Mapping, sensing and visualising the digital co-presence in the public arena

Ava Fatah gen. Schieck, Alan Penn, Eamonn O'Neill[1].
The Bartlett Graduate School, University College London, UK,
[1]Department of Computer Science, University of Bath, UK.

Key words pervasive systems, digital presence, urban encounter, digital identity

Abstract This paper reports on work carried out within the Cityware project using mobile technologies to map, visualise and project the digital co-presence in the city. This paper focuses on two pilot studies exploring the Bluetooth landscape in the city of Bath.

Here we apply adapted and 'digitally augmented' methods for spatial observation and analysis based on established methods used extensively in the space syntax approach to urban design. We map the physical and digital flows at a macro level and observe static space use at the micro level. In addition we look at social and mobile behaviour from an individual's point of view. We apply a method based on intervention through 'Sensing and projecting' Bluetooth names and digital identity in the public arena.

We present early findings in terms of patterns of Bluetooth flow and presence, and outline initial observations about how people's reaction towards the projection of their Bluetooth names practices in public. In particular we note the importance of constructing socially meaningful relations between people mediated by these technologies. We discuss initial results and outline issues raised in detail before finally describing ongoing work.

1. INTRODUCTION

The public arena offers a 'stage' for interactions on which people negotiate boundaries of a social and cultural nature. For instance, public spaces such as the bus stop or the café can act as ‘encounter stages’ on which people meet, recognise, interact with and ignore one another. Frome time to time events change the status of these interactions – the bus being late may stimulate conversations between strangers – but on the whole these interactions seem strongly bound to social conventions.

With the advent of mobile and pervasive computing, emergent technologies such as GPS, RFID and Bluetooth[1] are becoming rapidly embedded in just about every consumer good and artefact. Bluetooth-enabled mobile devices, if set to discoverable mode, can emit a digital field that enables them to interact with nearby devices creating a platform that could act as a ‘stage’ for potentially new interaction types that could give different meanings to our activities and our environment.

In an urban environment with mobile and pervasive computing systems interaction spaces are not limited to architectural spaces but also include spaces that are created by the mobile artefacts. Interaction spaces define the physical boundaries within which the device or artefact is usable (O’Neill et al, 1999).

We need to understand how pervasive technologies interact and interweave with the built environment to create the spaces that frame and influence people’s behaviour on a city scale. In order to achieve a better understanding of the urban landscape augmented with the digital landscape of a city, we need to expand and adapt our understanding and practice of urban design by looking at the urban environment as an integrated system mediating both the built environment and pervasive systems.

The current domain of mobile and pervasive computing lacks concrete methods for recording, modeling, analysing and understanding main properties of users and technologies in the urban context. Recent research has addressed some aspects of pervasive systems in urban contexts but has not considered the design of pervasive systems as an integral facet of urban design. Some work attempted to understand existing city behaviours, principally as a resource for designing new applications. Paulos and Goodman [2004] studied the phenomenon of familiar strangers – people we become accustomed to seeing in urban settings but do not communicate with – by asking subjects in Berkeley to record the people they recognised. This became the basis for tools designed, for example, to augment a user’s sense of social relationship to different parts of a city. Others have looked principally at physical behaviours in cities, which themselves are often rooted in social behaviours. Höflich [2005] studied the movements and body language of people in the Piazza Matteotti in Udine as they made mobile telephone calls, relating them to the architectural features of that

[1] A short-range electro-magnetic field that surrounds the mobile device forming a digital body.

square and the different types of engagement people have with their interlocutors versus their surroundings. He identified signature patterns and paths of movement, which the work of Mobile Bristol and Urban Atmospheres (Reid et al, 2005) also identified in their particular settings, reflecting a common interest in how technologies affect paths through space. While this informal study gives a flavour of aspects of city life in different places, we aim to develop a basis for more systematic comparisons.

Within the Cityware project we are observing the existing situations and practices, experimenting with wireless, mobile and located technologies, as well as constructing installations to experiment with new forms of human interaction (Fatah gen. Schieck et al, 2006). In our research we focus on wireless interaction spaces generated by Bluetooth devices. We are detecting, identifying and recording the presence, type and distribution of Bluetooth interaction spaces over space and time.

On one hand, Bluetooth proximity detection has been applied in a number of projects. For instance, Eagle and Pentland [2006] used Bluetooth proximity to determine the social network of staff and students in an experiment with one hundred students on a university campus over the course of nine months. A number of mobile systems apply proximity technologies to infer encounter by detecting nearby people. For instance the application Wireless Rope collects information of surrounding devices using Bluetooth. Like a real rope, the application gives a group immediate tactile or audio feedback when a member gets lost or approaches the group. In this way everybody can fully engage in the interaction with the environment, without worrying about keeping track of the group. Another example is Jabbwerwocky, which is based on proximity detection. The program recognizes strangers and familiar strangers when they meet, in addition to the direct interaction with familiar persons (Paulos and Goodman, 2004).

On the other hand Bluetooth technology and pervasive system are applied in a number of projects in order to make city centre easier to navigate, walk around, and to appreciate by pedestrians. The project Spatial Metro, for instance, applies a Bluetooth-activated process which is triggered when visitors' mobiles are detected by special access boxes installed along routes and at places of special interest in Koblenz, Germany (Heisser et al, 2006).

In our research we aim at understanding the city as a system including physical and digital forms and their relationships with people's behaviours in the city.

