

# Changing Connections: Wi-Fi, Tablets and Evolving Systems of Connectivity

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## Introduction

The internet is growing. This is evident by almost any metric: the numbers of servers, data centres, cables, connection points, devices, appliances, people, locations, times and services that are connected to and through the internet have rapidly grown over the last 20 years and consequently so too has the volume of data that circulates. This has implications for energy demand. The total electricity used to manufacture and power information and communication technologies is estimated to have grown over the last decade as a proportion of total global electricity production. This trend is predicted to continue: from an estimated 10% in 2015 to around 20% of global electricity use by 2030, or 50% in a worst-case scenario (Andrae and Edler 2015). Growth in the volume of data flowing through the internet is especially significant in this. If we are to better understand the basis for such growth, it is important to consider how even low-power and battery-operated digital devices are implicated in the expansion of data-intensive services and practices.

This short paper represents a combined effort to connect our research into two aspects of this expanding 'system of connectivity': the emergence of Wi-Fi and of tablet computers. In their own right both are fascinating cases for exploring change associated with emerging technologies. Firstly, both have emerged with remarkable speed. Secondly, both are products whose use depends upon other infrastructures and devices. This gives us plenty of opportunity to explore complex sets of relationships between these and other technologies, and thereby go beyond accounts of their diffusion as singular technologies. Thirdly, both have complex relationships to practices, either through an indirect, mediated and essentially infrastructural relationship, in the case of Wi-Fi, or by being embedded in many and varied practices, in both cases.

Yet Wi-Fi and tablet computers are inherently interconnected to one other. At a basic level, Wi-Fi technology is an integrated component of the tablet. But since Wi-Fi connections can only be established and used when and where networks are available, this relationship is more complex than it might first appear. This is because these elements 'circulate' separately from one another. So, by combining these cases, we hope to highlight aspects of the evolution of this 'system of connectivity' over time (specifically, the last decade) in a way that would not be possible by focusing on one or other.

We focus this paper, short as it is, on developing an empirical description of Wi-Fi and tablet emergence in the UK, rather than developing the conceptual framework that guides it. It draws on interviews, undertaken in 2014, with 7 adult iPad owners (as reported in Lord et al., 2015) and a range of survey-based reports produced by Ofcom, the UK national telecommunications regulator. Throughout we use a mixture of terms to describe sets of relationships (ecologies, systems, assemblies, packages) and their character (symbiotic, competitive). We recognise that these concepts are underdeveloped and at times applied indiscriminately and inconsistently. Our aim here is not so much to clarify and develop these concepts, as it is to experiment with ways of describing change across a 'system'.

Nevertheless, we do make some theoretical assumptions about the nature of this system: namely, that it is integrated through practices, and that different types of products (or technologies) also feature as elements of it. What we describe therefore is neither a system (Watson, 2012) nor an ecology (Kemmis et al., 2012) of practices only, but one that we also attempt to characterise through the relationships between various types of product. This draws on the notion of 'an ecology of goods' consisting of various forms of cooperative and competitive relationships between artefacts (Nieminen-Sundell and Pantzar, 2003). Yet we assume that such relationships only exist through practices and cannot be abstracted from them. Thus, where we use the terms technologies or products, we refer to phenomena that exist in relation to practices, that is, as "objects-in-use" (Hand and Shove, 2007).

We begin with Wi-Fi and explore its emergence, primarily in homes, as part of a shifting 'package' of desktop computers, laptops, and broadband connections. We argue that the connection between Wi-Fi networks and laptops has been symbiotic and particularly significant in establishing Wi-Fi. However, this is shifting as other forms of mobile computers have arrived in the home. In the rest of the paper, we turn attention to one of these, the tablet computer, and explore the basis of its especially rapid uptake, initially through its relationships to 'populations' of other products, then through its integration into a well-established practice and, finally, we hypothesize about how certain combinations of tablets, practices and Wi-Fi may be distinctively implicated in the extension of this 'system of connectivity' to new places and practitioners.

### **Establishing a Wi-Fi Connection**

Wi-Fi is a registered trademark that represents the certified interoperability of wireless communication technologies that transfer data, as part of a network, over relatively local distances (tens of meters). It is a connective technology that consists in access devices such as laptops or tablets, access points that provide the networks and their connections to wired networks. Wi-Fi was first incorporated, in its standardised form, in a mass-market product in 1999 (the Apple iBook). Since then the numbers of devices and networks has grown massively. By 2015, more than 25,000 different products had been certified by the Wi-Fi Alliance, up from 3,500 in 2007 (Wi-Fi Alliance, 2015; Lemstra et al., 2011). A provider of an international Wi-Fi roaming service, iPass, estimates a rate of growth in the number of worldwide 'hotspots' of about 270% between 2013 and 2015; in the latter year alone the estimated total grew from 62 million to 94 million between April and November (iPass, 2015).

