaborative opportunities. Current car share tools, such as Avego Driver, are based on real-time and user input to reveal sharing opportunities. Predicting the future convergence of individual vehicles, people and other moving objects presents a much more complex computing challenge. Concurrently, social scientists have been grappling with ideas about multiple temporalities and the emergence of a more flexible relationship with time and transport. There is limited understanding of people's response to temporal uncertainty and a need to better understand responses to time scheduling, time stress, degrees of travel accuracy and temporal fluidity. Time is integral to many explanations of tourism with many references to tourists stepping out of time (Deem, 1996; Elsrud, 1998; Richards, 1998). However, tourists are in many ways even more regulated by time as they seek to plan travel based around catching trains and buses while meeting the schedules of attraction opening hours and times for meals. Research on these topics will enable us to better understand how people respond to various temporalities of travel in the tourism domain.

Conceptual developement

All this adds new complexity to the transport model based on the movement of people and objects from point A to point B. While this is an over simplification of the transport problem, the use of smartphones introduces a new relativity to travel and sensistivity to the relationships: between people; between people, objects, places and information; and between objects and other objects. The factors at play are illustrated in a conceptual diagram (Figure 1). This illustrates how the smartphone and associated apps manage travel tasks for users through the smartphone's ubiquitous capabilities of information exchange, sharing, access to the Internet of things and tagging. Meanwhile context awareness manages content relevant to user space-time and needs. Connections to data repositories, and beyond these data mining initiatives, draw on collective user data to inform users of unique travel opportunities. All of this then provides new user travel competencies as the tourist relationship with space (destinations and attractions), time,

other people, objects and information is modified. This is altering the organisation of travel and tourist travel behaviour at a micro and macro level. At the current time, the main travel related role of smartphones is better visualisation of where objects, places and other people are relative to users. Future developments are likely to enable better understanding of patterns of mobility in order to make informed suggestions to users relative to where users and other moving people and things are going to be.

[Figure 1 here]

At a first glance, this might seem overwhelming for a user and several studies draw attention to the increasing scheduling complexity of contemporary life (see for example, Cass, Shove & Urry, 2005; Southerton et al., 2001; Szollos, 2009; Wajcman, 2008), however, given greater contextual awareness embedded in smartphones, much of this can be automatically filtered. Systems, in the app platform or smartphone operating system, have the capacity to selectively present relevant information to users dependent on the user context and choices previously input by users.

Emerging issues

At a destination level, traditional forms of tourism and travel information provision will become obsolete as smartphones re-engineer and personalise the delivery of tourist information and tourist travel products. Tourism providers therefore need to be agile to manage the currency of information delivered in a mobile context. This is especially so given the immediacy of user generated content (Kaplan & Haenlein, 2010). Also, given the relatively high proportion of apps that are used only once (Localytics, 2011), tourism organisations must consider carefully the app functionalities they wish to provide relative to the service delivered. They also need to be aware of the range of purpose made apps that might most effectively deliver relevant functions. At a macro level, travel agents, which have already declined due to competition from Internet based services and related growth in independently organised travel (Buhalis & Law, 2008), are likely to experience a further weakening in demand. Smartphones compete by providing a management tool for the overall tourist travel experience (Höpken et al., 2010) from anticipation, through purchase, to the actual travel experience and even in the management of subsequent memories.

There are also user inequalities as the level of ‘time sovereignty’ (Cass, Shove & Urry, 2004) and access to ‘network capital’ is socially differentiated. Some sectors of society have much greater freedom to dictate their timing of travel than others. The transport poor, who are more reliant on public transport, would benefit from better opportunities to visualise the available transport resources using smartphone technology, but are also likely to be those most excluded from use. While mobile manufacturers are developing low-end smartphones that will be much cheaper, primarily targeting emerging markets in India and China, use is likely to remain socially differentiated. In addition, even for those who have access to mobile media, research highlights the inequalities embedded in use

practices. For instance, women tend to play a greater role in maintaining social networks for travel assistance (Schwanen & Kwan, 2008) and mobile media is likely to reproduce social roles in tourism settings and reinforce the differentiation of society. However, on a more optimistic note, there is scope to embed accessibility travel information into apps enabling more fluid travel opportunities for people with disabilities and the growing ageing population (Plaza, Martin, Martin & Medrano, 2011). Much better understanding is required about technology uptake and acceptance. Use will inevitably be differentiated and therefore may lead to wider inequality.