We are interested in designing, not just the architectural space in which people move and interact, but also the interaction spaces (Kostakos and O'Neill, 2004; O'Neill et al, 2004) for information which they discover and use and which support their movements, behaviours and interactions within architectural space. An important feature of interaction spaces is that they are defined both by the characteristics of the device and by the architectural space in which they are situated.

Interaction spaces may be visual, auditory or wireless. Wireless interaction spaces created by technologies such as Bluetooth often have mobile centres, and move around as users carry their devices through the city. As they move, they may come into contact with various other features of the digital landscape: services beaming out of an interactive poster, Bluetooth phones belonging to friends, colleagues and strangers, as well as various Bluetooth devices such as headsets or keyboards.

In order to understand and analyse mobile and pervasive computing features as integral aspects of that environment, we are developing, applying and refining methods of observing, recording, modelling and analysing the city, physically, digitally and socially. We draw on our research on established methods in the space syntax approach to urban design. Space syntax, an architectural approach describing the relationship between space, movement and encounter on an urban scale (Hillier & Hanson, 1984; Hillier et al, 1993), provides us with a systemic approach to understanding and designing the city and with a range of methods and modelling tools that have been extensively tried and tested in both analytical and design practice.

In the following section we describe briefly our attempt to develop techniques that extend conventionally applied methods in understanding the traditional architectural features of the urban environment to take account of the digital, as well as physical, form of the city.

1.1 Exploring encounters in the city

The urban built environment plays a critical role in the construction and reflection of social behaviors. This can be seen in the way it acts to structure space. Urban spatial morphology not only reflects and expresses social patterns, but can also play a part in generating these patterns, providing a platform for rich and diverse social encounters (Hillier and Hanson, 1984). The potential impact of new technologies on shared interactions and their role in influencing social behavior in urban space is often accompanied by speculation.

In our work, we are interested in understanding new types of interaction in public space enabled through pervasive and mobile computing systems. In order to achieve this we are applying established methods for spatial observation and analysis used widely by space syntax researchers. Space Syntax analyses cities as systems of space created by the physical artefacts of architecture and urban design. Cities are very dense and heavily populated, and hence collective activity gives rise to a pattern of use and movement that is independent of the intentions of the individual, but reflects morphological factors in the setting itself (Hillier, and Hanson, 1984). According to Space Syntax research, key to urban function at the level of movement of people, is the way in which each space is accessible from every other space in the city, not only in terms of metric distance, but rather in terms of topological distance, or the number of changes of direction needed to move from one space to another. In many cases high correlations are found between the measures generated by Space Syntax analysis of urban spatial morphology, and flows of people counted in real urban space. This is supported by numerous studies, mainly of pedestrian movement, indicating that under normal conditions the spatial configuration of the urban grid is in itself a consistent factor in determining aggregate movement flows (Hillier, 2000). Our observations of movement flow in Bath indicated that flows of people in Bath ranged from high flows of 2750-4000 people per hour to low flows of 250 people per hour or less. The degree of correlation in Bath is low in comparison to that found in other cities. This indicates that patterns of movement are likely to be heavily influenced by a range of other factors – location of tourist ‘attractors’ for example (Fatah gen. Schieck et al, 2006).

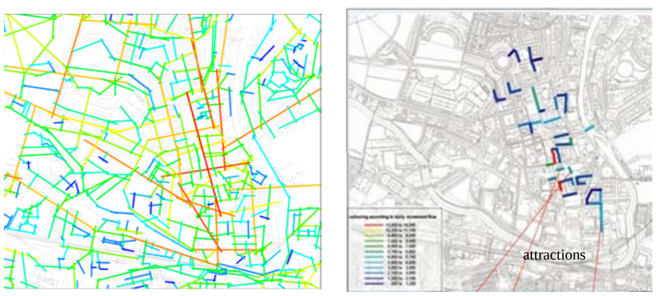


Figure1. left: Axial map of Bath, right: Movement flow The axial map is a representation of part of the street network of Bath as the ‘fewest and longest’ lines that cover the system (the axial map). Observations are then made at different times of day of movement flows along each street segment by counting people passing points on a street, ‘imaginary gates’, and indexing them in flows per hour through that gate

An urban pervasive computing system is a system that includes both humans and devices as components. When people and devices move through an urban environment they come into contact with each other creating additional patterns of encounter between diverse combinations of users, places, mobile devices, fixed devices, and services. In this complex environment we face the challenge of how to record, represent and understand the patterns of presence and use of the diverse forms of interaction spaces that are emerging in our cities through the use of ubiquitous technologies.

Within Cityware, we are extending Space Syntax consideration of the architectural spaces created by the built environment to include the wireless interaction spaces created by Bluetooth enabled devices. Bluetooth technology has a characteristic that makes it suitable for study by methods derived from those of space syntax. The majority of Bluetooth interaction spaces are created by small, personal devices such as mobile phones. Thus, in contrast to the interaction spaces created by typically static WiFi access points, the wireless interaction spaces created by Bluetooth devices map very closely to the movements of people around the city.

As part of our approach, in considering ubiquitous computing systems as an integral part of urban design, we are applying a series of different methods (Fatah gen. Schieck et al, 2006). We have reported elsewhere on our attempt to develop novel methods that extend conventionally applied methods in understanding the traditional architectural features of the urban environment to take account of the digital, as well as physical/spatial, form of the city. In our work so far, we have extended both the gate count and the static snapshot methods of observation of human space use and behaviour to include the observation and recording of Bluetooth interaction spaces and their relationship with people's movements in the city (O'Neill et al, 2006).

