Imperial College of Science, Technology and Medicine

Department of Electrical and Electronic Engineering

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The Disappearing Computer

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1. Introduction:

Computers are getting cheaper, smaller and more powerful all the time. The disappearing computer concept is essentially a futuristic vision. This vision is one in which our world of everyday objects and places becomes infused and augmented with information processing and exchange, where technology providing these capabilities is unobtrusively merged with real world objects and places, in a sense it disappears into the background and becomes an invisible entity.

Everyday there are breakthroughs in the computer equipment industry. In February 2000 the Los Angeles Times informed us that IBM had demonstrated a circuit on atomic scale. Most technologically aware people will know of Moore's law. "The number of transistors on a chip doubles every 18 months". In a similar way other hardware is being reduced in size and its performance increased.

Modern technology is constantly becoming faster, smaller and cheaper, while memory and processing power is on the up. But to what extent will it have an effect on our future? What will a computer be in a few years or decades?

At the moment most of us think "Computer? That is that big white thing next to my desk. It sits there and waits for me to ask it to do stuff like word-processing." or "A Computer is the thing that controls a robot that built my car". We do not expect a computer to be found in our toaster.

But as the systems are getting more powerful, we can suddenly use them to solve different tasks we have done manually until now. It will probably be possible to reduce size so that devices can be carried around which where normally used in a lab. Also, you may have read articles about fridges that will tell you that your milk will go off soon or microwaves that tell you to add a bit more salt.

This report tries to predict the future. By looking at existing systems, products in development and also by looking at peoples visions it tries to find out possible markets and how to pick out the products that may be successful in the short or long run.

Several sectors are examined, all of which are closely linked to everyday life and puts across ideas about how the technological possibilities we see today and in the future may be put to use. Moral issues and whether the product is likely to be accepted by society and its potential users will be looked into. Safety issues are discussed from varying points of view and how the disappearing computer may affect the world we live in is investigated.

For each piece of technology, the analysis is based upon how it would fit into the Western world. Of course, different cultures and countries have a wide range of different habits and views on technology. A piece of technology may have great potential in one country and be doomed to failure in another. This effect is real but it is beyond the scope of this report.

2. Generic Technology:

This section contains information about technology that is relevant to more than one field.

2.1. BLUETOOTH:

Bluetooth is based on radio wave which operates in a globally available frequency band (2.4GHz), ensuring compatibility worldwide. The Bluetooth technology makes all connections simply and instantly without the need to buy, carry and connect the cables. It facilitates fast and secure transmissions of both voice and data, even when the devices are not within line-of-sight.

2.1.1. Advantage:

Obviously, the Bluetooth technology virtually eliminates the need to purchase additional cabling to connect individual devices. You can, for instance, connect your desktop or mobile computer to printers, scanners and faxes wirelessly and you can increase your sense of freedom in your everyday work by wireless connection of your mouse and keyboard to your computer.

Also, devices can recognize and instantly connect to different types of networks through a Bluetooth connection. For example, you can just as easily connect to the Internet via a mobile phone as via any Bluetooth-enabled wire-bound connection.

Your Bluetooth-enabled devices can be set up so they automatically exchange information with one another. If you accept an appointment on your handheld device, the appointment is automatically saved in your desktop PC as soon as the two devices are within range of each other.

The potentials of the Bluetooth technology are virtually unlimited. One after another, new applications and products, as well as increased functionality, will be introduced.

Small handheld scanners, portable hard disks, “wrist watch information centers”, refrigerators, coffee machines and presentation projectors are just a few examples where fast and secure wireless connection will simplify our everyday life.

2.1.2. Disadvantage:

All these conveniences are based on Bluetooth-enable connection, which means that tiny Bluetooth microchips have to be built into all digital devices to incorporate radio receivers, otherwise the connection won’t be set up at all.

Figure 1: Bluetooth card

The transmission range of Bluetooth is still limited. For instance, Figure 1 is Bluetooth PC Card developed by TOSHIBA. Whenever it is inserted into your laptop, it will synchronously exchange information with other Bluetooth-enable devices such as mobile phone, etc within the transmission range of 10 metres. Probably in the near future, we could have wireless access to the Internet from your laptop through your landline at home regardless of your location.

Currently Bluetooth-enable devices are quite expensive. For example, you have to pay £140.00 for this TOSHIBA Bluetooth PC card, more than twice of a normal Ethernet card.

2.2. The IBM Hologram Data Storage System (HDSS):

A holographic storage system seems like an idea from some sort of sci-fi film but sure enough it has arrived at our doorsteps and will undoubtedly stay there for some time. It is a technology that promises 3D holographic movies, new forms of art and information storage so dense that you could put a feature film on a piece of the material the size of a sugar cube.

Holographic Data Storage System (HDSS) works by stacking up thousands of layers of special optic material, each layer being programmable with millions of bits using a laser. This results in a block of material with a storage capacity of several gigabytes of data per cm^3.

The specifications of such a device are astounding with data access times of at least 1 billion bits per second, more than 10 times faster than is possible today. Storage capacities could move up to the magnitude of 1 trillion bits. That is 12 times larger than the largest magnetic hard drives on the market.

The potential of this type of technology in the modern day world is endless. The device could be implemented within a host of applications, for example satellite communications, airborne reconnaissance, high-speed digital libraries, storage systems for evidence from extended outer space missions and image processing for medical, video and military purposes.

In terms of wearable electronics, implementation of the device would mean people could carry around trillions of bits of data at all times. It could be implemented within tracking systems whereby for example the police force could track a person's exact movements over extremely long periods of time. It would revolutionize the world of portable computing, giving people the power to carry around computers as powerful as today's top of the range desktops like a wallet, or even a button. These people would then be truly mobile.

