Getting Smart About Urban Mobility – Aligning the Paradigms of Smart and Sustainable

Glenn Lyons[a]

[a]Centre for Transport & Society, Faculty of Environment and Technology, University of the West of England, Frenchay Campus, Bristol BS16 1QY. United Kingdom.
Glenn.Lyons@uwe.ac.uk

Abstract

The digital age continues its advance, bringing with it remarkable technological possibilities. Such possibilities are founded upon an increasingly fine-grained electronic connectivity of people, places and objects allied to powerful data gathering and processing capabilities. Urban mobility of the future could be transformed, with developments such as: new forms of propulsion; new forms of vehicle control; changing business models of ownership and use; mobile technologies that equip and empower individuals; and opportunities to undertake activities without the need to travel. 'Smart' is the order of the day. Smart urban mobility conjures up a sense of new opportunity; of progress. However, what is really meant by smart? This paper examines this question, revealing a lack of consensus in terms of smart cities and a paucity of literature seeking to make sense of smart urban mobility. The paper considers how smart relates to sustainable, raising concerns about potentially dichotomous constituencies of commentators and discourses. Critical commentary associated with smart includes caution that large corporations are exerting significant influence in the era of smart in pursuit of goals that may not strongly align with those of urban planners concerned with social and environmental sustainability as well as economic prosperity. The paper puts forward and explores the following definition of smart urban mobility: "connectivity in towns and cities that is affordable, effective, attractive and sustainable". This is intended to help draw the paradigms of smart and sustainable closer together towards a common framework for urban mobility development.

Keywords

Smart Urban Mobility; Sustainable Urban Mobility; Sociotechnical; ICTs; Intelligent Transport Systems; Smart Cities

1 Introduction

Society is facing an urban renaissance. A growing proportion of the world's population is located in urban areas and this is projected to reach nearly 70 per cent by 2050 (UN, 2012). This presents challenges in terms of a growing concentration of people and the associated flows of resource required to support economic prosperity and social wellbeing, as well as addressing the resultant waste. An important component of this 'urban metabolism' (Clift et al, 2015) is mobility – in particular the movement of people. This has major energy and emissions implications. Such mobility has also been a long-term challenge for urban authorities faced with limited capacity (and capacity to invest) and substantial demand, with upwards pressure from urban population growth. Making urban mobility sustainable has been a longstanding pursuit. Lam and Head (2012) summarise sustainable urban mobility as being about "the ease, convenience, affordability and accessibility of travelling to one's destination with minimal impact on the environment and others". They suggest that accessibility and convenience can be increased "with good urban design, behaviour change, advance technology, supportive policies, economic incentives, and city engagement and leadership" (Lam and Head, 2012: 359).

While congestion and crowding in a heavily used transport system are products of the motor age, the digital age has advanced rapidly in the past two decades bringing with it remarkable technological possibilities (Castells, 2010). Such possibilities are founded upon an increasingly fine-grained electronic connectivity of people, places and objects, allied to powerful data gathering and processing capabilities (Miorandi et al, 2012). Urban mobility of the future could be transformed, with developments such as: new forms of propulsion; new forms of vehicle control; changing business models of vehicle ownership and use; mobile technologies that equip and empower individuals; and opportunities to undertake activities without the need to travel.

Where once the lexicon of transport professionals and urban planners centred upon sustainable urban transport and sustainable cities, this has now shifted in attention, or expanded, with reference to smart cities and smart urban mobility – reflective of digital age possibilities. (One wonders what in future will follow 'smart'.) While smart is the order of the day, it appears to be a contested notion that rather defies clarity of definition. This is surely a matter of concern given the extent of emphasis and resources being devoted to smart as a means of shaping urban futures. Accordingly, this article draws upon existing literature to critically examine what lies behind the terminology, and set out an interpretation of smart which ensures that it joins and strengthens (rather than detracts from) sustainable in relation to urban mobility.

The paper has four main parts. Section 2 offers critical consideration of the notion of 'smart' and similar terms in relation to cities/urbanism and more particularly in relation to mobility. Section 3 puts forward a suggested definition of smart urban mobility as a means to then articulate what are felt to be some of the important aspects of ensuring that urban mobility is appropriately developed. The definition has connectivity at its heart. Section 4 goes on to examine in more detail, aspects of connectivity – particularly those enabled through digital technologies – that contribute to the pursuit of making urban mobility smart. Section 5 concludes the paper by emphasising the importance of a sociotechnical perspective and an approach to urban mobility which brings the paradigms of sustainable and smart closer together.

2 Making sense of smart

We are now in the 'era of smart' – smart phones, smart watches, smart televisions, smart meters, smart refrigerators, smart cards and so on. Yet definitions of smart appear rather elusive. Wikipedia offers the following in terms of smart devices: "an electronic device, generally connected to other devices or networks via different wireless protocols such as Bluetooth, NFC, WiFi, 3G, etc., that can operate to some extent interactively and autonomously". Brenner (2007) makes the distinction between 'dumb' and 'smart' technologies. "[A]n active, intelligent human being "uses" passive, "dumb" technology (a simple tool or mechanical device)" (Brenner, 2007: 4). She suggests we are moving from using dumb technologies (e.g. a road atlas or telephone) to *interacting* with smart technologies (e.g. personalised journey planning apps on smartphones) that "exist to help us, serve us, to make our lives easier and more interesting" (Brenner, 2007: 4).

