



User attitudes towards wireless technology: 802.11b

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The opportunity for 802.11b WLAN technology is spreading; both in the business and consumer sectors. Journalistic genre in this embryonic area assert that people use WLAN because it liberates them from wires, which enables complete mobility to use WLAN in any location with 802.11b. This study addresses both business and personal sectors, and quantifies where and which specific tasks people engage in whilst using WLAN. The findings show that WLAN is 'liberating' offering all users increased 'mobility', 'flexibility' and 'convenience'. Also within the business sector, there are significant differences between the types of tasks employees undertake using WLAN at the office and the tasks undertaken elsewhere, working off-site. Initial multidimensional analysis suggests four groups of use of WLAN within the work environment: formal use, informal use, individual use and collaborative use.

USER ATTITUDES TOWARDS WIRELESS TECHNOLOGY: 802.11b

ABSTRACT

The opportunity for 802.11b WLAN technology is spreading; both in the business and consumer sectors. Journalistic genre in this embryonic area assert that people use WLAN because it liberates them from wires, which enables complete mobility to use WLAN in any location with 802.11b. This study addresses both business and personal sectors, and quantifies where and which specific tasks people engage in whilst using WLAN.

The findings show that WLAN is 'liberating' offering all users increased 'mobility', 'flexibility' and 'convenience'. Also within the business sector, there are significant differences between the types of tasks employees undertake using WLAN at the office and the tasks undertaken elsewhere, working off-site.

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KEYWORDS

User studies, mobile appliances, 802.11

INTRODUCTION

802.11b is the standard of technology implemented by the Institute of Electrical and Electronics Engineers (IEEE) that enables access to a wireless local area network (WLAN). It enables users complete mobility to receive and transmit information within range of the wired or wireless LAN base station (i.e. 30-50m); enabling them to transmit information at 11Mbps (million bits per second). In this scenario, WLAN technology is new to both business and consumer users. WLAN uptake, although slow, is beginning to spread as increasingly more users adopt the 802.11b technology. The value added being: 'liberation' from wires, increased 'flexibility', and 'convenience'.

At the beginning of the 21st century when IT surely comes of age, laptops and hand-held devices i.e. PDA's (personal digital appliances) are still very much in the realm of industry. Hopefully, investment in 802.11b technology by this industry will generate new opportunities for this technology in other sectors.

Investment in 802.11b technology within industry provides a number of benefits :

- mobility to access and transmit information from any location within range of the WLAN, thereby improving convenience of use and productivity
- increased ease of installation combined with reduction in medium to long term costs - eliminating the initial need to pull wires through walls and ceilings, life-cycle costs are significantly lower
- user mobility, enabling the WLAN user freedom from the traditional physical constraints, to work anywhere within the range of the WLAN range
- scalability of WLAN systems means they can be configured in many ways, to meet the needs and specifications of business and personal users; however this functionality depends upon the size of the network area covered and the number of people using the technology [1].

To date reports in this market have been mainly journalistic, and assert that, given the 'newness' of the 802.11b, WLAN networks will experience growth substantially over the next few years, as consumer demand for PC's to become 'portable' and 'mobile' increases [3].

Market researchers report 802.11b is mainly within North America, showing usage is comprised mainly of 'mobile professionals' (i.e. professional people using WLAN on the move) in airport lounges, hotels and coffee shops e.g. Starbuck's. All locations enable users to browse the web as well as accessing and transmitting data and e-mails [2]. Gartner Dataquest (2001) forecast there will be 19 million frequent mobile professional users of 802.11b and 38,000 gateway locations, 64% of which will operate within North America in: airports, hotels, coffee shops, retail outlets, restaurants, convention centres, shopping malls, exhibitions and university campuses, by the end of 2006. In addition, Gartner Dataquest (2001) predicts 30% of professional notebook PCs will have 802.11 WLAN interfaces [6].

Given all the advantages WLAN provides, there are two main constraints intrinsic to WLAN :

- *first, and foremost, security.*
Corporate businesses and individuals are increasingly using wireless technology for important communications they want to keep private e.g. e-mail, commerce transactions, and corporate data transmissions. As wireless technology grows in popularity and stores valuable private information, hackers are increasingly attacking these targets. However, mobile devices and PDA's with internet access were not designed with security as a top priority, thus wireless security is becoming a crucial area for research and development in all markets [4].
- *high mobility and flexibility*
Tempered with lack of speed, standards and reliability have held WLAN back. Although WLAN's now operate at 11Mbps and the Wi-Fi standard for compatibility, WLAN uptake in a world that relies on fibre for wide area connectivity is slow. Whilst it is difficult for the outside world to envisage why people would prefer to use airwaves over fibre optic cables, to implement world wide WLAN infrastructure, areas need to be established where the technology will be useful and beneficial in both a corporate and public market [5].