3. Wearable and leisure electronics:

There have been a number of very interesting and promising developments in this area recently with objects such as cloth keyboards, rings with RAM, wearable video displays and a host of other electronic gizmos which may or may not become the norm in years to come.

In the next few pages, the potential of some of these gizmos to have an affect on our lives will be debated. Some of them will be a roaring success and will drastically change the way people go about their everyday life and some of them are doomed to failure due to reasons such as moral issues, cost factors or that the human race is just not ready for such a development.

There are a number of areas in which research has been undertaken: from human computer interaction to communication. Either way, they are all very interesting and will all have a part to play in the future of humanity, however small that part may be.

3.1. Existing and Future Technology:

3.1.1. ThumbCode: A way to communicate?

'Professor Vaugh Pratt of Stanford University's Computing Department is a man with an obsession: to shrink the personal computer to an undetectable size, say, that of a shirt button.'

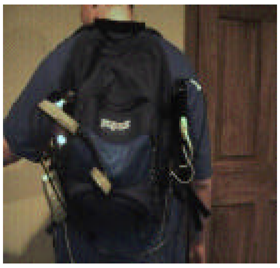

Figure 2: Early wearable computer.

One of the main set backs for wearable computers has usually been their bulk. With their weighty headgear, antennas, thick vests and waist packs, they tend to become a burden more than an asset. Also, developing a practical way to input data without a keyboard has always been a problem as your everyday keyboard has already been shrunk to its most nominal size.

Pratt has found a solution to the problem of communicating without a bulky keyboard through the use of a $2 hardware store knitted glove and a complex mesh of motion sensors. The user can 'type' letters of the alphabet simply by moving the hands, and tapping the fingers. The movements are sensed by the glove and processed into one the 96 character ASCII set.

With developments such as this, people would actually have to learn thumbcode to be able to use the product efficiently. This would be the main hurdle in creating a successful market for the device as learning the code could be a complex task and also some people only have limited use of their hands. Having said that, it seems a good solution to problem of interfacing with the wearable electronic device. In our opinion, it has a certain potential in areas such as the stock market as it would be better solution to communicate than shouting and waving hands.

3.1.2. Motion detector:

Toshiba has developed a 'motion processor', which is a device that allows the user to operate a computer or other appliances by gestures. With the proper software, it can also be used to detect and identify three-dimensional objects. It works by using a number of strategically placed LEDs. These LEDs illuminate an object and return data concerning that object's physical position and shape.

Figure 3: Motion detector

The 3D information is then calculated from the two-dimensional contrast distribution of the image. The LEDs use a wavelength in the infrared so ambient light does not interfere with the reflected light.

The fact that this technology is so versatile gives it a headstart on the 'thumbcode' device explained previously. As well as being useful for inputting data, it could be used within home electric appliances, security systems, medical appliances, health check systems and even education. You would not have to wear a sensor laden glove as with the 'thumbcode' device hence it would be less of a burden when travelling, though, at the moment it would not be feasible as a portable unit. This is because it would find it difficult to distinguish between significant motion and unintentional hand movements while walking around.

3.1.3. The Wearable Monitor:

To the left in Figure 4, is shown the Sony PLM-A35 – Glasstron Audio/Video Headset. This is the latest in FMDs (Face Mounted Displays) and produces a display equivalent to that of a 52" screen from about 6 ½ feet with surround-sound. It weighs 3.4 ounces and hence is very portable.

Figure 4: Sony Headset.

The question is: would people really wear such a thing? ; Is it really possible that the streets of the future will thrum with people lost in the depths of a wearable computer screen? In our opinion the answer to this question would be no as for a start nobody would be able to wander the streets while using it as they would not be able to see where they were going. You could have a small projection from a camera into only a part of the eye, but concentration on the world around would still be substituted for what that person is doing on the display.

Also people these days are extremely health conscious and this will undoubtedly remain for years to come. The idea of having a computer screen an inch from the face for hours would most probably send shivers down many spines.

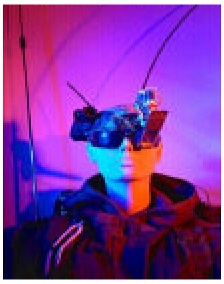

Figure 5: Wearcomp4 by Steve Mann (1995).

While in the office, wearing a screen as seen Figure 5 would be detrimental as the communication within a team would break down causing many problems. This invention will be the next step in interactive game-play and so a market would be formed in that area. But due to the reasons listed above the use for this kind of interface in everyday life is limited.

3.1.4. Active Badge System:

Figure 6: Components of the active badge system

The Active Badge system, developed at the Olivetti Research Labs, is a way of finding an individual's location in a building by determining the location of their active badge, which they would be wearing. Offices within the building contain networked sensors that detect IR signals transmitted by the badge every ten seconds, and from these signals, locations can be determined.

This system is used in some universities, such as Imperial College's Computing Department and MIT Media Lab, and other places such as Xerox Parc.

3.2. THE USER:

As can be seen from the few examples of wearable or leisure electronics given above is that the reduction of computer size has given the wearable market large potential. However, to predict the future of wearable and leisure electronics from the perspective of ubiquitous computing, we need to look at its philosophy. The late Mark Weiser, who coined the term 'ubiquitous computing' and is said to be its father, praised the value of invisibility. In his article, 'The World Is Not A Desktop' he said: "A good tool is an invisible tool. By invisible, I mean that the tool does not intrude on your consciousness; you focus on the task, not the tool. Eyeglasses are a good tool – you look at the world, not the eyeglasses. The blind man tapping the cane feels the street, not the cane. Of course, tools are not invisible in themselves, but as part of a context of use. With enough practice we can make many apparently difficult things disappear: my fingers know editing commands that my conscious mind has long forgotten… Unfortunately, our common metaphors for computer interaction lead us away from the invisible tool, and towards making the tool the centre of attention."