Moving beyond notions of smart devices and applications, is the need to consider what is meant by smart when applied at a systems level – be that the urban mobility system or the wider urban system. The former is integral to the latter (POLIS, 2015).

Smart cities

Growing attention appears to be devoted to smart cities in the literature in terms of documenting efforts to define and interpret meaning and indeed motivation behind 'smart'. Nevertheless, commentators point to a plethora of definitions that result in a common understanding of smart remaining elusive (Hollands, 2008; Caragliu et al, 2011; Albino et al, 2015; Goodspeed, 2015). Albino et al (2015) document 23 different definitions of a smart city from sources dating from 2000 to 2014 and note that "[t]here are terms analogous to "smart cities" that add to the cacophony of terms relating to this phenomenon" (Albino et al, 2015: 8). Across such definitions they observe that interpretation now extends beyond being technology-centric to (also) recognising people and community needs. Across the collated definitions, sustainability is often but not always referred to. This follows from, and contrasts with, the genesis of the term in the 1990s when digital technology innovations were pointing to ways forward in the future of urban development (Caragliu et al, 2011; Albino et al, 2015) (see also Papa and Lauwers (2015)).

Nevertheless, several commentators observe the hype and utopian tendencies (characterised for instance as "inherently transformational and positive" (Luque-Ayala and Marvin, 2015: 2109)) in depictions of smart cities and their association with the vested interests of big technology corporates (such as Cisco, General Electric, Google, Hitachi, IBM, Philips, Siemens and Toshiba) in what is an evolving and lucrative new industry that could be said to be seducing urban authorities keen to place themselves on the global smart cities map (Hollands, 2008; Albino et al, 2015; Goodspeed, 2015; Hollands, 2015; Luque-Ayala and Marvin, 2015). Luque-Ayala and Marvin (2015), while noting some exceptions, argue that "current understandings of SU [Smart Urbanism] lack a critical perspective compounded by an undue emphasis on technological solutions that disregard the social and political domains" (Luque-Ayala and Marvin, 2015: 2107). Hollands (2015) points to concern about smart cities being driven by corporate power and commercial interest at the expense of understanding the consequences for social and urban development "which is crucial to the liveability and sustainability of these cities" (Hollands, 2015: 68). This echoes many concerns raised in his earlier and highly cited polemical article (Hollands, 2008). Goodspeed (2015) emphasises the

complexity associated with making sense of smart cities by labelling it a wicked problem (eluding definition and in turn eluding clarity over the nature of solutions and their efficacy).

In summary, our understanding of smart cities is mixed - reflective of the complexity of city systems, the array of different actors and commentators looking to articulate interpretations against differing priorities and goals, and the heterogeneity across cities in terms of scale, urban design, populations and function. Giffinger et al (2007) suggest six characteristics of a smart city, namely: smart economy; smart people; smart governance; smart environment; smart living; and smart urban mobility. With this as a backdrop, what then is understood of smart urban mobility?

Anthropomorphising the nexus of transport and technology

Before addressing smart urban mobility, it is appropriate to recognise a legacy of terms used in relation to technology and its role in transport that are anthropomorphic in nature. The Oxford Dictionaries define anthropomorphism as "the attribution of human characteristics or behaviour to a god, animal or object". Caporael and Heyes (1997), in considering why people anthropomorphise, suggest that it is a cognitive default "engaged when explaining or predicting the behavior of an entity when it was important, but no handy explanation for its behavior was immediately available" (Caporael and Heyes, 1997: 63). This may go some way to explaining why the transport sector seems fond of anthropomorphising with a series of adjectives in use: *intelligent* transport systems (ITS), *advanced* traveller information systems (ATIS) and more recently *smart* motorways and *smart* urban mobility. These are perhaps shorthand progressive labels that try and encapsulate succinctly a rather complex and diverse array of technological forms, functions and processes and what they can achieve.

The adjectives themselves are defined as follows (Oxford English Dictionaries): *smart* – having or showing a quick-witted intelligence (or of a device – programmed so as to be capable of some independent action); *advanced* – far on or ahead in development or progress; and *intelligent* – having the ability to acquire and apply knowledge and skills. Albino et al (2015) (in relation to smart cities) suggest smart has emerged as a more user friendly term than intelligent from a marketing perspective with the latter seen as more elitist. Perhaps in some respects the use of these words attached to transport developments is not altogether inappropriate. The common theme behind these examples is to use information and communications technologies (ICTs) to monitor the transport system and its use and to translate data into information which can support or influence the decisions of transport operators and/or users. ICTs can, or are hoped to, enable users to get the most from what the transport system has to offer.

However, the adjectives are at risk of being a signal of technological sophistication rather than of being outcomes-oriented. Lyons (2001) puts forward a new term ETIS as a progression on from ATIS where 'E' stands for *effective*. The contention is that regardless of its technological sophistication, an (information) system cannot be truly advanced unless it yields benefits (at least perceived, and ideally tangible) for its providers and/or users, i.e. that it is effective. While conceptually appealing, the multiple goals applicable to an urban transport system make pursuit of effectiveness less than straightforward (Goodspeed, 2015).