These Wi-Fi connections carry a lot of traffic. Cisco (2015) estimate that half of all UK internet access (by volume of IP traffic) is carried via Wi-Fi networks. Globally this figure stands at 42%. In other words, Wi-Fi is a highly significant feature of the way that the internet, as a whole, currently operates and is used. Whilst other wired and wireless forms of connectivity are available, Wi-Fi appears to have 'normalised' as a default means of accessing the internet.

This 'normalisation' has taken place across many different sites. And whilst public hotspots, such as cafes, have received much attention, the home is an exceptionally important site, both for the initial uptake of Wi-Fi and for its ongoing use. Firstly, most Wi-Fi hotspots are domestic: of an estimated 94.1 million worldwide hotspots, 81.4 million are located in homes (iPass, November 2015). Secondly, Wi-Fi is widespread in UK households: in 2015, the majority of UK households (75%) had Wi-Fi networks: encompassing almost all (95%) households with a fixed broadband internet access (78%) (Ofcom, 2015c). Thirdly, Wi-Fi is used most at home: respondents in Ofcom's annual surveys report using Wi-Fi at home (79%) more than anywhere else, such as when abroad (28%), at a place or work or study (15%), while travelling (14%) or in a public place (11%) (Ofcom, 2014a).

We argue that the uptake of Wi-Fi in homes has taken place as part a 'package' that includes wired broadband infrastructure and subscriptions, a range of mobile computing devices, as well as Wi-Fi routers. Although these 'parts' are distinctive, with their own histories and trajectories, and often involve different groups to provide, implement, and update them, they appear to 'work' together in a co-emergent pattern, in a laptop/Wi-Fi/broadband assembly. We examine levels of ownership of these 'parts' in UK homes over the last decade to explore how this assembly has emerged and how the relationships that comprise it have changed.

For most of the last decade, Wi-Fi take-up in UK homes lagged behind broadband subscription rates (Figure 1). Whilst in 2015 almost all fixed broadband subscribers reported using a Wi-Fi network, this was true for only 19% of subscribers in 2005 (Ofcom, 2015b; 2015c). In other words, broadband connections were the first amongst the other aspects of the home laptop/Wi-Fi/broadband assembly to become widespread. This appears to have taken place initially in relation to desktop PCs. We can see from Figure 1 that in 2004 the number of home desktops were significantly higher than that of laptops, and continued to rise slightly until around 2007. During this period the adoption of broadband extended to 50% of UK homes.

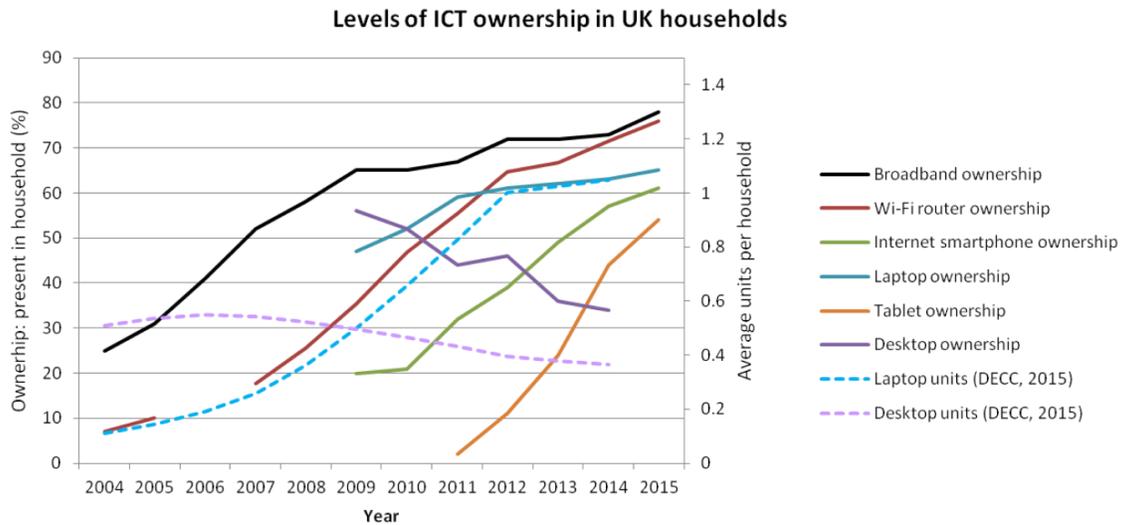


Figure 1. Household ownership of internet-related technologies. Source: derived from Ofcom (2005, 2015a, 2015c) and DECC (2015). Note: data from all years not available.