Overall, current thinking highlight people use WLAN because it liberates them from wires, therefore giving mobility to use WLAN in any location with 802.11b capability, allowing people to 'roam' around their building at work, or work in Starbuck's using this technology, given its range. However, current research in this area fails to qualify and quantify when, where and for which tasks people use WLAN.

PURPOSE

The purpose of this pilot-study is to extend and verify current research findings by utilising the WLAN infrastructure currently in use at HP Labs Bristol. In this study we have investigated the use of 802.11b technology in depth, using 2 methods of enquiry:

- User behaviour is analysed via a one-to-one semi-structured interviews study, to identify the important variables involved in using the WLAN 802.11b technology
- Based on this interview study we developed a questionnaire and interviewed employees to identify relevant variables

METHOD

Participants

25 participants were recruited, all employees within HP Labs. 6 males participated in the one-to-one semi-structured interviews, their roles were: research engineers and research scientists. The age of the participants ranged between 32 and 48 years (mean age 35 years).

19 males participated in the WLAN questionnaire; the age of participants ranged between 30 and 48 years (mean age: 38 years) all employees within HP Labs. Their roles were: 6 Research Engineers, 3 IT managers, 3 Technical Consultant's, 1 Senior Member of Technical Staff, and 1 Public Relations Manager.

Materials

Semi-structured interview schedule

WLAN Questionnaire

Procedure

Participants were selected both for the interview and questionnaire study using a purposive opportunity sample. Firstly, we conducted one-to-one semi-structured interviews. Participants were selected for the interview and questionnaire study if they met the criterion of using a Lucent (Agere) Orinoco wireless LAN adapter card to access the 802.11b technology within HP Labs Bristol using either a HP Omnibook 6100 laptop, a handheld Jornada or both. All participants were informed they would be asked how they used wireless LAN in their every day life. For example:

- Frequency of use
- Motivations for use
- Location of use
- Tasks completed using WLAN
- User likes and dislikes
- Speed and connectivity of WLAN
- Health and safety concerns about WLAN
- User Wants/Future Predictions for the WLAN technology

Semi- structured interviews were then transcribed and analysed by identifying recurring themes and ideas within each. Based on the themes and ideas that transcribed from the analysis of the interviews, a quantitative questionnaire was developed on WLAN attitudes and behaviour within HP Labs. This required participants to quantify how much they participated in a given activity or behaviour e.g. frequency of use, location of use, tasks completed using WLAN, speed and connectivity, comparison of a wireless LAN to a wired LAN and general attitudes towards wireless LAN use. All questions were in a graphics rating scale format [7], participants were asked to answer the questions by making a tick-mark on a line between two extremes e.g. "Not at all" and "All the time". The line was 100 mm long. "Not at all" was always on the left hand side, corresponding to the value 0 and "All the time" was always on the right hand side, corresponding to the value 100. Scoring was carried out in millimetres using a ruler.

RESULTS

Findings from the interview and questionnaire study highlight participants have used the WLAN for between 5 and 9 months. Motivations for using WLAN range from the convenience it provides, in terms of mobility and flexibility of use within their working environment i.e. not being constrained to a workstation but being able to move and work wherever they are in the building, the idea of being able to 'pick up and go', which a wired

LAN did not provide. In addition, participants wanted to investigate WLAN use in meetings, as well as experiencing the technology overall and finding out what it was like to use.

All participants used WLAN for a range of tasks including: use in meetings, reading and sending e-mail, development work, file transfers, browsing the web, working in the coffee area, work in their cube, use as backup to the building, and use when travelling to America.