For leisure electronics, the issue of invisibility is not so great a problem, because in this area, technology should come into the foreground to a certain extent.

From this, it can obviously be seen that a wearable electronic device cannot fit into this vision solely by its feature of portability. There are many complications concerning the integration of wearable electronics into the idea of ubiquitous computing.

There is the danger of the device being the focus of the user's attention. A device that the wearer carries about will not readily fade into the background, and for something like ThumbCode, the user's attention would be on its physical use, instead of, for instance, making notes. However, it is possible that gradually the use of ThumbCode would become invisible, but this can only be a matter of speculation.

In my opinion, there are two possibilities to the problem of computers being too prominent instead of a mere tool; computers should be embedded in everyday, familiar wearable which would already be in the background, or designed with such intuitive interfaces (Is ThumbCode one? We don't think so.) that quickly the piece of technology becomes unnoticed. This is what should be held in mind when designing future wearable. Pervasive computing is a move from an interaction between an individual and a single device to a network of mobile and embedded computing devices that individuals and groups use across a variety of tasks and places. Wearable computing is the intimate apparel of pervasive computing - body worn sensors, devices, computing engines, and software that inter-link personal and public space.

3.3. SOCIAL ACCEPTANCE:

Wearable electronic devices would create an impact on society: a change in human-computer and human-human relationships. The extent and nature (positive or negative) of this change is difficult to predict because it depends on the question "To what extent would wearable electronic devices be accepted into society?"

People fear that a move towards a more technological society would be dehumanising, and more invasive than pervasive. Certainly with wearable electronic devices, technology would become a much greater part of everyday life. However this could be positive: E-mail was not intended for social applications, but people adopted it as a social tool. People would use technology in a way that would suit their best interests, such as strengthening and not inhibiting relationships. Social acceptance further depends on the user friendliness of the devices and whether they are intrusive and fashionable, i.e. is it good for your image to obtain the device and will it be consistent with your style and looks?

3.4. MORAL IMPLICATIONS:

The biggest moral issue concerning pervasive computing is that of privacy. The idea of networked computers embedded in everyday objects brings a threat to the individual, in having a person's location (such as the Active Badge System, 3.1.4 or 6.2) or personal details available to people unknown to them. The idea of ubiquitous computing conjures up an Orwellian glimpse of the future in people's minds (The Active Badge System was seen as dangerous; a technology to control and track people).

3.5. HEALTH AND SAFETY:

Health and safety is definitely an issue when considering wearable electronics. There are many risks involved with the concepts and products researched previously. Some of the possible risks encompassing wearable technology are explained below.

One of the main issues would be the emission of certain types of radiation from electronic equipment. This topic has already raised its ugly head in the world of mobile communication. In the last couple of years the publicity attached to radiation leaking directly into our brains through the use of mobile phones has been enormous. Though this fact may have been extremely over hyped by the press, it is still a fact and there is significant scientific evidence to back it up. Imagine if the wearable monitors investigated previously gave off even small amounts of toxic radiation. Surely this would prove more dangerous to human health than a mobile phone solely due to the fact that the user would be exposed to this radiation for elongated periods of time. Other dangers of wearable headsets could be linked to damage of the eyes, or the risk of induced epileptic fits.

Loss of concentration when driving or even walking down the street could cause accidents, and serious ones if the user is driving. Again, using the example of mobile phones, there are over thousands of deaths and serious accidents each year related to the use of phones while driving. If for example, a person was tapping away in thumbcode, writing an email for example, while driving a car, that person's reflexes in the event of an oncoming accident would be seriously affected and it could mean the difference between life and death.

In general the risks may only be slight and small in number but, as with many modern concepts for example genetically modified food, the serious effects on the human body, of developments such as this are unknown. With this ignorance comes human paranoia and this can be one of the biggest killers of groundbreaking research.

3.6. Military and terrorist applications:

It is likely that wearable electronic devices would be put to military use due to their ability to link many mobile individuals to a large network. This potential, to basically make it easier to run coordinated campaigns, could be used by the police and also by terrorist syndicates. It is hard to determine whether the advantages outweigh the disadvantages here.

With wearable devices getting smaller and smaller all the time, health risks such as electric shock has been reduced to practically nothing. This decrease in risk has come with the growth of a number of other risks associated with technologies such as this. One of the main risks is the threat of terrorist or enemy action using weapons so advanced that you do not even notice them. What better way to blow up a building than plant a bomb on the managing director of that company while brushing past him in the street.

This shows that due to the potential of wearable electronics, there is also a potential for misuse and this should be considered as well as the advantages of wearable devices, in order to prevent them to be misused and for them to be truly beneficial.

4. The medical sector:

4.1. INTRODUCTION:

Historically the medical sector has been one of the first to benefit from technological advances due to a general recognition of the importance of human life and improving quality of life.

There are several ways in which computing is within medical practice. The most obvious being larger machinery (intensive care monitoring, CAT scans etc.) some of which has been in use for many years. Improvements in computer technology lead to improvements in the operation of these devices. There is extensive use of computational facilities, databases for patients and medical stocks.

This report will not investigate these areas as information handling and medical machinery are both parts of older markets with existing companies investing in research and development and brand awareness to the extent that there are considerable barriers of entry to the market.