In this paper we demonstrate the application of the following methods with examples from two pilot studies conducted in the city of Bath, UK:

1. Mapping the physical and digital flows in Bath (macro level):
   By adapting established methods for spatial observation and analysis used extensively in the Space Syntax approach to urban design, we are applying a 'digitally augmented' version of the gatecount method. This includes scanning for Bluetooth devices in different locations throughout the city of Bath to cover low, medium and high pedestrian flows.
2. Observation of static space use (micro level):
   We are using methods drawn from ethnography, including people following and observation of static activities, local movement and the pattern of social behaviour and interactions. These methods are complemented by applying 'digitally augmented' versions of static snapshots coupled with observation sessions in each of the static snapshot locations mapping the types of mobile device usage behaviours that occur at various locations.
3. Sensing and visualising the digital identity:
   We are also interested in looking at the social and mobile behaviour from the individual's view. In the UK there is a thriving culture of giving Bluetooth names to mobile phones.

> Users appropriate the way in which Bluetooth operates, as a partially embedded medium, to project their digital identity making it a unique paradigm of socially and physically embedded communication. Through the selection of Bluetooth name, the user defines the ‘feel’ of that interaction space (Kindberg and Jones, 2006). As part of our methods we are projecting Bluetooth names in public and capturing the way that people respond towards the projection of their Bluetooth names in public.

In this paper we report on two pilot studies as part of our ongoing efforts to develop apply and refine methods for understanding ubiquitous systems as an integral facet of the city. In section 2, we describe in detail a pilot study applying extended and ‘digitally augmented’ versions of two key observation methods: gatecounts and static snapshots. In section 3, we present initial findings from our scanning, and projection of Bluetooth names in two selected public areas in Bath. We conclude by summarising our ongoing work.

2. METHODOLOGY AND DATA COLLECTION

We have illustrated elsewhere early results of our first steps towards building an integrated spatial and functional database for the study area bringing together observation-based surveys of land-use, space-use and pedestrian flow in addition to the information related to the digital landscape (Fatah gen. Schieck et al, 2006; O’Neill et al, 2006). Here we describe a pilot study applying the first and the second method outlined above.

2.1 Mapping and visualising digital flow

As part of our effort to capture the presence and distribution of Bluetooth interaction spaces over space and time, we ran previously a series of pilot Bluetooth gatecounts in various locations around the city involving a pair of observers working together on each location. The two observers, one of them with a notebook computer that performed Bluetooth scanning, iterated around the gates throughout the city of Bath, recording the flow of people by direct observation and Bluetooth activity at each gate over a course of two days (O’Neill et al, 2006). In the next stage of our work, we carried out a follow-up study involving 18 observers (nine pairs) throughout a network of nine locations over the course of one day. These observations closely resembled the conventional gatecount method, but involved a pair of observers working together at each gate. On each location one observer performed the observation of movement flow while the other performed the

Bluetooth scanning using a laptop with a Bluetooth scanner. Unlike the previous study, each pair of observers was working together at only one location throughout 6 time sessions from 10:30-16:30. The selection of the locations was based on the results of a previous study of the movement flow in Bath. The aim was to cover spaces with low, medium and high pedestrian flow and also to cover various types of spaces, from open spaces to long narrow streets with no nearby junctions (Fatah gen. Schieck et al, 2006).

Our technical setup, replicated across 9 sites in the city of Bath, involved installing a mobile computer that constantly recorded the presence of Bluetooth devices within approximately a 10-meter range with the exception of the open square near the Bath Abbey where a Bluetooth scanner with a 100-meter range was used. We applied the lessons learned from previous trials and recorded at each location for 30 minutes (identified as a suitable period for Bluetooth gatecounts at both high and medium traffic locations). A device was recorded if it had Bluetooth and was set to discoverable mode. The scan results were recorded in a 'text' file. For each record we had the timestamp, the device Bluetooth ID, the device Bluetooth name (if available), and a code for the location where the scanning took place. The constant Bluetooth scanning and observation of movement flow in each session was complemented by human observations of static activities in particular within the open spaces. The purpose of these observations was to correlate and verify the recorded Bluetooth activity with the human activity in the area.

2.2 Data visualisation

The data recorded of Bluetooth scans is essentially a set of individual Bluetooth discovery events. A single discovered device usually generates multiple events while it is within range of a scanner. An essential feature of the Bluetooth scan data is the temporal aspect. A temporal view allows us to begin making sense of the individual Bluetooth discovery records. (O'Neill et al, 2006). In order to visualise the data collected in Bath we generated a 3 dimensional visualisation of Bluetooth flow and presence ranging from being 'persistent', to having 'medium-term presence', to being 'highly transient'. Whenever a new device is discovered in the environment, a new cube appears within the visualisation, representing that device. The cube is placed at the scan location on the map of Bath. If there is another device discovered in the same location, a new cube (representing the new device) is positioned on top of the previous cube. When the device disappears from the scan range, the cube that represents that device will disappear from the tower. In this way, over time a tower is built up and demolished reflecting the degree of co-presence of devices at each scanning location. The tower's height changes over time. The result is a dynamic animation representing different types of interaction spaces with high to low Bluetooth flow. For instance, a rapid change of height indicates a transient space, whereas a slow change of height over time might indicate a more persistent space.