Smart urban mobility

There is precious little explicit consideration, let alone critique, of what is meant by smart (urban) mobility in academic and wider literature. Garau et al (2016) note the lack of a unique definition of the concept. Papa and Lauwers (2015) offer a welcome recent commentary on smart mobility, examining its presence as a 'buzz phrase' over the last ten years while pointing to the gap between notions of smart and sustainable. Where smart (urban) mobility is referred to in the literature, it appears to commonly be the case that its definition is vague, ambiguous or even absent. There is almost a sense that its meaning should be implicit, and assumed to be an axiomatically positive manifestation of technologically-based developments in transport systems, services and their use.

Given the paucity of attempts to clearly articulate the meaning of smart urban mobility, it is instructive to focus upon one of the most recent attempts to do so that has emerged. Note, however, that in this example there is an apparent return to what is suggested above as the more elitist term 'intelligent' in place of 'smart'. The terms seem interchangeable and synonymous in their use.

The UK Government established the Transport Systems Catapult (TSC - https://ts.catapult.org.uk/) in June 2014 as its innovation centre to "explore intelligent mobility" where Intelligent Mobility is described by the TSC as "the future of transport – harnessing emerging technologies to improve the movement of people and goods around the world". In July 2015, Centro (the organisation then responsible for public transport services in the West Midlands in England[1]) and the TSC announced a joint initiative named the 'Intelligent Mobility Incubator'. The launch stated that "[t]he ground-breaking business incubation centre will focus solely on Intelligent Mobility, which uses emerging technologies to enable the smarter, greener and more efficient movement of people and goods. In particular, it will encourage the development of smart phone and other apps that provide real-time information and advice for passengers" (http://centro.org.uk/about-us/news/2015/intelligent-mobility-incubator/). This quote helpfully and rather aptly depicts what is perhaps a mainstream viewpoint from (transport) technology professionals on the prospects for improved mobility in the digital age in our cities. The TSC comments further on intelligent mobility as follows: "As well as offering solutions to major challenges in the transport sector, Intelligent Mobility is a fast-growing and lucrative market in its own right, with an estimated global market value of £900 billion[2] by 2025" (https://ts.catapult.org.uk/intelligent-mobility/introduction/). One assumes that this 'lucrative market' arises from potential *effectiveness*. Yet pursuit of such value might place the importance of promoting technological sophistication and possibility (and shareholder returns) ahead of more fundamentally considering how our urban mobility systems and their use can evolve in a way that best supports the sort of future urban environments society might seek or most benefit from overall.

With latest developments such as that above, smart urban mobility could be summarised as follows:

- using technology to generate and share data, information and knowledge that influences decisions;

[1] From June 2016, Centro has been superseded by Transport for West Midlands (TfWM).
[2] The origin of this figure – which seems to have become widely cited – is not clear.

- using technology to enhance vehicles, infrastructure and services; and
- deriving improvements for transport system operators and users and for shareholders.

One of the risks with such an interpretation is that we confine ourselves to helping better fulfil the *consumption* of mobility and indeed building an industry around assumptions of supporting (a growth in) such consumption (note reference earlier to strong corporate interest in smart cities). There are often unintended and undesirable consequences of improving mobility: improved ease of movement tends to induce the demand for more movement (Næss et al, 2012). This can put additional pressure upon the mobility system and deepen a mobility dependence that may be progressively more challenging to sustain. We have now entered an era where the transport and digital technologies industries and market interests are beginning to overlap and collaborate or compete in relation to mobility consumption. The ITS industry has centred upon trying to tackle congestion and improve transport networks' operation and user experience (McDonald et al, 2006). Meanwhile ICTs have created a huge market centred upon mobile devices and mobile internet access and services that not only have the prospect of supporting mobility but exploiting it. A report by McKinsey (Cornet et al, 2012) identifies that on average every car passenger spends 50 minutes in their car per day. The report suggests that with the market penetration of internet-ready cars, if even 5 minutes of this 50 minutes can be acquired by the 'attention economy' then this could amount to 25 billion euros of revenue generation per year. 'Smart' is big business!

Private sector providers must look to the interests of their public sector clients (and regulators) and those of their end user customers, alongside their own bottom line. While these considerations need not be mutually exclusive or opposing, it is highly unlikely that they will all align (or necessarily also align with the interests of other urban stakeholders). There are multiple factors at play amongst the different actors and processes involved in shaping urban mobility systems and their use. The relative strength of influence from public sector urban governance and political leadership, and from market forces will be significant in shaping the future of smart urban mobility.

While not adopting the terminology of smart at the time, some ten years ago the UK Government's Foresight Programme examined, in effect, the (long-term) future of smart (urban) mobility. Under the title 'Intelligent Infrastructure Futures' the project's central emerging message is one of four perspectives on intelligence (where smart could be substituted for intelligent):

- "**intelligent design**[3], minimising the need to move, through urban design, efficient integration and management of public transport and local production
- a system that can **provide intelligence**, with sensors and data mining providing information to support the decisions of individuals and service providers
- **infrastructure that is intelligent**, processing the mass of information we collect and adapting in real time to provide the most effective services
- **intelligent use** of the system where people modify their behaviours to use infrastructure in a sustainable way." (OST, 2006: 10)

The middle two perspectives very much concern the translation of data into information that can support decision making. However, importantly (in relating smart to sustainable), the first and last perspectives recognise the crucial role of design in *minimising* movement and of

[3] Original emphasis

human behaviour itself. This set of perspectives offers a more holistic consideration of smart, pointing more strongly towards effective outcomes.