However there are computational advances have facilitated innovations in this area such as portable automatic defibrillators that may be used by an untrained person. The device is programmed to shock the patient in the correct way and is currently used in specialised first aid kits such as those aboard commercial aircraft.

There are two main areas of the medical sector in which pervasive computing is playing an active role in the development of products that will be discussed in this report. Firstly implantable or miniature devices; pace makers, cochlea implants, the swallowable imaging capsule etc. Secondly Biochips and BioMEMS, miniature silicon based devices reliant on fabrication techniques developed in the semiconductor industry.

4.2. TECHNOLOGY:

4.2.1. Implantables/miniature devices:

<u>Pacemakers and defibrillators</u>:

In the last ten years pacemakers and defibrillators have grown from using simple digital logic to full computers. This is due to the miniaturisation of microprocessors and memory chips. Pacemakers are now able to 'pace terminate'; the speed of pacing[1] and regulate the intensity of pacing using more sophisticated software. The minicomputers within these next generation pacemakers allow the functionality to be more sophisticated and tailored to the individual patient's needs.

Memory chips have become so much more efficient to use that when a patient visits his doctor the doctor can refer to a full cardiac history for the previous six months or a year. These improved memory capabilities also allow an increased rate of refinement of the product as the memory components provide ready clinical data. Miniaturisation of these devices has meant that implant times are shorter,

[1] 'pacing' = regular electrical shocks to the heart to ensure it continues to beat healthily

surgery is less invasive and the device is more aesthetic for the consumer. Paula Skjefte (Bradycardia Products Medtronic Inc) indicates that the next technological advance will be that of a combined pacemaker/defibrillator[2].

Feasibility:

Pacemakers and defibrillators are life saving devices and have been successfully used for many years. Thus there is little resistance to enhancements to the device. Indeed enhancements to the operation of defibrillators would be enthusiastically received as defibrillators can provide a potentially fatal shock. There could be initial resistance to a combined defibrillator and pacemaker as both patients and doctors might be unwilling to have potentially dangerous devices implanted unless they were absolutely necessary. However this is unlikely to be the case as implantable defibrillators have been available for the last decade and patients with these conditions are likely to be reconciled to the possibility of heart failure. They would value the benefits of a device more tailored to their individual needs over worries as to the small risk of the device incorrectly functioning.

Insulin pumps:

Figure 7: Implantable Insulin Pump

These devices are an alternative to diet control and direct insulin injection for diabetics. They deliver insulin to the blood supply of a patient that closely mimics healthy insulin production (insulin is short-acting). They may be internal (implanted) or external. Operation is set by an independent control - the Basal[3] rate is set and Bolus[4] boosts to insulin levels (for instance after meals) are controlled by the patient. Obviously the operation this is reliant on computational ability (in the pump, controller and, communication between them). Research is taking place into the possibility of further automation of the system; communication between a blood glucose sensor and the pump.

Feasiblity:

These devices are in use however their expense is prohibitive. If technology facilitates further miniaturisation and cost reduction then their appeal will be more widespread. However in the long term this area is vulnerable as it treats a specific disease in which there is promising research that might lead to a cure. Dr Peter Thule, of the Atlanta Veterans Affairs Medical Center and Emory University in Atlanta has had success with research into curing diabetes in rats with gene therapy, improving blood sugars to “not quite normal, but they are impressively better than [if the diabetic] rats [were] given insulin [by injection]." Dr. Thule speculated that clinical trials could be 1 to 2 years away.

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[2] A defibrillator is a device that shocks the heart to restart the circulation after heart attack. Implantable defibrillators are suitable for patients suffering from frequent heart attacks.

[3] Continual level of insulin supplied to the bloodstream.

[4] An additional larger amount of insulin supplied to the blood stream.

Swallowable Imaging Capsule:

The M2A Swallowable Imaging Capsule is a capsule that photographs the patient’s internal digestive tract when swallowed. Miniature electronics and complementary metal oxide silicone technology have facilitated this product which transmits two images/second which are recorded on a wireless recorder worn on a belt around the waist. Diagnosis is later carried out when the images are downloaded from the recorder and viewed on a computer workstation. The device has passed preliminary US Food and Drug Administration tests and should be ready for use in a year.

Feasibility:

The Swallowable Imaging Capsule is likely to be popular with patients and the health care industry being less uncomfortable than endoscopy and allowing flexibility of care (it may be done any time). It can also provide images of the entire small intestine when endoscopy can only reach the upper third. However it does not provide such a detailed picture as conventional endoscopy or features such as biopsy capabilities. As the cost is currently considerable ($30,000 for hospitals) this technology is not likely to replace endoscopy but to compliment it. This development suggests that if improvements to this image technology and the introduction of microrobotics to the device were to overcome these disadvantages in the future the device would entirely replace traditional endoscopy.

Cochlea implants:

Figure 8: Cochlea implant

These are devices that bypass most of the mechanics of hearing. The nerve endings in the cochlea are directly stimulated electronically. Sound is detected, then analysed using a decoder and converted into electronic signals. Currently devices rely on externally worn sound processing equipment and battery power supplies however Epic Biosonics based in Canada are currently developing a low power technology fully-implantable cochlea device by exploiting new low power microelectronic speech processing technology.

This implant provides the user with greater control; the patient will be able to control the device's 'tone' intensity directly, which at present can only be done during a visit to a cochlea implant centre. The device also is successful in dealing with one of the main difficulties that face implantables area, that of the lifetime of the device. Currently most implantable devices must be replaced or have battery replacements frequently. However this low power device operates without an external power supply. This new technology should also provide significant cost reductions making the new technology available to a larger number of patients.