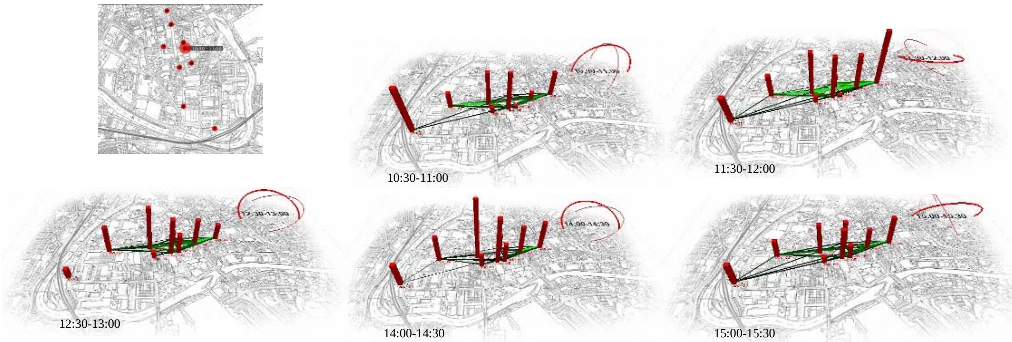


Figure2. In making sense of our data, we relate the individual events to the patterns of presence and absence at a given scanner site. A mobile computer was constantly recording the presence of Bluetooth devices within the Bluetooth range for 30 minutes across 9 sites

2.3 Results

The combination of manual observations and Bluetooth scans enables us to estimate the number of discoverable Bluetooth devices in relation to number of people in a specific location. From previous studies in Bath we have established empirically that approximately 7.5% of observed pedestrians had discoverable Bluetooth switched on. In some locations different percentages were identified. The reasons for these variations seem to be related to the specific context and nature of the locations. For example, in more open areas conventional gatecount observation will not necessarily capture the movement of all people, moreover there may be more static people within Bluetooth range and this could lead to variations in proportions scanned (O'Neill et al, 2006). In the study we describe in this paper we noticed that the percentage of Bluetooth devices varied across different locations in one time session. For instance, in a busy street, such as Union Street (G8), the percentage of discovered devices between 10:30-11:00 was (3.9%), whereas the percentage of devices discovered for the same time period in a quieter street such as Church Street (G3) was (10.8%). This percentage also varied in one location across different time sessions.

Table 1. Percentage of discoverable Bluetooth devices to number of pedestrians

	10:30-11:00	11:30-12:00	12:30-13:00	14:00-14:30	15:00-15:30	16:00-16:30
G1	5.3 %	15.1 %	9.1 %	16.5 %	18.9 %	5.2 %
G2	13.1 %	10.6 %	6.8 %	12.1 %	11.5 %	14.8 %
G3	10.8 %	10.4 %	8.2 %	9.7 %	8.3 %	18.5 %
G4	11.0 %	7.3 %	4.4 %	6.5 %	5.7 %	7.0 %
G5	12.1 %	6.9 %	9.0 %	6.4 %	9.7 %	8.6 %
G6	n/a	7.4 %	6.5 %	4.7 %	6.0 %	4.5 %
G7	n/a	6.7 %	5.2 %	5.2 %	9.8 %	7.6 %
G8	3.9 %	8.0 %	5.6 %	6.5 %	7.4 %	6.5 %

This variation could be for a number of reasons in addition to the nature of the location. For instance, factors relating to the accuracy of Bluetooth scanning such as the effectiveness of Bluetooth dongles for scanning purposes may be involved. Our scanner consisted of a single Bluetooth dongle. This meant that if many Bluetooth devices passed our gate at the same time, we might expect a higher rate of 'failure to log' events due to contention. This meant that in busy locations more transient devices might have gone unrecorded. This might explain the low percentage of discovered devices in busy streets in comparison to the relatively quiet ones. In order to overcome this limitation, we would need to continue to refine our methods. One way of doing this is to scan with more than one Bluetooth dongle concurrently. Another approach would be to reduce the amount of information recorded for each device.

Our 3D visualisation distinguishes between persistent and transient Bluetooth devices, rather than between activity on the street and in buildings. In general it is unlikely that scanning location and range will match precisely with the spatial morphology. However, the dynamic 3D visualisation could help designers in studying Bluetooth flow in a particular urban space. Generating a dynamic 3D visualisation helps one to recognise patterns of Bluetooth presence and Bluetooth flow in different part of the city, and perhaps to identify the appropriate architectural and interaction spaces through which information may be delivered or accessed at run time. Through this visualisation the designer can construct, at a glance, the relation between the scan location and the spatial morphology across different locations in the city.

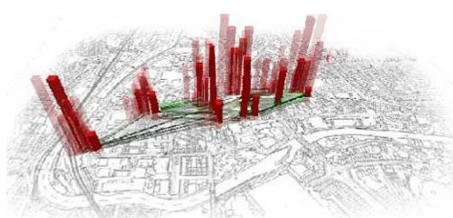


Figure3. A dynamic visualisation of the digital flow and co-presence over 6 time sessions in 9 locations in the city of Bath. Transparency indicates different time sessions

Our Bluetooth scanning allows us to record data and infer information that is not accessible to conventional gatecount and static snapshot methods. For, instance by establishing a network of gates throughout a city, we can infer the movement of devices over time. Observations carried out by human observer can classify movement flow depending on people's characteristics such as men, women, locals, tourists, children or adults. This is not possible to attain by looking at the Bluetooth data, however, Bluetooth data reveal information such as the Bluetooth ID (each Bluetooth device carries a unique MAC address). This data carries with it date and time signatures, which makes it possible to trace a specific device throughout a city by looking at the recorded data from several gates (Figure 4).