3 Rethinking Smart

It would seem self-evident that, with a growing proportion of the world's population locating in urban environments, we need cities that are economically, socially and environmentally sustainable. It follows that urban mobility must contribute to that sustainability. The digital age introduces both challenges for, and opportunities to pursue, sustainability. In this context one would expect pursuit of smart and pursuit of sustainable cities and urban mobility to be closely connected. The previous section highlights that our lens on urban development may have skewed towards becoming more technology-centric. Technological opportunities may, at their worst, be being treated as solutions looking for problems. More likely is that opportunities are being taken forward in the belief that they can benefit (higher) goals of sustainability but with potentially conflicting commercial motivations or poorly understood consequences for urban environments.

Bringing smart and sustainable together

Given the lack of clarity of interpretation of what smart means, it is difficult to readily gauge how it relates to sustainable. However, it is important to at least outline possible relationships or interactions. Figure 1 offers an attempt to do so.

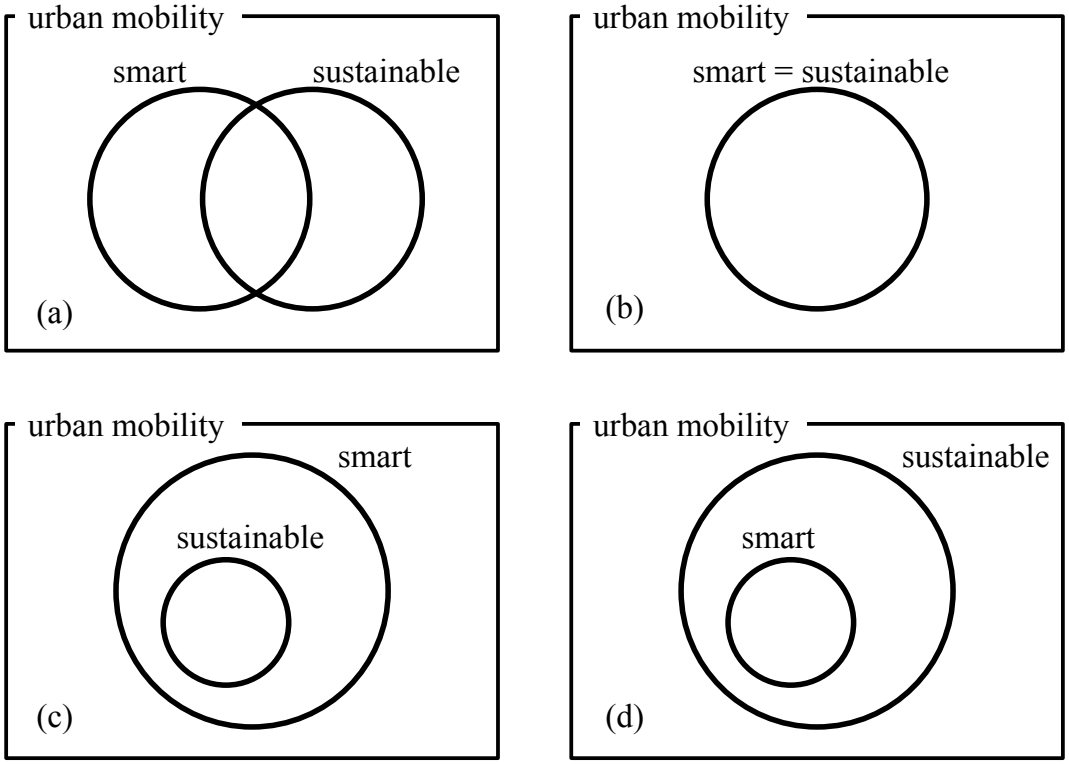

Figure 1. Alternative Venn diagrams of urban mobility

The Figure depicts four alternative Venn diagrams for urban mobility – in relation to how it functions but also in terms of how it is researched and developed. The diagram that does or

should prevail in practice will depend significantly upon how smart and sustainable are defined or understood. Nevertheless, the four alternatives can be described as follows:

- diagram (a) reflects what might be a present reality, in which smart and sustainable are not opposing paradigms but are nevertheless not in all respects in harmony;
- diagram (b) may, for some, depict an optimal reality in that all that is smart is sustainable and vice-versa as terminologies, or more importantly their meanings, converge;
- diagram (c) reflects what for some would be a rather dystopian reality in which the paradigm of smart has become dominant and has 'consumed' the diminished paradigm of sustainable (notwithstanding that some elements or outcomes of smart urban mobility would prove also to reflect a tendency towards sustainable); and
- diagram (d) might suggest a stronger level of stewardship over urban futures in which the smart paradigm is subservient to the sustainable paradigm, with the former 'confined' to contributing to the latter.