Given the growing importance of social networking and the potential for wider social assistance in travel, there is a need to explore existing patterns of social assistance and the potential for further collaboration in the tourism domain. Research needs to explore not only types of collaboration but also the scope of commitment with different people be they family, friends, acquaintances or other tourists. This raises privacy and security issues with two areas of concern. First, the transmission of individuals' data by apps to unknown providers, often with little or no user knowledge of this taking place. Here the concern is that data is misused. Given the sensitivity of this data, for instance, records of user location, there is pressure for further regulation and ongoing work analysing the issues (Sadeh, Hong, Cranor, Fette, Kelley, Prabaker, Rao, 2009). Second, the growing tendancy of users to upload personal information to shared communities. While some degree of personal information exchange is essential to develop trusting communities that might provide travel assistance, there is concern about abuse of trust and significant safety issues. All this requires careful analysis on the part of developers and stringent systems to maintain an appropriate level of privacy and provide a safe and secure system for users. To this end, in June 2009 the UK Information Commisioner's Office released a Privacy Impact Assessment handbook (Information Commissioner's Office, 2009) and guidance on Privacy Enhancing Technolgies (Information Commissioner's Office, 2012). An example of these issues is provided by Sixth Sense Transport which asks tourist users from the real world community of a campsite to join an on-line social network to facilitate sharing of local travel resources. This raises questions about the degree of trust required in both real and virtual tourism communities to enable user adoption. Existing tourism research has not considered the potential for collaborative travel of this nature. Early indications suggest limiting the community to an individual campsite provides reassurance to users who feel part of a mutual community.

There are also concerns about data use when tourists are abroad. While there is an ongoing move to restructure mobile data roaming tariffs for use in other countries (BBC, 2012), this has been a barrier to use at the present time. Current evidence suggests price structures will be amended in the near future and wifi will be increasingly available in tourist settings such as accommodation, attractions and cafes/bars. There has also been an increasing customer migration from pay-as-you-go to pay monthly mobile contracts, especially for smartphone users (Ofcom, 2011). These contacts increasingly embed incentives such as as package of international data usage to overcome international data roaming tariffs.

Conclusion

The smartphone, and its associated apps, is in the process of revolutionising the tourist negotiation of the travel domain. Technology in this field is rapidly evolving and designers, together with users, are realising new opportunities to mediate travel experiences. Technology innovators have recognised the potential of smartphones within the tourism field (Höpken et al., 2010) and research in the computer science field is well established. On the other hand, research on the role and impact of mobile media in the tourism travel domain, and the transport domain more widely, is in its infancy. Tourism studies has yet to grasp the full implications of the revolution taking place which has significant implications for our understanding of transport systems and will require new transport models to understand demand. This paper contributes to understanding how evolving mobile technology mediates travel decisions.

Leading visitor attractions and destinations are increasingly adopting smartphone app technology. A review of apps demonstrates a range of functionalities are being employed from basic systems delivering information via 'light' web sites to more sophisticated context awareness tools. Apps have emerged with functions tailored to different elements of the travel experience providing a suite of apps suited to tourism travel. Based on enhanced contextual tools, smartphones are evolving society's contemporary understandings of time and relationships with place and things in significant ways for travel. First, smartphones have enhanced the temporal alignment between people, the things they need, destinations and attractions, and activity options by providing better awareness of opening hours, immediate opportunities and the time required to access resources. To some degree this offers a liberation of tourism from clock-time regimes enhancing the tourist pursuit of 'time out' from the temporal constraints of everyday life (Elsrud, 1998; Richards, 1998). Second, smartphones provide tourists with enhanced spatial tools and awareness. The ability to access place related information and to visualise the spatial relativity of tourist facilities, resources and activities leads to knowledge rich visitors. This temporal and spatial awareness improves travel coordination and there is significant potential for destination based transport management tools. These opportunities are highly individualised and provide the tourist with personal travel planning tools.