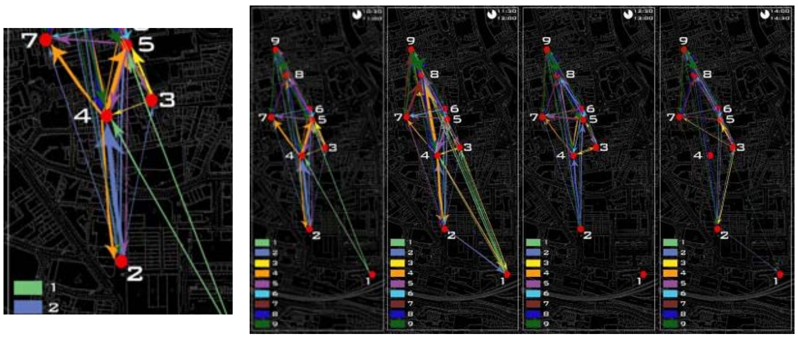


Figure4. (right) In investigating the flow, we relate flow patterns across different devices throughout different sites. The arrow shows the direction between two sites (the device disappears from the first location and reappears in the second location within 30 min.). Arrow thickness indicates number of devices. For instance, in the time period 10:30 -11:00 (left) the highest number of devices were scanned at location 2 and they reappeared at location 4

Knowing people's 'Bluetooth trails' can help us identify the direction of the movement of a particular device (Figure 5). Recording the trail could prove useful in various ways: For instance, digital trails could be used to study the effects of 'digital attractors'. By looking at people's digital trails we can measure this effect (perhaps with Bluetooth enhanced posters located throughout a city). Knowing whether interaction spaces remain static or move dramatically can help designers determine what information to deliver

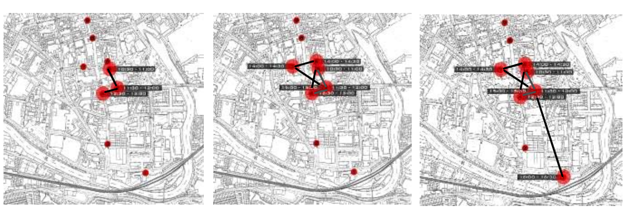


Figure5. A device's Bluetooth trail reconstructed from 10:30-16:30 by looking at the recorded data from several gates

and how to present it (eg, visible, audible, etc). Bluetooth scan data may provide us with an understanding of the movement rhythm in real time. Being able to draw on the temporal aspect of our scan data and determine the pace of movement is of value in cases where the rhythm of the flow is important, for instance when designing the content of Urban Screens. Understanding movement flow and movement rhythm, for example, in the morning and evening commute, when people aim to get to work or go home, is an important part in determining the choice of content for the Urban Screens. Although the 'commute' may appear obvious, the different role played by different urban locations during that period is less so. Some spaces become important meeting and interaction spots, where one buys the paper or coffee, while others are strictly 'head down and move through' spaces. Good local knowledge of these rhythms with respect to the spaces is key in determining appropriate content scheduling for screens in these places (Glancy et al, 2007).

Other opportunities also arise. Data visualization is becoming increasingly real-time, immediate access to easy-to-read data maps are becoming the norm (consider traffic data on sat-nav devices). Once a user moves about with her mobile phone and comes into contact with the Bluetooth scan range, a map on her phone could be populated with different types of information in real time giving rich contextual information about the usage patterns of other spaces within a short walking distance.

3. VISUALIZING THE DIGITAL IDENTITY

In our previous work we have reported on different scenarios that explore digital interactions in the city, specifically, we noted the importance of two key human capacities: consciousness of communication and intention of interaction. At any given instant people can be conscious or unconscious of the communications taking place, and can carry out interactions intentionally or unintentionally (Fatah gen. Schieck and Kostakos, 2007). According to the Bluetooth protocol, each device can have a 'name' which can help users communicate using the device. A device will broadcast information about this 'digital identity', as long as its Bluetooth is switched on and set to discoverable. When a person moves into the range of Bluetooth sensors, his/her digital presence can be sensed and information about his/her digital identity can be communicated. By default, the Bluetooth names on mobile phones are set to the phone model, e.g. '*Nokia N70*', however, users may customise their name and select their own digital identity. What happens when people are made aware of their digital presence and identity in the public space? Would this encourage different types of interactions? How does this affect or re-inform people's perception of the space itself? In order to address these questions, a pilot study was conducted to investigate the interrelation between the Bluetooth names, digital identity, and active participation within the public arena.

In the following section we first describe our method; we then describe early responses before we outline some factors that may influence this approach.

3.1 The experiment

We ran an experiment at two sites in Bath: in a café during day time and inside a night club during the evening. The aim was to identify people's interaction forms and possible changes in the Bluetooth names triggered by our intervention. Bluetooth names were scanned and projected on a projection surface in real-time. This was complemented by 'snapshot' observations. During the sessions a human observer recorded people's positions, behaviours and movements through space, as well as the time of these activities. The form of interactions with the projection surface and the projected information was captured. In addition the type of interactions with the other people in the area was observed and recorded with a digital camera. Various interactions were video-taped by two researchers using a digital video camera. Finally, changes in the Bluetooth names (projected on the surface) were tracked over time and analysed. These observations were subsequently compared with the data recorded by our Bluetooth scanners. Following the scan sessions, a selected number of participants were asked to fill in questionnaires. Twenty-five questionnaires were collected, ten at the club and 15 at the café.