However, during the same time the number of laptops was also increasing. But it took until 2010 for levels of laptop ownership to reach those of desktop PCs, which were at the time in decline. This exchange in fortunes does not entirely appear to be the result of a simple substitution of one for the other, that is, a competitive relationship, at least at the time. For example, assuming a complete correspondence of broadband and computer ownership (which is not necessarily accurate), Figure 1 suggests a large overlap in desktop and laptop ownership in 2009-2010. Qualitative research with recent purchasers of laptops in 2009 supports this: many kept and continued to use their previously owned desktop PCs (Spinney et al., 2012).

A wireless router makes it possible to realise the promise of broadband, allowing for multiple devices to connect to the internet simultaneously and at any time (without the need for re-wiring the house). Since Wi-Fi ownership had extended to well over half of households with broadband by 2009, it may have helped to avoid competition between desktops and laptops. More generally, the number of computers per household has grown: in 2005, 53% of respondents to the Oxford Internet Survey owned one computer in the household, and only 16% had more than one. By 2011, this had changed: 34% owned one and a greater proportion (43%) owned more than one (Dutton et al., 2013).

Nevertheless, it seems that the single most significant computing device in the mutually promoting relationship with broadband shifted from desktops to laptops. In the initial years of the last decade (2004-2006) the former appeared to be in a symbiotic expansion together with broadband, as both increased. Yet this pattern of coinciding growth subsequently became more characteristic of the laptop-broadband relationship. Intuitively, this makes sense.

More striking is the correlation between Wi-Fi ownership and the rate of growth in laptops numbers. These appear to be closely matched, making it difficult to assess if either trend preceded, and thereby facilitated, the other. However, in 2009, laptop ownership was more

widespread (47% of households) than Wi-Fi networks (35% of households) (Ofcom, 2015b; 2015c). By 2012, this position was reversed as more households reported owning Wi-Fi routers (65%) than laptops (61%). From this, we might hypothesize that the domestic take-up of laptop computers, prior to 2011, helped to establish demand for Wi-Fi networks at home.

This account of Wi-Fi emergence is based on a rather limited set of evidence. Yet it is an intriguing exercise to 'read' ecological relationships from this data on ownership levels and unit numbers, as if it were some kind of ecological 'population' graph<sup>1</sup>. The image of a 'succession' of species each building incrementally on the conditions established by the former is compelling. Yet this picture of an evolving ecology of products tells us little about the practices in which these relationships are rooted, beyond a generalised shift towards greater degrees of internet-connectivity. If we are to argue that these patterns of 'population' growth, decline, symbiosis and competition have only been possible *because* of practices, we need to know more about how these assemblies are used. In the rest of the paper, we aim to develop this account by focusing on the recent 'population' explosion of the tablet computer.

### **Taking-Up The Tablet**

Compared to other 'high-tech' products, the adoption of tablets has been remarkably rapid in the UK (Figure 1). The Apple iPad in was released 2010, prompting other manufacturers to follow suite and release their own versions; there are now over three hundred different models of tablet available internationally. By 2015 over 54% of UK households owned at least one tablet computer (Ofcom, 2015c). This is a quicker rate of adoption than smartphones, which were first introduced in around 2005 and over the equivalent period of 5 years were taken up by 26% of households; taking 9 years to reach more than half of UK households (Ofcom, 2015c).

At first glance, the rapid uptake of the tablet might seem a little puzzling: these devices do not offer anything particularly new in function, compared to smartphones and laptops. In fact, tablet computer owners tend to own a range of other computing devices (Ofcom, 2013). This hints that the adoption of tablets may be in some ways complementary to, and possibly even facilitated by, the ownership and use of laptops and smartphones. Indeed, the 'population' graph (Figure 1) shows no evidence of competition between other species of product (with the exception of desktops, which do not seem to be thriving in this ecology).