Policymakers, providers and researchers should be mindful of which reality is developing over time and be prepared to challenge how the relationship between smart and sustainable is evolving. In policy terms, it seems nonsensical to countenance two separate but concurrent paradigms for urban mobility. Smart and sustainable need to be brought together. Banister, in his paper 'The Sustainable Mobility Paradigm', sets out a sustainable (urban) mobility approach that "requires actions to reduce the need to travel (less trips), to encourage modal shift, to reduce trip lengths and to encourage greater efficiency in the transport system" (Banister, 2008: 75). He contrasts this with what he sees as the dominant paradigm or approach that has shaped land use and transport hitherto which is founded upon travel as a derived demand and the need to speed up journeys. In his exposition of the sustainable mobility paradigm, he highlights the need to make best use of technology, particularly in reducing the need to travel but also in addressing efficiency of mobility (in relation to energy use and emissions). However, his paper makes no mention of smart or intelligent and from a cursory examination of the paper's many citations, the majority of commentators referring to the work are not themselves addressing the 'smart' agenda.

This seems to point to rather divided constituencies of research and development, being either focused on smart in a technology-centric sense or focused on sustainable in a planning-centric sense. Each may tacitly or superficially acknowledge aspects of the other's paradigm and both may have as their reference or departure point a current paradigm that is neither especially smart nor sustainable.

In the same special issue of Transport Policy (New Developments in Urban Transportation Planning) as Banister's paper above, Curtis (2008) emphasised the importance of a focus on accessibility rather than mobility in addressing urban sustainability – with particular attention given to land use planning as a means to enhance the sustainability of urban mobility. Reference to accessibility is important in underlining that mobility is commonly a means to an end – it is one means to *connect* between people, goods, services and opportunities.

In an effort to bring sustainable and smart (closer) together, the paper now sets out and unpacks a definition of smart urban mobility that explicitly espouses sustainability while emphasising connectivity.

A definition of smart urban mobility

In simple terms, mobility is defined as "the ability to move or be moved freely and easily" (Oxford Dictionaries). It relates most readily to the movement of people. However, as noted above by the TSC, it also concerns the movement of goods. For a more complete picture still, the movement of information should be added. Taken together, mobility concerns the freedom to, and ease of, being able to connect between people, goods, services and opportunities. Drawing upon Lam and Head (2012), Banister (2008) and Curtis (2008), the following definition of smart urban mobility is proposed: *connectivity in towns and cities that is affordable, effective, attractive and sustainable*.

Connectivity - Reference to connectivity recognises that (motorised) physical mobility of people and goods is only one means of providing access (albeit an important one). Physical mobility concerns transcending distance. If such distances are reduced then motorised mobility needs are reduced and active travel alternatives become more viable. Digital connectivity is an alternative means of transcending distance – for people and for goods in some cases (notably digital products and services such as software, music, books, etc.). Hence smart urban mobility reaches beyond consideration of motor vehicles. These may be the cause of greatest negative externalities from urban mobility but urban mobility solutions should not be confined to motor vehicles or even to physical transport.

Affordable and effective - Being affordable and effective for users involves a recognition that users encompass a diverse urban population reaching beyond the smartphone-wielding urban knowledge worker to include people with differing (unmet) needs and abilities in cognitive, physical and financial terms (Lucas, 2012). Users have particular goals they are seeking to achieve in relation to mobility and connectivity and these need to be understood as part of developing smart urban mobility solutions. Affordability and effectiveness relate also to urban mobility system providers and their resources and goals.

Attractive - The definition also concerns being attractive *for everyone*. As individuals, we may be one or more of the following at different points in time: mobility system users; urban dwellers; or business owners / shareholders. While users must find the mobility system is able to meet their needs, account must also be taken of how this system and its use affect the experience of urban living and working. Meanwhile, for the mobility system to be maintained and enhanced there is a requirement for investment which means the system must be attractive in terms of a return on that investment.

Sustainable - The definition finally concerns being sustainable – in other words, achievement of affordability, effectiveness and attractiveness must be able to be maintained on a long-term basis economically, socially and environmentally. This comes in the face of an uncertain future in terms of how people will want to connect and the extent to which they will be able to afford to connect (Lyons and Davidson, 2016).

In the context of the definition offered, the paper now briefly considers, through illustrations, how 'smart' can be interpreted in terms of possible solutions for our connectivity needs and the part played by technology. The illustrations refer to components of an overall urban mobility system. This is a reminder that 'smartness' needs to be considered at different levels and with an appreciation of the combined effect of the many components involved.

Smart

Smart need not be technologically sophisticated. Consider a recent experience of the author upon arriving at Glasgow Airport in Scotland with the temptation to take a taxi to the city centre hotel in the absence of any local knowledge. Immediately in front of the terminal awaits a Glasgow Shuttle bus with advertising on the side indicating clearly a frequent service to the city centre. Boarding the bus with no sense of how readily the bus might help access the hotel destination, the driver responds to mention of the hotel name by providing a paper copy of a local map. He points out the first bus stop and the numbered hotel on the same map – within easy walking distance of the stop. The cash fare is paid with change given. A relaxed if not luxurious urban mobility experience follows, concluding with a short walk to the hotel. Overall – *affordable* and *effective* (for the user), (reasonably) *attractive* and, it would appear, *sustainable* (notwithstanding broader complexities of debate about the part played by air travel within Glasgow's mobility system).

Smart?