3.2 Methodology and data collection

The Bluetooth discoverable devices were detected using a computer that was constantly recording Bluetooth devices and their Bluetooth names within a 10-meter range. The scanned Bluetooth names were visualized in real-time using a program written in the Processing language. The results were projected on a surface in a noticeable location.

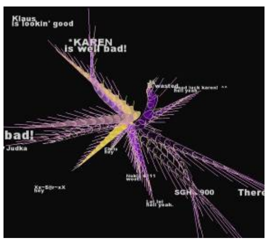
3.3 Data visualisation

Whenever a device was detected, its Bluetooth name was displayed on the projection surface. At the same time, a tentacle appeared around the name (Figure 6). As an attempt to trigger people's attention to what was projected on the screen, and in order to encourage the emergence of novel social interactions, a ‘tag’ was attached on each name (e.g. an expression or a social description such as *hey!* or *Is looking good!*). Every Bluetooth name was linked to a randomly selected ‘tag’. This meant that the visual representation was not limited to the presentation of the ‘name’ of the Bluetooth device assigned by its user, but it was rather an attempt to provoke reactions by creating a kind of dialogue between the people and the screen content.

With several names appearing along with several tags, the visualisation became a dynamic representation of an evolving social network. Once the Bluetooth device was not detected any longer, the tag faded away and disappeared from the projection screen. This meant that the projection represented all devices that were present at the same time at the same place.

3.4 The projection surface

At the club, the projection surface was sufficiently large, it was placed in the centre of the main wall in front of the main entrance to the space, so it could be seen directly when people entered the space. In the café, unlike the club, there was no dedicated projection space. The projection was on the wall next to the entrance, but in a less obvious location. Its size was smaller, and the ambient lighting made it less clear. People were therefore not as immediately aware of it as they entered the room as they were at the club.



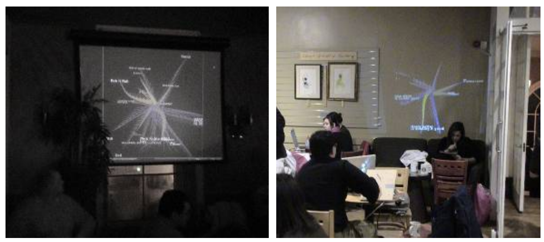


Figure6. Every Bluetooth name is linked to a randomly selected ‘tag’

Figure7. Projecting the digital identity in two places; a club (left) and a café (right)

3.5 Sensing Bluetooth names and observers’ reactions

Our approach in the real setting, unlike in a ‘lab’ setting, involved applying a range of methods from interpretative-ethnographic to experimental. The approach we adopted was engaging**.** Assigning the ‘tag’ to the Bluetooth names triggered mixed reactions by the observers. Questionnaires showed that people varied in how comfortable they were with the projection (in the café, uneasy; in the club, comfortable). During the projection we felt that the casual atmosphere at the club made people somewhat more receptive to the projection, unlike the café where people's reactions were more reserved and the social interaction was very limited and it seemed that having the projection of Bluetooth names in such a space was unexpected and to a certain extent, rather intrusive.

In the club when people were faced with the visualization of Bluetooth names of other people present in the physical space, various social interactions were triggered. Most people found the process playful and entertaining; they kept changing their Bluetooth names and waited to see the result on the screen. For instance, '*Davey-G*' changed his/her name twice. From '*Davey-G*' into '*Everyone wants lonsdale!* ' and then changed it into '*Pete has ten inches?*' Some people used the projection as an interactive message board using their mobile phone. For instance, from Table 2, we can see how *'Optimus prime'* turned her/his Bluetooth name into *'Hi camera lady'* referring to our human observer who was capturing the interactions with her camera. Altering the device's name may suggest an intention for social interaction with the observer through this new electronic medium.

Figure8. Most people found the approach playful and entertaining. Some people started changing their Bluetooth name

Table 2. Interactions though the Bluetooth names at the club

Time sessions	No. of people at the club	Scanned Bluetooth names		Tags
22:00-22:15	25	Hello beautiful! Davey-G Jodie Jx W880 JawaDemam Scarlet x x Man Mountain Kurva! Gorgeous D*ck Willie C* x Princess 2 unknown		Is looking good Woot! Hey ROCKS! Is bitchin'!
22:15-22:30	38	Pleb Nokia 6300 S*X APPEAL BUT DESPERATE PLZ Gem Abel Lonsdale is GAY Optimus Prime		Smelly Is well bad - Is wasted
22:30-22:45	45	Everyone wants lonsdale! Jodie Get ur spade out! Rob N Roll Hey camera lady... Pete has ten inches? Jesson is Gay Newman is a s* x pest Likes To L*ck BP4232-MBPRO-4 Jo wants to sh*g Dom Rob N F**kin Roll 1 unknown	(from Davey-G) (from Optimus Prime) (from Davey-G) (from Gem) (from D*ck Willie C*x) (from Lonsdale is GAY) (from Rob N Roll)	Hell yeah Is shaking it good Hey ROCKS! Smelly -
22:45-23:00	42	Helphire are shite Mcraith wants jesson I want c*ck! Theres only one! 2 unknown		Woot! Hey Is well bad - Is shaking it good -

Data collected through the questionnaires indicated that people who were broadcasting devices' names were mainly between 21 to 25 years old. Older people tended to suggest that they didn't not know technology well and that they are not inclined to use it. To the question 'How do you feel about your name made public and interacted with?' eight people were comfortable and only two responded negatively. These reacted in an extreme way and expressed their anger about this type of 'surveillance' and the way technology was projecting hers and her friends' personal information. Interestingly, to the questions 'Do you feel this kind of interaction can have an impact on the space?' and 'Does it enhance your experience of that space?', only 11 out of 25 expressed positive feelings.