INTERVIEW STUDY

Analysis of interviews enabled 8 common themes to be identified. These include the following:

User Likes

Participants reported WLAN allowed them complete mobility within their working environment, and a great sense of liberation from wires that enabled them to work wherever they were in the building without having to disconnect. For example:

- **Liberation:** *“It’s the liberation, the sense of being liberated from cables”*
- **Convenience:** *“I can pick the laptop up and move to somewhere else without sort of having to disconnect”*

User Dislikes

The majority of users expressed some kind of dislike with wireless LAN based on:

- **Security of WLAN:** *“I’d worry about security, I don’t want people to go through my stuff and.....how do I make my machine secure from their network and how do they make their network secure from my machine, so I’d be very wary about taking my laptop into say Starbuck’s, I’d like to know what security provisions were in place before I went”*
- **Form factor of Orinoco card:** *“it protrudes a bit, it would be nice if there was an internal version”* Having said this there is an internal version of the card that has been developed, thus solving this problem.
- **Amount of battery power 802.11b consumes to work in PDA’s:** *“if I was to have a wireless LAN in the jornada, my battery power would go down from about 10 hours to about 3 or 4”*

Changed Behaviour

WLAN has changed behaviour at work, for example, users now take their WLAN PDA’s (HP Omnibook 6100 laptop or jornada) with them to meetings and are able to send, scan and read e-mails.

WLAN facilitates meetings, allowing information to be pulled in, thus allowing interaction with real time information ‘on the fly’, improving work productivity e.g.:

“it’s useful to be in a meeting and be able to have a tool to be able to send an enquiry, to get a response and be able to relay that information back into a meeting”

WLAN has changed the way in which participants make notes in meetings, a transition away from paper and pen and towards note taking in the form of saving URL and web searches:

“if someone’s saying something where you might just make a pencil or paper note or something, what I tend to do these days is just go straight to a web page or... I’ll save a search...so my note taking and my responses have become a lot more electronic”

WLAN is also of great user value when travelling to America. For example, users were able to use WLAN in hotel rooms, both to browse the web to access UK radio stations to listen to the news, and to read and send e-mails, both of which they were able to do free of charge.

Social and Cultural Concerns

Some users reported reading and sending e-mails in meetings, although there was some scepticism about whether this was socially acceptable to do. Participants were concerned about the following issues:

- **Distraction:** *“you see people sitting in meetings with wireless LAN cards not really paying attention to the meeting....but replying to email or browsing the web..... but it’s a bit rude really”*
- **Self-Consciousness:** *“I’m quite self-conscious about how I will present it or... how the person presenting it feels about me tapping away and not making eye contact”*
- **Body Language and lack of eye contact:** *“a high percentage of communication is body language, so if people are sitting in meetings with laptops in front of them, it’s not possible to see body language, which creates a barrier”*

Users reported browsing the web to pull information into a meeting, or sending and reading e-mail was only socially acceptable to do if it added value to the meeting in terms of addressing the meeting agenda, and subsequently using this ‘pulled information’ to facilitate discussions in the meeting. Users stated they would not otherwise use WLAN because they believed it was socially unacceptable, reporting WLAN would act as a disturbance to peoples’ concentration and create social barriers both for the person hosting the meeting and others in the meeting.

In addition, some users reported feeling self-conscious about note taking using a PDA as opposed to pen and paper. In particular, issues arose concerning communication in the form of body language, and lack of eye contact being made.

Speed and Connectivity

All users reported speed and connectivity was generally good inside HP Labs. Although some users did report having to move around the building and meeting rooms in order to get a better connection.

Users reported speed was inadequate when using WLAN to back up data, or when downloading information, where speed was reported to be slower than a wired LAN connection.

In addition, users showed concern over more people using the WLAN and traffic being created as a result, and what affect this would have on speed and connectivity.

Health and Safety Concerns

The majority of users were not concerned by the microwave radiation emitted from appliances with wireless LAN connectivity. However, one user raised an important issue that the 802.11b wireless infrastructure is ‘always on’, and if an appliance was giving signs that it was emitting radiation e.g. the appliance became hot, people would be more cautious about its use. For example:

“one disadvantage I’ve seen from 802.11b PDA’s is they tend to get quite hot and if a device gave signs that it was emitting some kind of radiation, then people are going to be quite worried about whether to use it...and in a way I suspect people might be a bit more nervous about 802.11 cards because they’re always on.. whereas, with mobile phones people only use it for short periods of time”

However, WLAN is not in a sense ‘always on’ because it only transmits when there is data to transmit.