Being technologically sophisticated may not always be smart. The connectivity of the (mobile) internet has given rise to a tremendous richness of innovation potential, living as we now do in the era of the App (alongside or within the era of smart). According to Wikipedia, the Apple App Store (launched in 2008) now has more than 1.4 million apps and over 100 billion copies of apps have been downloaded. Numerous new creations of apps continue to emerge in relation to mobility (a particular focus of the TSC's Intelligent Mobility Incubator referred to earlier). They are often bottom up and driven by curiosity and closely felt frustrations or unmet need from users. Not all apps that may appeal in concept, flourish in terms of their level of use. This can be because the perceived unmet need is not widespread or because other contextual factors influencing people's mobility behaviours have not been accounted for (Lyons et al, 2012). Some apps can, however, gain traction and attract investment and develop growing use. One such example is that of a brokerage service between householders with vacant driveways and motorists seeking available and affordable parking spaces in our cities and towns (e.g. https://www.justpark.com/). This is an ingenious idea able to be brought to life through the connectivity of the internet. It is (presumably) *affordable* and *effective* for the householders and motorists who are matched. Indeed it may contribute to some reduction in time motorists contribute to traffic levels by searching for parking spaces. However, in making urban mobility by car easier it may not, ultimately, be making urban mobility *attractive* for everyone and may be preserving and nurturing a motorised mobility culture that is not *sustainable* in terms of the negative externalities imposed. Hence there is a need to question whether all developments that may be attributed with the label 'smart' are roundly smart if the definition offered is subscribed to.

Smartest?

It is appropriate to consider *relative* smartness in terms of assessment of connectivity options for both providers and consumers. Connectivity is a means to an end and there may be more than one means to that end as noted earlier. This suggests we should be seeking to identify and promote the smartest means to the end we seek. Connectivity with paid employment is a case in point. For some, and perhaps a growing number of, workers there is now a degree of flexibility in terms of where and indeed when they work. Two connectivity options can exist. The first is the traditional means of connectivity (that could be depicted as follows in the case of using an urban metro system): leaving the household to then cram onto a metal tube to

travel to a workplace at another location, at which to sit at a computer engaging in knowledge work. The second is to remain in the household and sit at a networked computer to engage in knowledge work. The suggestion here is not to naively assume that the latter is always more *affordable*, *effective*, *attractive* and *sustainable* than the former. However, in at least some key respects it is surely a strong contender. Indeed it was used to good effect during the 2012 London Olympics as part of efforts to alleviate overall demand on the city's transport system (TfL, 2013). There should not be an assumption that smart urban mobility is confined to how people and goods are moved around urban areas. Connectivity concerns the land use system, transport system *and* the telecommunications system (Lyons and Davidson, 2016).

4 Pursuing smart urban mobility

The definition of smart urban mobility set out in the previous section aims to bring smart and sustainable closer together. This section of the paper now moves to consider in further detail how smart urban mobility (as defined) can be pursued. Since the definition also espouses sustainability, such pursuit should have resonance with the detail of how to pursue sustainable urban mobility (as set out by Banister (2008) and others). However, the intention here is to more strongly emphasise the role played by digital age developments since these have significantly shaped prior consideration and articulation of notions of smart.

Pursuit of smart urban mobility should fundamentally be about improving the fulfilment of access needs (Geurs and van Wee, 2004; Abley and Halden, 2013). This concerns: (i) influencing how we connect; (ii) minimising the externalities of connection; and (iii) supporting how we connect.

Influencing how we connect

The maxim 'prevention is better than cure' should surely apply to smart urban mobility. In other words, through influencing how we connect, we may lessen the challenges of how to support and sustain people's fulfilment of connectivity needs. There appears, at present, a greater dominance of smart cure interest in (parts of) the transport sector rather than smart prevention. A central element of influencing how we connect concerns our urban design. Urban design should be considered a legitimate form of pursuing smart urban mobility. It can create attractive environments for people to work and play in close *proximity* to one another, reducing the need or desire for motorised mobility (Rode et al, 2014). Movement priorities in terms of the design and use of the transport infrastructure (including the role of pricing) can influence the relative attractiveness and use of different modes of physical travel. Ensuring enhanced permeability for pedestrians and cyclists can enrich the urban realm and influence how people connect in urban environments.

Another central element that, alongside design of the land use and transport systems, can now influence how society connects is the maturity of the telecommunications system. This is creating new possibilities for digital connection (Kenyon et al, 2003). While the telecommunications system is the enabler, the real influence on how we connect arises from the encouragement of new social and business practices that shape where, when and how we engage in activities. Such influence may work in harmony with good urban design (Page and Phillips, 2003). A blend of proximity and digital connectivity may offer smart urban mobility that still fulfils needs for co-presence and social interaction without the same degree of reliance on motorised transport. Digital connectivity can influence motorised transport in a number of ways (Mokhtarian, 2009). It can substitute for motorised transport. It can also

supplement physical mobility by enabling more connectivity digitally (for economic and social ends) without adding to the physical mobility burden on urban areas. Digital connectivity can of course also lead to increased physical mobility. However, this is not inevitable if attractive and effective design of the urban realm is embraced, alongside how we provide for different forms of connectivity and what pricing signals are introduced to influence behaviour. Influencing how society connects is not about *dictating* how we should connect but concerns the need to ensure that all the goals of smart urban mobility are being met: affordable, attractive, effective and sustainable.