Our findings, albeit quite informal, indicated that most people liked the experiment and wanted to participate in the playful interactions. Only a few people were critical about the exposure of their personal data, and about our approach in provoking intervention to their digital identity.

Reflecting on the pilot study of our research, we believe that a number of factors may have influenced people's responses encouraging mixed and sometimes ambivalent reactions. These are related to the individual, such as age, knowledge and use of digital media, and perhaps socio-economic status. Other factors are related to the space and activities in that space, and finally factors related to the projection itself such as the projection location and its relation to the main space, clarity and the projection time and length.

This study demonstrated that the projection of one's 'invisible' digital identity and making it part of our physical environment triggers various types of interaction, not only in a conscious-intentional form of interaction, but also as an unintentional projection of our self. This experiment was a pilot study and only ran for a short period of time. We believe that further research is needed in order to evaluate the degree to which this approach might provide a motivation to change the way people communicate and engage with others in various environments. We need to examine in greater detail which factors influence people's behaviour and, possibly, to quantify the role of different factors relating to the participants and to their spatial context.

4. CONCLUSIONS AND ONGOING WORK

The public arena provides temporal and spatial mechanisms for generating and promoting various social interactions. With the emergence of pervasive systems, the environment for interaction is likely to change. The introduction of new technologies might modify existing social practices, and on occasion stimulate the emergence of new social behaviours.

The current domain of mobile and pervasive computing lacks concrete methods for recording, modeling, analysing and understanding main properties of users and technologies in the urban context. As part of our ongoing effort to understand the city as a system encompassing both the built environment and ubiquitous technologies, we are applying 'digitally augmented' methods based on established methods for spatial observation and analysis used broadly in analysing and understanding the traditional architectural features of the urban environment.

In this paper we have presented a pilot study that illustrated the methods deployed for mapping the physical and digital flow and the digital co-presence. Here we draw on two main concepts that address issues of urban space, interaction space and the relation between the two.

Our extended methods combine Bluetooth scanning with conventional observational techniques. This allows us to gather additional data about the devices generating the new interaction spaces, giving us a rich dataset that allows us to classify people and their overt social behaviours through these new digital modalities in terms other than the characteristics recorded by conventional ethnographic observation methods. It also allows much more consistent and longer term datasets to be gathered.

Recording data on this scale allows us to make considerable advances beyond traditional approaches to modelling and understanding the city. For instance, we can inform our aggregate level modelling and analyses with real world empirical data and, if needed, update these in real time. In addition the 3D visualisation enables the designer to construct, at a glance, the relation between the scan location, the Bluetooth interaction spaces, and the spatial morphology and across different locations in the city. By establishing a network of observation gates throughout a city, we can track devices over time with digital trails. This could prove useful in various ways: For instance, digital trails could be used to study the effects of 'digital attractors'. Establishing the relation between the spatial morphology and the network of gates and the volume of devices that appear and reappear in the adjacent locations within the scan period can help designers determine strategies for what information to deliver and to which location, supported by better knowledge of the volume of Bluetooth devices in each of the scan locations (including the direction of movement and the change of pace) with respect to these spaces, and depending on how the locations and the devices are connected and clustered.

Finally, Bluetooth scans may provide us with an understanding of city rhythms – the way that variations in pace and density are structured over time – which could play an important part in determining the choice of content and appropriate content scheduling for urban screens sensitive to the different locations where they are located.

Our ongoing research continues to develop and refine these and other methods. However, we are certain that spatial sampling of this kind will only give a very partial view of the complexity of social and technological interaction. In order to understand various facets of socio-technical behaviours, we are deploying other methods that cover different perspectives related to the physical and social context. In this paper we have presented our attempt to investigate the role of technology in supporting social interactions within the public space. We have applied Bluetooth scanning coupled with human observations in the context of a café and a club where people are likely to use mobile and wireless technologies in order to address questions such as 'What happens when people are made aware of their digital presence and identity in the public space?' 'Would this encourage different types of interactions?'. To answer these questions we have conducted a pilot study by projecting the scanned Bluetooth names in the café and the club on a surface as part of these spaces. By applying an experimental approach we intended to trigger people's attention to what was projected on the screen.

Our initial findings suggest that by altering the relation between consciousness of communication and the intention of interaction, technology can be appropriated to support emergent social interactions. This may help throw further light on the complex relationship between the digital space and public space in general, and the way that this is mediated by and mediates people's relationship to each other.

While demonstrating differences in how users' intentions and consciousness can vary, our approach offered a digital stage that facilitated and encouraged different types of social interactions. Presenting people with a visualisation of their unconscious-intentional (or unintentional) projection of their digital identity and sharing it with others made people aware of the impact it has on others. This influenced their behaviour and provided them with a motivation to change the way they communicate and engage with others.