Feasibility:

Cochlea implants have been increasingly successful since their introduction. As well as restoring hearing to older patients there has been much success with implants to young deaf children resulting in normal speech development immeasurably improving these patients’ quality of life. Indications are that if new totally implantable cochlea implant is as cost effective as indications show the device will be highly successful.

4.2.2. Bio-microelectromechanical-systems (BioMEMS) and Biochips:

BioMEMS:

The area of microelectromechanical systems (MEMS) is a result of recent progress in microfabrication and micromachining technologies. MEMS are miniature components fabricated using techniques developed in the semiconductor microelectronics industry. These techniques have been refined for the integrated circuit industry meaning that MEMS can be low-cost and high performance. These devices are already used in applications such as airbag-deployment accelerometers (automotive industry). The expansion of this area into the health sector has given rise to BioMEMS (MEMS for biomedical applications). Indications are that this is a very promising sector. Indeed BioMEMS has one of the fastest growth rates in the MEMS market.

There are a few products already on the market such as FREESTYLE ™ : A Small (300 nL) Volume Electrochemical Glucose Sensor for Home Blood Glucose Testing, Macroflux ™ Systems for Protein Drug Delivery The LabCD™ as a Molecular Diagnostic Tool.[5] However in this area products like these are only just beginning to make it to the market place. Areas of research include drug delivery systems (dispensing and targeted drug delivery), diagnostic tools (screening, genetic analysis, point of care and hand held portable diagnostic systems), micro surgical instruments and artificial organs. From current levels of research it is clear that these products/systems are physically possible. Areas of concern are now manufacturing technology and producing products that are low-cost, efficient and reliable. There is a wealth of investment and interest in the area and it looks as if there will soon be an explosion of these products in the market.

This variety of possible products has an associated range of benefits. Robert Michler, director of research and chief of cardio-thoracic surgery at University Medical Centre at Ohio State University said biomedical nanotechnology “has the potential to let physicians assess the benefit of their work right in the operating room rather than waiting to see if symptoms show up” when diagnostic tools are used in conjunction with surgery. Microchips swathed with a chemical substance - pain medication, insulin, different treatments for heart disease patients or gene therapies would allow physicians to work with heightened level of detail.

Biochips:

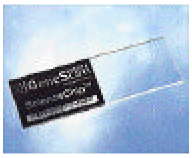

Figure 9: A Biochip.

“Biochip” is a relatively new topic that has a lot of potential on the market and it is a very good example of microelectronics in biotechnology. It will allow highly sensitive analysis of complex biological interactions in real time. These advances promise to transform genetic diagnostics and drug screening because of their reproducibility, low cost, and speed.

[5] For an explanation as to the operation of these devices: Bibliography 32 – 34.

The main areas that are under research and development for biochips are the following:

- They can be used for the detection of mutations in specific genes as diagnostic "markers" of the onset of a particular disease. The patient donates test tissue that is processed on the array to detect disease-related mutations. This may prove to be a truly mobile device.
- The DNA-based biochips are designed to detect the differences in gene expression levels in cells that are diseased versus those that are healthy. Understanding these differences in gene expression not only serves as a diagnostic tool, but also provides drug makers with unique targets that are present only in diseased cells.
- Besides these two immediate array-based applications for this technology, there is potential to create the equivalent of a wet laboratory on a chip. Which may involve micro fluidics technology to manipulate minute volumes of liquids on chips. Applications include chip-based PCR as well as high-throughput screening assays based on the binding of drug leads with known drug targets.
- Protein chips are under development. Researchers are designing chips that will contain entire, functioning enzymatic pathways that can be used rapidly screen gene products for metabolic function.

The challenge to the biochip industry is standardisation. Biochips have to be interfaced so that the data can be easily integrated into existing equipment.

The potential is that biochips microelectronics could replace cumbersome equipment to provide ultra-sensitive mobile detection methodologies at significantly lower costs than traditional methods.

Feasibility:

It seems that there is little doubt that these devices will be successful. Any improvement on existing technology that they provide would result in their use as silicon based microstructures should be cost-effective to produce. Indeed it seems that much work on the diagnostic systems is based on the assumption that the chips will be disposable. There is a great deal of investment into developing the technology to facilitate this. A further advantage of many of these products is that they will be displacement products providing more efficient forms or care/testing often resulting in a reduction in people-hours (and thus cost of care). For instance BioMEMS might allow even seriously ill patients to be monitored after surgery or treatment on an outpatient basis or savings to be made if hand held diagnostic tools could replace lab analysis. Even if these technologies are not immediately less expensive than existing technology they may well be successful if they provide new technology: one of the features of the on-site testing products is that only a very small sample is needed.

Biochip/MEM making is an important and emerging industry. However, it is currently quite a closed market as there are already established market players investing in intensive research. Indeed it is competitive to the extent that Affymetrix (one of the current market leaders) is involved in legal battles with competitors over patent infringement.

The possibility for the future development of biochips are tremendous, recent research shows that an analysis on a biochip can take around one day, as the technology improves diagnosis may become available within seconds of the analysis.

The possibilities for this technology are endless. In the future gene analysis using biochips could be a simple sampling process using saliva. Within seconds of analysis using a light portable device DNA could be obtained. Similar methods could be used to diagnose possible diseases, length and stage of disease development etc.