Minimising the externalities of connection

Influencing how we connect through urban design and digital means can help ameliorate the externalities of connection. However, beyond this is the need to reduce the externalities of our physical mobility. Addressing this can be especially suited to technology, allied to changing social norms and behaviours. This notably involves the emergence of the sharing economy (Hamari et al, 2015) in relation to shared ownership and use of vehicles. This holds the prospect of fewer vehicles (and in turn less land take for parking) and higher occupancies making vehicle use more efficient. It involves attempts through ICTs to encourage more efficient (Barkenbus, 2010) and safer (Young et al, 2011) driving behaviours. It involves vehicle design itself in terms of forms of propulsion and also vehicle control. In these domains, however, it is especially important to be mindful of rebound effects and unintended consequences. The considerable current interest in a possible future pathway towards (electrically powered) self-driving vehicles is a key case in point: we cannot yet draw conclusions about how strongly or positively this will fulfil the goals of smart urban mobility as defined in this paper (see for example recent modelling work (Le Vine et al, 2015) highlighting a possible conflict between increasing road network utilisation (effectiveness) and reducing the disutility of travel time (attractiveness)).

Supporting how we connect

A dominant manifestation of the digital age and motor age coming together has been the role of ICTs in supporting how society connects – both in terms of travel information services and also in terms of facilitating the consumption of travel time itself. Such support can help address effectiveness and attractiveness of mobility for the user and may also contribute to affordability (in time if not monetary terms).

Stradling (2006) refers to three forms of effort in relation to physical mobility: the *physical* effort of undertaking a journey; the *cognitive* effort of undertaking and completing the journey; and the *affective* effort of the journey experience. For active travel modes the physical effort may either be a burden to the traveller or a positive, sought-after attribute. For most travellers, aside from those in 'explore' modes perhaps as tourists, it is attractive to have cognitive effort minimised. This concerns knowing at every stage of the journey what one should be doing to complete the journey, so as to minimise the mental attention one is devoting to the travel task itself. The affective effort of a journey could be positive in terms of the stimulation and perhaps exhilaration it provides. However, it could be emotionally negative if successful journey execution is in doubt or is requiring a lot of cognitive effort; or negative because of the nature of the travel environment and travel experience itself. ICTs have a potentially important and growing contribution to make to smart urban mobility where it is desirable to minimise the cognitive and affective efforts of physical mobility.

Information services can both influence and support how we connect and indeed they have for some time been seen as an important feature of smart and sustainable mobility in terms of supporting individuals in both planning and executing their journeys. They are seen as a means, for those able and minded to access them, of encouraging awareness and consideration of alternative modes of travel to the car. They are also a means of informing and influencing mode and route choice in the face of real-time traffic and travel conditions (Chorus et al, 2006).

There has, to some significant extent, been an industry and research mentality of 'build it and they will come' with regard to travel information services. There has been a long-held view that by providing information services, people would use them and in turn be influenced in their travel choices. However, empirical research concerning online public transport information has revealed that demand for using information services, for journey planning at least, derives from people wishing to consider travel options – not vice versa (Farag and Lyons, 2010). As such, in order to influence travel choices there is a need to better market the travel alternatives themselves. This can then give rise to demand for the information services which can in turn support travel decisions and potentially smarter mobility. This offers an important reminder of the need to understand users and the context of smart urban mobility in order to deliver effective outcomes. More recent research on this topic (Nyblom, 2014) has challenged some of the thinking above by looking in depth at people's travel planning in the context of the 'muddle of everyday life' and revealing a greater richness of information use (especially when a wider array of information sources are recognised). This highlights the complexity of understanding users and contexts and also the fact that users and contexts are changing over time as further innovations in ICTs diffuse into people's everyday lives.

Travel time use, with cognitive and affective efforts of travel reduced through mobility-related information services, can also benefit from ICTs. Mobile technologies – notably now in the form of multifunctional devices such as smartphones and tablet PCs – enable a traveller to be equipped and able to flexibly make use of their travel time either in active (e.g. working) or passive (e.g. listening to music) ways. This can increase the attractiveness of physical mobility and render it more affordable in terms of the time costs associated with the journey. It offers a form of connectivity multitasking (Kenyon and Lyons, 2007). In other words, an individual can simultaneously be pursing connection through physical travel while using mobile technologies to connect digitally with remote services or other people.

5 Concluding discussion

This article has sought to get to the bottom of what we think we mean or should really mean when we label urban mobility 'smart'. Its writing has been motivated by a concern that we may be at risk of reserving smart for a focus on technology enablement. Technology has an important part to play, without question. However, technological possibility, driven by commercial attractiveness of innovation potential, may risk lessening the important attention that should be given to helping deliver connectivity in towns and cities that is affordable, effective, attractive and sustainable. There is a need to ensure paradigms of smart urban mobility and sustainable urban mobility are aligned. To a significant extent, this is about bringing technological and social considerations closer together and ensuring due importance it attached to both.