User Wants

The majority of users would like to see the wireless LAN technology interconnect with other appliances: telephone, VoIP and camera . For example:

“a useful device would be to have a version of the Jornada which had 802.11 capability and a camera and my mobile phone on there”

Users also reported having VoIP integrated into their PDA's and suggested using VoIP to make international calls would be highly valuable. For example:

“It would be really nice to have a phone integrated into outlook...as well as using voice over IP to make international calls when travelling”

Users also expressed ideas that WLAN could be used to interact with the home/domestic environment. For example:

“I would want it to be able to provide me interconnections in the home environment, like tell me the washing machine has finished its cycle”

Predictions for future technology

From the study we got a sense that the opportunities available for WLAN technology are multitudinal. Participants in the study had many ideas about future technology use. Many ideas were based on using wireless LAN PDA’s on the move, both for buying merchandise, and finding information in libraries. For example:

“if I’m walking down a street, and I go into Waterstone’s what’s to stop me checking Amazon, and deciding yeah this book looks interesting... I may be watching a news feat and think I’d like to learn a bit more about this story, perhaps I’ll buy a newspaper, so it might encourage me to go into a newsagents”

WLAN in libraries:

“ a 802.11b PDA in libraries would be very useful because it would mean it wouldn’t be necessary to have to refer to computers, you could actually carry it around while you were doing your investigation.”

In addition, users believed WLAN would be very useful in a home setting, making use more convenient since users could use the internet in any location in the house, and WLAN would enable more than one user to use the internet at the same time, thus allowing multiple-connections.

One user suggested that future WLAN development could enable ‘private networks’ to be set up between people. For example, a group of people in a meeting, in comparison to logging onto the wider HP network. This would make exchange of information and sharing of files easier e.g. in a departure lounge at an airport:

“something that’s not available yet is the ability to quickly set up little networks of your own, for instance, if three of us join in a meeting room, we can’t all instantly set up a private network between us. At the moment in labs we would all individually connect to the big network and be members of that network, but say we were all in an airport departure lounge and we wanted to share some files before we got on a plane that would be a very useful to be able to do with 802.11”

QUESTIONNAIRE STUDY

Statistical analysis of the WLAN questionnaires included descriptive statistics (Figure 1). In addition, questionnaires were then analysed via repeated measures pairwise testing, using analysis of variance (ANOVA) to determine the significance of the results obtained. Finally, multi-dimensional scaling (MDS) was completed which allowed a graphical representation of the dissimilarity and similarity that exist between variables (Figure 2).

Location of use of WLAN

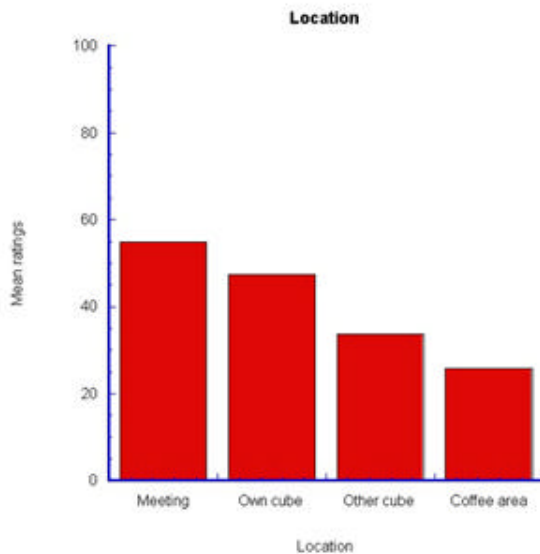


Figure 1: Mean ratings of WLAN use in different locations

Participants use WLAN more in meetings (spending on average 55% of their time) than any other location: own cube, other cube and coffee area, which is the least used location of WLAN, only being used on average 25.9% of time.

ANOVA enabled significant differences between WLAN variables to be identified. For example, use of WLAN in meetings is significantly different from using WLAN in other cubes and the coffee area at significance levels of .05 and .005. In addition, using WLAN in own cube is significantly different from using WLAN in the coffee area at a significance level of .05; whereas analysis of other cube and coffee area highlighted no significant differences.

Use of the WLAN in meetings supports the findings of the interview study where participants reported WLAN facilitated meetings enabling: note taking, referring to other documents stored on their PDA to supplement the meeting, and pulling in information from the web to facilitate discussion forums.

WLAN use during different tasks

The top three tasks participants completed using WLAN were: reading e-mail the highest of the three, sending e-mail, and browsing the web. All were done regularly encompassing >68.7% of participants time.