Earlier attempts to launch tablet-like devices in the 1990s met with limited success, perhaps with the exception of personal digital assistants (PDAs). The basic technology certainly changed since then: they look, feel and 'work' differently from anything that would have been possible in the 1990s. But much else has also changed, not least the prevalence of other mobile types of computing devices, the range of internet-based services, the apps developed specifically for smartphones, the skills and understanding associated with using them, and the infrastructures that support them. Arguably, these trends have established the conditions that allow tablets to thrive. Specifically, we might suggest that they represent the circulation of a range of 'elements' that tablets also depend upon and 'integrate'.

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<sup>1</sup> See for example [http://www.balticuniv.uu.se/environmentalscience/ch3/Fig03\\_09.gif](http://www.balticuniv.uu.se/environmentalscience/ch3/Fig03_09.gif)

Of particular interest, here, is the relationship between tablets and Wi-Fi. Whilst other options are available for connecting to the internet with a tablet, evidence suggests that Wi-Fi is the dominant mode. Our research with 7 iPad owners in 2014 found that only one used a cellular data (3G) connection (Lord et al., 2015). Moreover, in 2015, only 12% of tablet owners reported using a non Wi-Fi connection (3G, 4G and other) when using their devices to make a 'call' on a voice over IP service such as Skype or Twitter (Ofcom, 2015c). In 2010, when iPads were launched, over half of UK homes already had a Wi-Fi router: without this established positioning of Wi-Fi in many homes it seems unlikely that tablets would be as quickly adopted. Of course, tablets may also, symbiotically, facilitate growth in the 'population' of Wi-Fi networks and the broadband subscriptions on which they depend. We return to this possibility later.

Tablets depend upon internet connectivity, through Wi-Fi, in another sense. Many of the apps used on iPads are designed to work best, and in some cases only, when there is an internet connection. Indeed, our research with iPad owners suggested that these connected applications are significant to defining how the iPad is used. For instance, one interviewee described taking her iPad with her when staying away from home in UK and abroad, but not using it when she got there, either because she couldn't connect to the Wi-Fi or because it "wasn't free". This seemed to be mostly about keeping in touch: Facebook was one of the apps she used most regularly and she had specifically planned to use the iPad to "contact my family for cheaper" whilst away. This also highlights that Wi-Fi networks outside the home are neither always free nor easy to connect to; though this is largely the expectation.

Drawing on this specific example of a tablet-in-use helps to illustrate that the apparently co-operative relationship between tablets and Wi-Fi networks does not exist in the abstract, or between these technologies per se. Rather, it inheres in how the tablet is used, such as when interacting with friends and family when away from home.

Developing this basis in practices, beyond ecologies of goods alone, lets us pose a set of questions about the rapid adoption of the tablet, some of which we explore in the rest of the paper. Firstly, is the rapid coming-into-use of this new form of computer based upon the 'ease' with which they can be integrated into existing practices? Secondly, how have these existing practices themselves come into existence? What are the sequences, connections and sites in which they have taken shape? Thirdly, what are these practices? Do some matter more than others? If so, in what ways? Fourthly, how are such practices continuing to evolve? And as they do, how do the relationships between tablets and other technologies shift and adapt?

In the fourth section of this paper, we explore aspects of the ongoing evolution in the relationship between tablets and Wi-Fi. Before that, we examine the integration of tablets into existing practices, specifically those associated with visual entertainment.

### **Insertion: Integration into Watching**

Watching TV and films is an incredibly well established practice in the UK. In 2014, it accounted for an average of between 3.6 and 4 hours per day per person, depending on the survey (Ofcom, 2015c; TV Licensing, 2014). Here, we illustrate how tablets are being integrated into watching practices in two ways: as the device used for watching, and as a device used for something else at the same time as watching.

In the first sense, tablets are amongst a range of devices that are used to watch on demand TV: in 2015 23% of adults with internet access at home reported doing so within the previous month (Ofcom, 2015c). Moreover, tablets were cited by 17% of adults as the computing device most often used for watching TV or films online (Ofcom, 2015b). Anecdotal experience and data from our interviews indicates that such incidents of watching TV may take place away from the living room and the main TV set. For instance, one interviewee reported: "I'll have it like standing up and have a TV series on while I fall asleep. And then I might fall asleep for half an hour, and then jerk awake and be in the zone to fall straight back asleep at that point, so I'll literally pick it up and put it to the side".