As part of our ongoing work we are trying to address a number of issues that came up through our two prototypes. Specifically, we are exploring how digital encounters can improve the experience of public space, and whether a system can improve the quality of social encounters. In this respect a particularly important insight comes from the effects we observed of 'tagging' the digital identity in public with an additional phrase. It seemed that this was interpreted by the viewers as giving the installation a personality, or at least suggesting that there was a human author involved in the piece. It encouraged a conversational form of interaction, including name changing or the use of the Bluetooth device name to establish a conversation.

We suspect that in order for public display of these technologies to be engaging the viewer needs to be able to construct a meaningful social relationship of which the display forms part. The engagement with the 'camera girl' offers one example of this, and required that user to put together the presence and behaviour of the display with the presence and activity of the human observer recording the event.

The conversation between '*Davey-G*' and, presumably, one of his friends '*Pete*' offers a different kind of socially meaningful engagement. This time by making public a socially risky innuendo, the user took advantage of the degree of personal anonymity coupled to very public display afforded by this medium. Everyone in the club could see the display, but there would have been some doubt in the minds of all those except close friends as to the identity of '*Davey-G*' or Pete. What one can read from the interchange, and presumably its intended message was that these users had a sense of humour and were outgoing.

5. ACKNOWLEDGEMENTS

We would like to acknowledge the efforts of the MSc Adaptive Architecture and Computation of the 2006-7 and 2007-8 cohort, we thank Kaiti Papapavlou, Adi Ahmad and Olivier Ottevaere. We thank Vassilis Kostakos and Alasdair Turner for their valuable contribution. The pilot projects presented in this paper are partially funded by Cityware: Urban design and pervasive systems (grant EP/C547683/1).

6. REFERENCES

Eagle, N. and A. Pentland, 2006, "Reality mining: Sensing complex social systems", *Personal and Ubiquitous Computing*, 10 (2006), p.255–268.

Fatah gen. Schieck, A., A. Penn, V. Kostakos, E. O'Neill, T. Kindberg, D. Stanton Fraser, and T. Jones, 2006, "Design Tools for Pervasive Computing in Urban Environment", in: *DDSS,* Eindhoven, Springer, NL.

Fatah gen. Schieck, A. and A. Kostakos, 2007, "Exploring digital encounters in the city", in: *proceeding of the 25th International Conference on Computer & Human Interactions CHI 2007*, San Jose, USA.

Fatah gen. Schieck, A. and C. Mottram, 2007, "*Collective Choreography of Space: Modelling Digital Co-Presence in a Public Arena*", in: George E. Lasker and Ana Luz (eds.) *Systems Research in the Arts and Humanities I,* Canada, p. 59-63.

Glancy, M., K.O'Hara, B. Crowther, J. Moore1, S. Robertshaw, A. Pressland, M. Cartwright, A. Collins, N. Smyth, J. Thomson, M. Sparks, S. Kurniawan, E. Geelhoed, 2007, "Understanding audience behaviours around the Big Screens in public spaces", *Big Screen Report,* UK.

Heisser, M., S. Klapdor, M. Maron, and S. Schaefer, 2006, “Way Finding, Routing and Getting Information with Mobile, Internet or Stationary Information System”, *Spatial Metro ICT workshop report*, Koblenz, Germany.
Hillier, B., R. Burdett, J. Peponis, and A. Penn, 1987, “Creating Life: or, Does Architecture Determine Anything? ”, *Architecture and Behaviour*, 3 (3).
Hillier, B., 2000, “The Common Language of Space: a Way of Looking at Social, Economic and Environmental functioning of Cities on a Common Basis”, UCL.
Hillier, B. and J. Hanson, *The Social Logic of Space*, 1984, Cambridge University Press.
Hillier, B., A. Penn, J. Hanson, T. Grajewski, and J. Xu, 1993, “Natural movement; or, configuration and attraction in urban space use”, *Environment and Planning B.*
Höflich, J. R., 2005, “A certain sense of place”, in: K. Nyíri (ed.) *A sense of place – the global and the local in mobile communication*, Passagen Verlag, p. 159-168.
Ito, M., D. Okabe, and M. Matsuda, eds., 2005, *Personal, Portable, Pedestrian: Mobile Phones in Japanese Life*. Cambridge: MIT Press.
Kindberg, T. and T. Jones, 2007, “Merolyn the Phone: A study of Bluetooth naming practices”, in: *Ubicomp 2007*, Innsbruck, 318-335.
Kostakos, V. and E. O’Neill, 2004, “Pervasive computing in emergency situations”, in: *Annual Hawaii Intl Conference on System Sciences*, IEEE Press.
O’Neill, E., P. Johnson, and H. Johnson, 1999, “Representations and user-developer interaction in cooperative analysis and design”, *Human-Computer Interaction*, 14 (1).
O’Neill, E., D. Woodgate, and V. Kostakos, 2004, “Easing the wait in the Emergency Room: designing public information systems”, *ACM Designing Interactive Systems*, Boston, MA.
O’Neill, E., V. Kostakos, T. Kindberg, A. Fatah gen. Schieck, A. Penn, D. Stanton Fraser, and T. Jones, 2006, “ Instrumenting the city: developing methods for observing and understanding the digital cityscape”, in: *UbiComp2006*, Springer, Berlin.
Paulos, E. and T. Jenkins, 2005, “Urban probes: encountering our emerging urban atmospheres”, in: *CHI 2005*, ACM, p. 341-350.
Reid, J., R. Hull, K. Cater, and C. Fleuriot, 2005, “Magic moments in situated mediascapes”, in: *ACM SIGCHI International Conference on Advances in Computer Entertainment Technology (ACE 2005)*, ACM, Spain.