ANOVA comparisons between the 3 tasks show there was a significant difference between reading e-mail in meetings and sending e-mail in meetings. Participants read more e-mail in meetings, mean rating: 54.6% of time than sent e-mail in meetings, mean: 35.5% of time. In addition, there was a significant difference between browsing the web, which on average the majority of participants did, mean: 68.8% of time, and browsing the web in meetings, which participants did on average only very occasionally, mean: 37.1% of time. Both these results highlight participants in the study complied to 'good social etiquette' in meetings i.e. they stayed focused on the meeting agenda, giving their full attention, and only sent e-mail when it was necessary; or as some participants reported in the interview study: sending e-mails or browsing the web before a meeting began in so called 'dead time'. These results support findings found in the interview study.

Multidimensional Scaling of Work Patterns

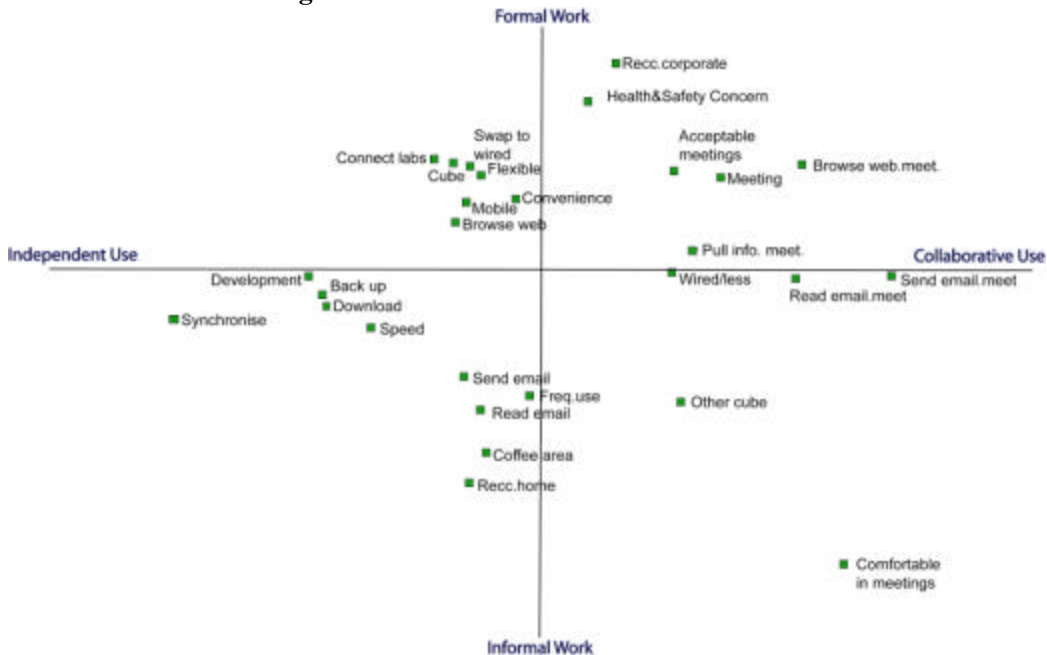


Figure 2 Multidimensional Representation of WLAN variables

To gain an insight into the similarities and dissimilarities between the variables in the questionnaire study, analysis of variables was completed using multidimensional scaling (MDS). Figure 2 shows a graphical representation of WLAN variables after MDS. MDS analysis suggests four groups of use of WLAN within the work environment e.g.:

- **Formal use** e.g. for development work in their cube;
- **Informal use** e.g. reading and sending e-mail in any location e.g. coffee area;
- **Independent use** e.g. for development work, backing up data to the building, downloading data, synchronisation of information to appliances; and finally
- **Collaborative use** e.g. in meetings to pull information in from the web, or to read and send e-mails in meetings.

DISCUSSION

All participants benefited from the use of WLAN in their working environment; users reported WLAN was more convenient to use than a wired LAN offering: increased mobility and flexibility. For example, participants found they were 'liberated' from wires i.e. they were not physically constrained to their workstation, but could 'roam' around the building with their WLAN PDA appliance at their convenience, and work in any location: the coffee area, a meeting room, their cube, or someone else's cube; all benefits that a wired LAN connection did not provide.

The main use of WLAN for participants in the study was use of the WLAN in 'meetings', which was reported to be 'highly valuable', in particular, going to websites to pull information into meetings. Pulling of information into the meeting enabled participants to interact with 'real time information', which facilitated the meeting agenda in the form of discussion forums; and enabled people to come to quicker decisions, thus improving work productivity.