Watching TV in the bedroom is not a new phenomena, but as tablet numbers have grown, the number of TV sets in households has declined (TV Licensing, 2013). Putatively, this suggests a competitive relationship between the bedroom TV and the tablet. This clearly also depends upon other alliances: on the availability of on-demand services such as BBC iPlayer, broadband with sufficient capacity to stream, and again, Wi-Fi.

Yet a non-competitive relationship between tablets and TVs appears to hold at other times and places. Several participants described using tablets whilst watching the TV:

"Yeah I'll be in the room with my family, and the TV will be on, it's kind of like sometimes if my parents are like watching a show that's not great, I have to do something like just for fun. But even sometimes when I'm watching a show I'll feel compelled to use it"... (Rebecca)

"so especially when the adverts are on – I'll go on my iPad until my program is back on, and if I get bored whilst it's on I find that I might end up something on there and switching off, not really watching the program but it's still on"...(Erica)

"I'll probably have the TV on in the background but my iPad will be on my lap and I'll be constantly scrolling through Facebook and stuff like that" (Mandy)

In these examples, the tablet is used alongside the TV in what appears to be a relatively symbiotic relationship. But the relationships between practices are also more evident in these accounts, and complicate the dynamics. Whilst the practices of watching, using social media or browsing the internet are intertwined and may supplement each other, there are also signs of competition and conflict in their merged performance. The implication is that the apparently symbiotic relationships between TVs and tablets may be underpinned by a variety of other relationships between practices, which include but are not limited to forms of 'co-operation'.

More generally, the key point here is that there are different ways that tablets substitute for or complement established elements of watching practices, whilst leaving the overall configuration largely in tact. In other words, forms of watching are not only well established but appear readily able to incorporate a newer element such as the tablet. This suggests that at least certain aspects of the rapid arrival of tablets in UK homes may be predicated upon existing and well-established practices.

#### **Extension: Connecting New Practitioners and New Places**

The tablet is also implicated in extending established forms of internet-based practices to new practitioners and in extending previously on- and offline activities to new places. As it does so, it helps to facilitate, extend and further entrench the 'need' for internet, and thus Wi-Fi, connectivity. So whilst the availability of Wi-Fi networks most likely facilitated the rapid uptake of the tablet, the tablet may also be 'returning the favour'. Our research into this ongoing relationship is, well, ongoing. We include some ideas here, since they help to explore how this apparently symbiotic relationship works through practices; but this is speculative. We consider two groups of practitioners, old and young, and two locations beyond the home, restaurants and hospitals.

Whilst many tablet owners may own a range of internet-connected devices, this does not necessarily apply to all. In particular, the use of tablets by children has received attention in the media. Indeed, Ofcom reported in 2015 that over half of 2-3-year olds use a tablet (53%) and 15% of 3-4-year olds actually owned a tablet (15%) (Ofcom, 2015c), rising to 40% for 5-15% (Ofcom, 2015e). In contrast, in 2005, in a different study, the majority of parents (61%) reported that their 0-6 year-old child had never used a computer by themselves (Marsh et al., 2005).

Arguably, the appropriation of tablets by, and on behalf of, young children in many ways entrenches the need for relatively high-speed broadband access at home, especially if these uses are online and simultaneous with other internet uses. Indeed, an image of the multiply connected family that includes a youngish child watching catch-up TV on a tablet has already been used by Ofcom to illustrate "why a household might need 10Mbit/s" (Ofcom, 2015d: 27). Also, it may be particularly in relation to this children-tablet coalition that numbers of TV sets in UK homes have fallen: the proportion of children with sets in their bedrooms fell from 66% in 2009 to 44% in 2014 (Ofcom, 2014c).

This is not limited to the home: the coalition of families with young children, tablets, and watching practices may well be implicated in the adoption and use of Wi-Fi networks in restaurants and cafes. We have certainly observed instances where parents eat and converse whilst a young child, with headphones, quietly watches something on the tablet. Yet it is unclear to what extent this is a more general trend, and to what extent it might feature in the rationale associated with expanding Wi-Fi provision in restaurants and cafes.