A sociotechnical perspective

Understanding and delivering smart urban mobility, in what is a complex system and one facing significant change and uncertainty, requires that technological possibilities are considered in the context of how they interact with the wider set of actors and processes that define and co-create the evolution of the urban (mobility) system. In short, a sociotechnical perspective is called for. Klein (2014) reflects on sociotechnical theory and studies having emerged from an historical standpoint, where different constituencies of analysts and developers focused *either* on optimisation of technical systems *or* on optimisation of social systems. This was in ignorance of the reality of inter-dependency of the social and technical systems which warrants a more holistic approach in order to achieve advance and improvement. While acknowledging the imprecision of the term 'sociotechnical', Klein emphasises the central importance of *interdependence*. "Sociotechnical theory makes explicit the fact that the technology and the people in a work system are interdependent. Each affects the other" (Klein, 2014: 138).

Apple can take significant credit for the mainstreaming in society of smart technologies. At Steve Job's last Apple product launch in 2011 he said, "It's in Apple's DNA that technology alone is not enough – that it's technology married with liberal arts, married with the humanities, that yields us the result that makes our heart sing" (Isaacson, 2014: 486-487). Isaacson (2014) concludes his extensive account of the emergence of the digital age (from the 1800s and the early conception of computers and networks to the present day) by suggesting that (as in the past) future innovators will be "creators who can flourish where the arts intersect with the sciences and who have a rebellious sense of wonder that opens them to the beauty of both" (Isaacson, 2014: 488). Examination of how the digital age has evolved thus far reveals (according to Isaacson) that humans and (networked) computers work best in partnership and that there is little sign of true artificial intelligence emerging to suggest otherwise. Much as we might be drawn to the anthropomorphic use of 'intelligent' or 'smart', it seems computing is yet to deliver developments that are able to pass the much debated Turing test whereby intelligent behaviour is exhibited that is indistinguishable from that of a human (Cohen, 2005). Such points are relevant to make in the conclusion of this article because they underline emphatically the importance of how people (society) and technology come together in determining how innovation takes place and to what extent it flourishes and diffuses (Rogers, 1962) and with what consequences for the goals being pursued.

Lipservice can be paid in research and development to the interaction between people and technology. However, research and development need to balance technological expertise with social and behavioural science expertise. Pursuit of smart urban mobility requires an understanding of context – an appreciation of people's lifestyles, constraints, needs, desires and behaviours as well as the practices of businesses.

New labels, new challenges, new actors, enduring imperatives

We must not let the fashions of labels, or our challenges in interpreting or defining what we face in terms of sociotechnical developments of the digital age, obscure the enduring importance of higher level goals. 'Smart' may be a convenient label for the swell of technologically enabled possibilities for how urban mobility can be adapted. However, there is a need to ensure – at least from the point of view of stewardship of the future of urban living and urban metabolism – that we do not lose sight of what we seek to achieve.

Alan Atkinson in his article 'Sustainability is Dead – Long Live Sustainability' points to a paradox: "[a]t precisely the moment when humanity's science, technology, and economy have grown to the point that we can monitor and evaluate all the major systems that support life, all over the Earth, we have discovered that most of these systems are being systematically degraded and destroyed by our science, technology, and economy" (Atkinson, 2006: 231). This underlines why we cannot allow smart urban mobility and sustainable urban mobility to exist as unaligned paradigms. Considerable progress and economic prosperity (for some) may have been brought about through how science and technology have been employed to espouse and propel the motor age in our cities. However, this has also come at some considerable cost. There are indeed now technological possibilities to mitigate for our historic dependence on motorisation, but we must look to positively exploit these and guard against any unintended perpetuation of aspects of connectivity that run counter to sustainability.

It is important to recognise that technology is only one means to the end of smart urban mobility with good urban design something not to be undervalued. Technology itself has multiple roles in the fulfilment of smart(er) urban mobility, with opportunities not only in terms of transport technologies but also non-transport technologies. Lastly, the actors in the smart urban mobility fulfilment process are changing with new models of innovation, involving players from outside the traditional 'intelligent transport systems' industry. There is also involvement of a much greater number of smaller players (indeed individual innovators) who are developing 'bottom-up' solutions to some of the urban mobility challenges and opportunities. Getting smart about urban mobility must involve strong urban governance in planning the sorts of future urban societies that we consider desirable; and delivering affordable, effective, attractive and sustainable connectivity that supports this.

Beware of dichotomous discourses

In January 2016, the new Institute for Social Futures at Lancaster University (http://www.lancaster.ac.uk/social-futures/) ran a workshop on the theme of 'Cities of the Future: Smart or Happy?' which the author attended. A strong sense emerged that very different constituencies of professionals exist with correspondingly different discourses associated with urban development. Indeed reference to smart *or* happy perhaps underlines an impression of dichotomy between smart *and* happy. Other commentators are emphasising this sense of dichotomy. For example, in his TEDx talk (titled 'why smart cities, what about happy?' http://gehlarchitects.com/news/why-smart-cities-what-about-happy/) Riccardo Marini questions whether making cities efficient through the lens of smart is as important as the happiness of the people inhabiting cities.

It is important in terms of smart urban mobility that we do not allow a position to evolve or harden where the technology industries champion their interpretation(s) of smart while other constituencies (planners and architects perhaps) see smart championed in this way as the antithesis of happy (or of sustainable). To be truly smart about urban mobility requires multidisciplinary collaboration that enriches perspective and makes sense of how to achieve the most positive outcomes for an increasingly urban population.

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