The first application of this new technology will be more Biochip/MEM testing and monitoring devices. Current research indicates that these will become increasingly cheaper, more portable and faster in operation. In the near future these devices will be able to multi-test for different substances. There is currently research into applications such as bedside blood testing as a way of monitoring the health of patients prone to heart attacks. Indications are that monitoring devices they will initially be superficial and once technology has become more sophisticated, implanted. These monitors will initially build on existing, larger scale monitors such as the pocket size Samsung HD-303S Wrist Type Digital Blood Pressure Monitor. Implantable monitoring devices will build on existing technology/functionality such as the NASA-developed pill-sized implantable transmitter[6] for monitoring pregnancies.

The possibilities for this technology in the far future are as extreme as allowing those with severed spinal cords to walk (sensor devices would be implanted at the site of the spinal cord injury and would communicate with further devices stimulating muscles) and enabling the blind to see (sensors would communicate with devices implanted at the brain or optic nerve).

4.3. Moral Issues:

There is a heightened moral and emotional reaction when dealing with new medical/biological technology, as people can easily empathise with something that results in a physical effect. For instance when cochlea implants were first introduced the deaf community saw them as a threat to their culture and way of life.

Cost raises moral issues as those providing medical care must make decisions as to how money is spent: Commercially the medical world is complicated due to the way care is provided with varying levels of funding and sources of funding (from country to country). This affects, to a certain extent, the success of products. Countries such as the States drive medical research as wealthier individuals benefit from health care in which they act as consumers, able to choose. In most instances neither the provider (doctor) nor the customer are price sensitive as the care is paid for by medical insurance. Therefore new technology is often readily taken up if there are clear benefits to the patient. However in the UK as care is provided by the NHS many new products (these are more expensive) cannot be provided to individuals. An example of this is insulin pumps. An insulin pump would improve the quality of life of many diabetics (perhaps even improve their health as shorter acting insulin used by these devices is more like natural insulin) however they are not often provided on the NHS due cost considerations.

[6] http://www.manufacturingcenter.com/med/archives/0199/199pill.asp

As monitoring devices replace direct patient care (due to cost considerations) quality of care issues are raised. For instance if a patient that would have formerly been hospitalised for monitoring was allowed home with remote monitoring there is an increased danger that deterioration of the patient's condition would not be detected if the monitoring equipment was configured inaccurately etc.

An effect of implantables technology is increased responsibility of the manufacturers and risk to the consumer as any error in manufacture/design of equipment such as pace makers and insulin pumps can have fatal results.

As the analyses using biochips/MEMS become simpler, cheaper and thus more easily obtained moral issues regarding the suitability and security for such a technology are raised; whether it's appropriate for someone without proper medical background to use these instruments for their own or other's diagnosis. Misuse of this technology may lead to the possibility of wrong diagnosis, of contamination and private research on illegal drugs.

If genetic information or information as to a person's health can be quickly and easily analysed using a small sample there is the danger of information being easily available without the patient's consent. However these dangers should only form a small risk confined to criminal activity as governments are aware of the possible risks and protective legislation for privacy exists and is being introduced: In the United States measures are being taken to limit the use of genetic information.[7]

4.4. Conclusion:

New developments in existing technologies are becoming increasingly intelligent; microprocessors enhance the operation of the devices, tailor them to individual patient needs. Larger scale implantable devices are featuring increasing amounts of computational ability mainly resulting in more complex and tailored functionality. This often results in increasing the numbers of patients to which products are useful and improving the quality of life of users. The next generation of implantable device will be less specific, smaller and more reliant on microrobotics.

However many areas, in the long term, can be high risk for investment due to the possibility of parallel products treating the condition the device provides care for. For example the entire diabetic care industry is threatened by research that indicates diabetes could soon be treated with gene therapy.

Indications are that the newer area of biochips/MEMS will have a significant role in technological advances in the medical sector. This is as this technology provides the next step in the miniaturisation process and exploiting computational power for monitoring, testing and treating patients.

[7] In February 2000, President Clinton signed an executive order limiting use of federal employees' personal genetic data. Federal agencies may not use genetic information in hiring or promotion. The order also prevents health insurers from using any genetic information it might obtain from federal employees to raise rates or deny health care coverage.

5. Computers at home:

In the future, human-centred notions, such as real objects and everyday settings, could come more into the foreground than the computer-centric ones which have determined the evolution of the computer as we know it. It offers the opportunity of seeing how objects can become augmented with new properties and qualities and how these can be designed to enrich everyday living in completely different ways.

Artefacts will be able to adapt and change, not just in a random fashion, but based on how people use and interact with them. Together, new functionalities and new forms of use will emerge and that will enrich everyday life, resulting in a world that is more ‘alive’ and ‘interconnected’.

Imagine being able to push a button labelled ‘Good Night’ that locked all doors, closed your windows, shut your drapes, set the temperature, closed the garage door, set the security system and checked for appliances that had been left ‘on’. You do not have to run up and down the stairs trying to prepare to go to bed. The ultimate system will also control heating and blinds and will water your plants.

Microwaves can suggest the cooking time. Fridges inform that your milk will go off soon and advise you to cook “Meatball Stroganoff” as you do actually have all the ingredients in the house but some of them will go off soon and this meal will cause you to waste as few as possible. For those stubborn stains that normal machines just won’t wash out, LG Electronics have come up with a washing machine that can download new wash cycles from the internet. This Korean company is now working on a microwave that downloads recipes and has our dinner ready for us when we get home.

5.1. The smart house:

A smart house, the “Electrolux screenfridge”, with some rather nifty technology that can change the way we shop, cook, sleep, store food and do pretty much anything around the house has recently been put on the market by a Swedish company. The ‘e home’ has attracted great debates and innovations to realise the augmentation process. It may be best presented by adopting a real-life example at our home, the lighting system.