While it would be future gazing to identify the next major developments there is obvious potential in data mining. The ubiquity of smartphones means they compile vast quantities of mobility related data that has enormous potential for understanding and predicting travel patterns. Each time a smartphone user moves they leave a travel data trace that can be captured through different sensors. Mining of these data is in its infancy but could provide a myriad of opportunities. For instance, visualisation of travel traces to users might make people appreciate the time input needed for a potential journey and cause them to re-evaluate their plans and use of time. At a destination level, travel congestion might be better understood and managed in real-time leading to the development of new leisure travel models. As a technological development with opportunities to enable sustainable travel, smartphone adoption raises research challenges. Given that

smartphones are altering the spatial and temporal 'presence' of people, objects, vehicles and information, there is a need to better understand these emergent 'flows' to feed into new tourism transport models. Models need to be more receptive to abstract as well as physical space-time and would do well to consider concepts such as 'action space', developed by Couclelis (2009), that encompase physical movement as well as communication over space.

Since this paper presents material pertaining to a fast moving technological field, the analysis is limited to a particular point in time and will date quickly as the capabilities of smartphones evolve rapidly. The paper's intention is therefore primarily to draw attention to a current issue of significance to research and industry. Society is at a point of transition where socio-technical devices are evolving new travel practice that might be harnessed to tackle contemporary travel problems. While the technical functionalities described will evolve, and therefore require new conceptualisation, it is hoped the paper will stimulate interest and research to grasp the opportunities that smartphones afford to decrease travel related CO_2 emissions.

The policy implications are manifold through reducing the need for car travel, avoiding unnecessary trips, reducing the distance travelled or time spent in congestion both to and at destination areas. Travel behaviour change is seen as a core policy to address the climate change impacts of both utility and tourism related travel. Evidence to date suggests limited success of behavioural measures to bring about suitable reduction in car use and distance travelled for tourism (Prillwitz & Barr, 2011). Mobile media therefore provides an innovative new avenue of exploration. Personalised travel planning has been seen as an optimal policy to affect behaviour changes (Sustrans, 2005) and the smartphone is emerging as a suitable implementation tool.

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Table 1. Visitor attraction apps

	N	%
Attraction specific app	20	12
National Trust generic app	43	26
English Heritage generic app	10	6
None	91	55
Total	164	100

Table 2. App functions in the tourism travel domain

Function	Description	Tourism travel use	Examples
Information	Information only or information plus search function.	Attraction/destination description or interpretation Timetables for travel Static maps to locate attractions, accommodation etc	Jurassic Coast @Swanage
Two-way sharing capabilities	Two way implicit sharing - information from the user (eg about their location) is sent to the provider. User consent is embedded in user agreements and user may not be aware.	Data mining by app provider, for example, to research visitor catchment, travel routes, frequently viewed elements of attractions.	Beachfinder
	Two way explicit sharing - users specifically provide information back to the app. This may build on social networking capabilities to share information with selected friends, a social network of users embedded in the app, the wider Internet community (eg blogs) or the app provider.	Use by industry in market research, for example, to better target travel marketing material. Location sharing. Web 2.0 – user recommendations both live and historic	Facebook Glympse Avego Driver Comob
Context awareness	Services based on the smartphone's contextual sensors. The most prominent of these are current temporal and spatial location. Capabilities are emerging relative to other context awareness tools embedded in smartphones such as accelerometers.	Attraction alerts targeted relative to visitor proximity. Provision of live travel information, weather, attractions currently open, changes to attraction timetable. Travel itineraries specified by users.	Secret London TubeMap National Trust
Internet of things	Ability to communicate not just with other people but also with everyday objects such as vehicles and parcels.	Provision of real-time bus/train positions. Tracking of deliveries.	London Bus Checker
Tagging	Ability to leave messages on places and objects for future visitors.	Destination and attraction interpretation. Visitor generated stories.	Visit England