Returning to domestic internet connections, many households of older age have continued to subscribe to broadband connections at home for the first time. The adoption of tablet computers has been used to explain at least some of this increase (Ofcom, 2014d). In our research, one

participant (in her 30s) described using her iPad to contact her parents via their iPad, and in particular using the instant messaging feature in Skype:

“I use it more for instant messaging, especially since my parents got the iPad, it's, I think they've suddenly decided how much they like Skype since having the iPad 'cause they can keep in contact. 'cause quite often I'll be busy so I won't answer the phone, or something but they can at least send me a message and I'll get it. Yeah and they love calling me from abroad, every time, like I always have to make sure I answer 'cause every time they go, they want to show me the video image” (Kathryn)

We do not know from this interview if Kathryn's parents used the internet at home, prior to the iPad. But it does seem that by having an iPad they are able to keep in touch with their family in a different way. As seen with other participants, this extends to times when they travel abroad. In addition, Kathryn talked about using her iPad to interact with her parents (presumably on their iPad) when a new baby joined the family: “I Skyped my dad from the hospital 'cause he couldn't make it over to see the baby... So that he could see a video of the baby”. This particular example of “Skyping” did not depend on Wi-Fi connectivity; Kathryn was the only participant who had and used a mobile SIM card in her iPad. However, it does help to illustrate how iPads and the internet-based modes of communication that they facilitate, and which are becoming established between family and friends, are being mobilised across different spaces and times.

The case of hospital Wi-Fi is particularly interesting. In December 2015, the health secretary Jeremy Hunt announced a £1bn budget aimed at balancing the spread of access for free Wi-Fi in hospitals nationwide (Guardian, 2015). Whilst one of the aims is to provision for developments in the organisation and implementation of health care, the other aim is to allow patients (and their visitors) to stay connected to their family and friends whilst in the hospital. In addition to extending internet-based communication practices, this move will also allow for greater mobility of watching practices within these spaces. Just as witnessed in restaurants, it is likely that tablets will play a distinctive role in this.

## **Conclusion**

In this short paper, we have presented a case of what is ostensibly the adoption and domestication of the inter-connected technologies of Wi-Fi and tablets. Yet in tackling these together, our aim has been to embrace the complexity of these changes as part of a wider, evolving system, by exploring *some* of many dynamics that have emerged and shifted, in sequence and in concert, over time.

No doubt there are other (and better) ways to select and to present these ‘system’ dynamics, and other conceptual resources we could draw upon to develop and clarify our approach (ecology, systems theory, path dependency, economics of increasing returns etc). Moreover, we are aware of relevant differentiations and relationships left unelaborated, such as between initial and ongoing appropriation, and how we might define and bound the system to which we refer. Nevertheless, piecing together this case has been a useful experiment in combining, not only our respective research projects, but also different types of data. It also allows us to draw some useful observations about the kinds of relationships analysed.

We presume that practices are the fundament of changes within this system, the 'site' at which these dynamics transpire, yet our account did not always prioritise practices. Instead, it focused more consistently on the (ecological) relationships between 'species' of technology. Yet in moving between different types of data, from the national 'stock' or 'population' figures of products to examples of how they are used, it was possible, and indeed more important, to 'pull' practices, such as watching and keeping in touch, into the packages or coalitions we were describing.

This complicates things in terms of the changes we are looking to 'explain': a challenge for our own clarity in undertaking analyses of this kind. For instance, in considering the example of hospitals, we can claim in general terms that a coalition of keeping in touch / tablets / Wi-Fi and maybe even particular groups is implicated, not exclusively but significantly, in extending a 'system' of, say, 'everyday connectivity' to hospitals. Yet we might 'read' this coalition in different ways in order to arrive at an account of more specific phenomena, such as a) the expansion of open, free Wi-Fi networks in public buildings; b) the extension of keeping in touch to new times and spaces, and its associated evolution; and c) the recruitment of new groups to tablet ownership. Each may be explicandum or explicans. If change transpires in complex systems through recursive or circular causality, this may be unavoidable to some extent. But it is intuitively unsatisfying.

Intuitively, systemic relations do not (necessarily) transpire at once, but in sequence. They unfold. In our account, we attempted to emphasise some of these sequences. We started with the desktop PC and its relationship to home broadband connections, a relationship that was initially supplemented and then overtaken by the laptop. Although we have not followed this relationship here, we can say from other work that it was important in the earlier emergence of Wi-Fi networks in non-domestic places, such as hotels, cafes, libraries; a trend which also plays into the rationale of providing free Wi-Fi in hospitals. Meanwhile, the prevalence of broadband connectivity was significant in the establishment of a range of internet-based services, like Skype. And it is this 'territory' that had been already colonised by a range of existing practices and technologies, into which tablets emerged. In other words, we might say a 'niche' for the tablet had been established firmly within the existing system.

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