5.1.1. Existing and future technology:

RadioRA, the first and existing wireless lighting control system that uses radio frequency technology, makes it simple for any new or even existing home to have reliable and affordable whole-house lighting control. The system maintains Master Control, dimmers, and Switches. They ‘talk’ to each other via high-frequency radio signals. All controls employ true two-way communication, which assures the user that all commands have been sent and received. Each RadioRA system operates independently according to a unique communication code upon installation.

The RadioRA system really simplifies our lives by concentrating on a universal IR remote. But in the future, can we use our own voice to control lighting as well as audio and video components such as DVD players, stereos or projection screens? For instance, how wonderful will that be if we can enjoy our movies at home by simply calling ‘I want movie’?

5.2. Convenience:

Flexibility, efficiency, economy and beauty are the main demands for consumer need in the fashion age. Wireless communication systems will certainly help us to achieve those critical desires. Such as by using the RadioRA system, homeowners can save time and trouble by simply pressing one button to switch off all lights in the house before they go to bed. RadioRA system can also be used in the entertainment area in our lives and most importantly, by using systems like this based on radio communication, homeowners do not have to pay the cost of tearing walls apart or rewiring when they would like to improve their houses by installing the system. It also features many convenient options including a car visor control which turns on interior and exterior lights before entering the house. We believe that once this product goes to the market, it will make our lives much easier and more wonderful.

5.3. Social impact and acceptance:

Based on the different cultures, history and economy, people in different countries demands in different levels and ways. Since the RadioRA system is a nifty technology, it will probably take more time to be widely recommended and used due to the lower average income in the developing countries.

Also, RadioRA system makes a lot more sense in the large buildings. People living in the smaller places would not consider the technology as a big issue to improve their living quality. Since the new product makes lives more convenient and efficient, fashion followers, IT people and old people would be the first group of owners.

5.4. Moral implications:

In recent years, wireless control technology has been used in improving the security level for cars. For instance, Mercedes-Benz is one the most successful companies to use that technology in their cars. But this in fact creates more chances for those car thieves who use hi-tech equipment themselves. Another example is secure homes which are controlled by the wireless controlling system as these can become an ‘open house’ to anybody whom passes the door if the signal is generated by some other sources.

5.5. Health and safety issues:

Wireless technology can control almost everything in your house, which could cause big problems too. If there is a failure in the product or the system is damaged by an unknown virus, then the whole house could then become a horrible place. For example, the two-way communication system can send us a wrong message which says that gas has been switched off, but in fact it is not at all. Then we would like to know if the system could call the ambulance automatically itself.

The positive benefit to our society which is brought by the new technology is proved to make our lives a lot more convenient, so that we don’t have to walk from downstairs to upstairs to switch on or off all the lights and this benefit makes us lazy. Medically, being lazy for long time can finally weaken our bodies and cause lots of diseases.

6. Security and surveillance systems:

What makes a good surveillance system? If it sees you and you cannot see it and if it is placed or moves to places you don't expect it to be. It should not be forgotten that surveillance systems are not always there to catch people doing something they should not be doing. They are also placed in places where you want to have an eye on things just in case.

That existing cameras will shrink in size and will therefore be useable in more situations is inevitable, and also that they will deliver better quality and will often be wireless. This report will look at two more advanced systems, one static one and one very flexible.

6.1. Robo-Roach:

A robo-roach is a cockroach, to which researchers have fitted electrodes. By sending little electrical pulses to the insect they can control its movement and make it for example walk up a ramp. Not any insect will do of course. Cockroaches were chosen because you can use larger species which are therefore slower and also very strong. According to Dr. TE Moore of the University of Michigan, they can carry about 20 times their own body weight.

Professor Isao Shimoyama of Tokyo University and his team first managed to implant the electrodes in January 1997 and were awarded $5 million by the Japanese government in order to enable them to continue the research. In the beginning the movements where restricted by wires but by now everything is remote controlled.

Nearly any movement can be produced but two problems have not been solved yet. Firstly, as Raphael Holzer, one of the researchers in Tokio, admits, the electrodes are not placed very accurately yet and movements are often unpredictable. Secondly over a period of months the cockroach will become less sensitive to the impulses. That of course sets a limit to the length of any mission.

6.1.1. Uses for the Robo-Roach:

The insects can crawl into places other devices could not reach. They could carry cameras and other sensors and therefore for example help saving earthquake victims. They could be used for espionage and by the police. The potential is immense. A quite different use would be a cockroach as a pet, which might seem odd to Europeans but is fairly common in Japan.

6.1.2. Social acceptance and moral issues:

It is hard to imagine that in a few years time you will buy your son not a remote controlled car but an insect. Also we very much doubt that anyone will be very happy about the idea that cockroaches could be climbing into your window with a little microphone or camera and just listen to your conversations.

On the other hand it would be very nice to save a few more of those earthquake victims and some scientists will be keen on exploring places that were not accessible until now.

From a moral point of view it seems harsh that the poor cockroach will have no control over its own movements. Imagine it sees this nice green leaf and it is very hungry, but its legs are doing something totally different. I am sure Professor Shimoyama will have had several experiences with Greenpeace and similar organisations already.

The only good new is that, if the cockroach gains back its own will, it is unlikely to do any harm to us.

6.2. Radio Frequency Identification Technology (RFID):

In October 2000 Swissair/Sabena have introduced a faster and much more efficient check-in system called “e>track” at Zurich airport. The new “I-CODE contact less smart label technology” developed by Philips Semiconductors enabled them to issue a card to their frequent flyer club members which speeds up and simplifies the check-in process enormously. The passenger’s details are automatically recorded when entering the airport and as the card will submit the details while it remains in the wallet, the passenger is checked in when within reach of the sensors and will not have to show any form of identification to enter the lounges either. There are plans in existence to expand the system in order to track luggage and therefore increase efficiency and decrease the amount of lost luggage.