The 'coffee area' was the location that on average was used least by participants, thus decreasing to some extent the 'hype' about complete mobility since the majority of participants in the study either used WLAN in meetings or at their desk. This is not surprising given 802.11 is a fairly new technology, therefore, one would not expect a significant amount of people to use the coffee area for working; (e.g.: reading e-mail, sending e-mail and development work) mainly because they would be prone to most distraction and interruption in this location. However, this may change in the business sector and cause some shifts given the 'novelty' of reading and sending e-mail in the coffee lounge. Similarly, in the consumer sector, checking e-mail and browsing the web may become prevalent in Starbucks. However, security is a major concern in industry as our results support, therefore possibly dulling the amount of people who partake in this activity.

The small sample of participants with WLAN infrastructure implemented at home reported WLAN was very convenient, enabling use in any room of the house, and both they and other members of the household could hook up to the internet at the same time, thus allowing multiple connections to the web to be set up.

A key user issue identified both within the interview and questionnaire study, which is further supported by literature [4], is the problem of making the 802.11 WLAN infrastructures secure. All participants were more concerned over the security of the WLAN than a wired LAN, not so much within HP Labs where they had trusted security provisions set up, but outside of work when using public WLAN networks e.g. in Starbucks coffee shop, or in hotel rooms in America. Concerns over security are holding WLAN development back. This is an issue that needs to be fully addressed before individuals will use WLAN, since businesses and individuals are increasingly using wireless technology for important communications they want to keep private: email, commerce transactions, data and corporate transmissions. Thus, trustworthy security provisions need to be in place for WLAN to become prevalent.

Some users recommended the use of WLAN in a home environment, however, the network needs to be made secure to be a favourable solution for the consumer sector which participants reported took considerable effort to achieve at present, thus WLAN cannot yet be recommended as a standard package. In addition, WLAN needs to become more prevalent in the wider market place before people at home adopt this relatively new technology, at present the cost to install the 802.11 infrastructure and appropriate security provisions is higher than a wired LAN connection. In addition, persuading consumers to favour radio waves over cable is another challenge the WLAN market face, thus reasons need to be established via global advertising campaigns as to why WLAN is more favourable than a wired LAN. Once WLAN becomes more prevalent in both the corporate and home

environment, economies of scale will significantly reduce the cost of implementing the 802.11 infrastructure and all being well in the long run become the norm in the global market.

The limitations of the current study are: it is highly specific, only encompassing a very small sample of employees at HP Labs, all of whom were male and to some degree had quite technical backgrounds. This limited and biased sample mean generalisations to the population as a whole cannot be made. A much wider sample needs to be taken encompassing a range of 'mobile professionals' both within HP as a whole and other organisations to investigate both user attitudes and identify if WLAN would be beneficial in a corporate environment.

Further investigation also needs to take place into whether WLAN would be a favourable solution to encompass in the home environment, investigating users behaviour and whether they find it more beneficial than a wired LAN and to investigate whether they would be prepared to pay for a WLAN over a wired LAN connection. Finally, further work needs to incorporate better security solutions for WLAN in both corporate and public settings.

CONCLUSION

WLAN enables the mentality that people can 'get up and go' without having to worry about connecting to a wired LAN, thus allowing complete mobility within business and consumer sectors, therefore increasing: flexibility, convenience and work productivity.

The most salient result to come from this study is the value WLAN provides in meetings. The ability to bring PDA's into meetings with WLAN capability is a significant finding which is invaluable to industry; enabling information to be obtained from the web 'on the fly', thus facilitating the meeting, and improving work productivity. The use of WLAN in meetings has huge potential and is an area that is likely to expand in both the business and consumer sectors, which our data clearly supports.

This study has revealed some changes in work behaviour e.g.: the increasing use of WLAN in meetings in the business sector; and use of WLAN in 'social settings' e.g. the coffee area in HP Labs, and Starbuck's coffee shop in the consumer sector. However, there is more to changing work habits than a new technology.

In conclusion, although WLAN will lead to changes in overall consumer consumption, both consumer and work habits will not lead to major changes in behaviour. There may be shifts in behaviour given the novelty of a new technology, but significant changes in work and consumer habits will take time to substantiate, and will be due to more than just a new technology.

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