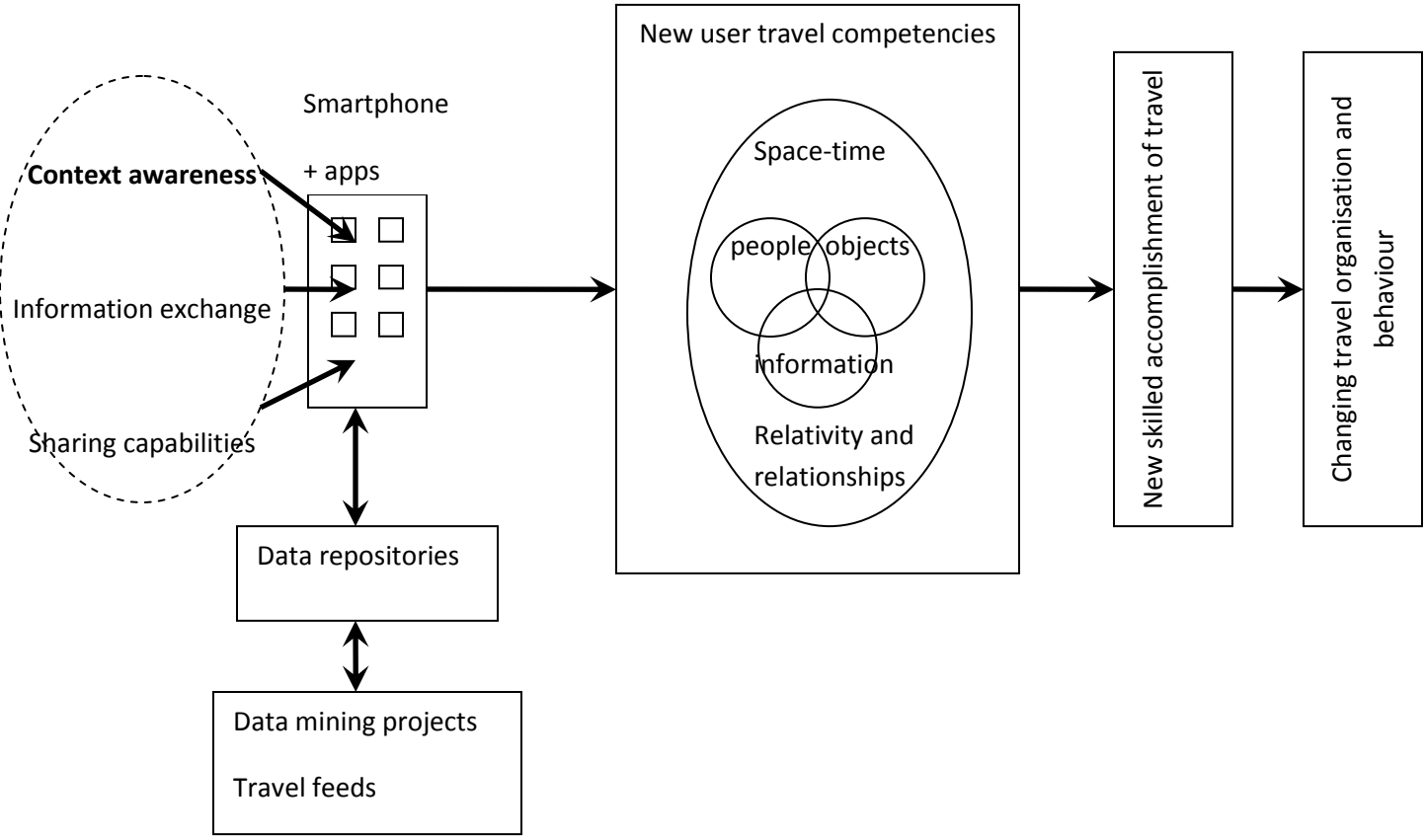

Figure 1. Conceptual diagram