Figure 10:An identification transponder integrated on an antitheft sticker.

In 1997 Philips also managed to develop plastic circuits which are so flexible that you can fold them in half and they will still work. Production costs are much lower than for equivalent semiconductor circuits and it is possible for example to include a complete RFID transponder on a piece of plastic which you can then stick onto or into any product including soft packages as an anti theft sticker.

6.2.1. Future developments:

We are pretty sure other airlines will include the service and hopefully the whole luggage system will be equipped with the system soon enough as this is likely to reduce the amount of lost luggage enormously.

The greatest potential could be in combining the two aforementioned technologies into one system and equip shops and supermarkets with it. The customer will now just pick up stuff and walk out of shop. His purchase will be registered and automatically deducted from his account. This will also make shoplifting nearly impossible. Information on whether the same product can be obtained cheaper close by could be displayed on your mobile phone as soon as you pick it up, and if the cheapest solution is online shopping you could order it right away. This system will also make stock keeping very easy as you won’t have to employ anyone to count the stock, you just run some kind of “tag-scan”.

If the government forced all citizens to carry this kind of ID, they will never know when they are being registered and any kind of illegal action will be very hard to conduct. The only problem with that is to find a way you could not carry someone else’s ID and go shopping or commit a crime in his name.

At the workplace you will be signed-in and given access to security areas automatically. If you have too long a break, the system will automatically shorten your next one but if on the other hand you rush to get some equipment, you will not have to worry about being accused of strolling around aimlessly. Any phone calls will be automatically forwarded to wherever you are and your colleagues can look up your location on the intranet.

When on the road, you will not have to queue at boarders or toll stations because your details are checked while you are driving along steadily.

6.2.2. Social impacts and acceptance:

Though this way of shopping seems a bit futuristic at the moment, we are convinced that it will make life easier for all of us. Face it, except the British, no one likes queuing in a supermarket.

What people will definitely not like is to be identifiable at any time, but this problem can easily be overcome by allowing you to switch the device off. Shoplifting will still be hard as an alarm can be raised whenever goods leave the shop without successful identification of the shopper. Of course you could also have normal checkouts in case the customer would rather pay cash as he wishes to stay anonymous. For the workforce control system, as everyone likes to have a longer break, we expect employers to have quite a problem convincing their staff to carry their ID.

Free cultures like Europe or America will have more resistance to total control than countries where that kind of control exists already. Being identifiable at all times might make one think twice about expressing ones opinion as you never know who might be listening and therefore this system could conflict with freedom of speech.

6.2.3. Moral implications:

These kinds of systems could reduce our privacy close to nothing. The government and, even worse, anyone else in possession of a device capable of reading the ID-containing media could have total knowledge about anyone walking past them. Supermarkets do log which products you bought and Simsbury’s claim they could produce a very accurate shopping list for any of their frequent shoppers. But firstly it is you choice to use a reward card and secondly they new system could carry customer research to the next level as it could even record which products you picked up and then decided not to buy.

The user should be allowed to switch off the device and thereby control when he wants to give up his/hers anonymity.

6.2.4. Health and safety:

Dependence on the system could increase fast as the supermarket will reduce the number of checkouts to make more room for products. In case of a failure of the system we could obviously pay by cash but the queues would be enormous.

7. Transportation:

7.1. Existing and Future Technology:

7.1.1. What is in existence?

GPS has already been developed to sophisticated levels, with in-car navigation systems already available on the mass market. Their only limitations are availability of a signal and hence lack of precision. This can be overcome by using gyroscopes/accelerometers so that the car has more than one reference. Using gyroscopes or accelerometers has the additional advantage that you have an autonomous system which corrects itself using GPS satellites at some interval.

Automated cars and automated highways have been tested in the US by the National Automated Highway Systems Consortium (NAHSC). This testing included a demonstration of automated cars travelling down 7.6 miles of specially constructed roadway.

There are various different approaches to automation, relying on special lanes just for automated traffic and autonomous cars with all the technology on-board to navigate independently of the driver. Most of the technology required in cars is available ‘off the shelf’ such as radars and laser range finders.

The obvious advantage of individual cars driving themselves is that no new infrastructure is needed for these cars to be usable. In the other case either new roads must be built or existing ones modified. This inevitably requires a large capital investment. A new computer network would also have to be established, with control systems along the highways to direct all the individual cars, and also inter-car communication would be needed to exchange information for example on speed and obstacles. The emerging Bluetooth technology could make this possible.

Automation of cars need not come at such a cost. Cruise control has been available for some years and there are already systems that can control speed to stay a certain distance from the car in front. Each piece of technology needed to create a car capable of automatic driving has potential safety benefits. For example, radar and distancing systems could form an advance proximity warning system. This could be further modified to perform emergency braking if the driver did not respond in time.

The advantage of both these automatic driving systems is that it is not affected by driver error, the cause of nine out of ten road accidents. In addition, in the case of cars travelling down separate lanes, there would be advantages of cars being able to travel in groups, acting like an electronically-coupled train.

7.1.2. Future Development:

As well as the obvious market for the individual systems needed to realise automated travel, there are other possibilities. This may include a taxi service which could make use of this technology. For example, you could call a number on your mobile phone. A control computer could pinpoint your location and signal the nearest automated taxi which could then use a GPS system to come and pick you up. Eventually this could lead to the abandonment of private cars and reliance on this form of transport.

Having discovered that NAHSC had been disbanded, Chuck Thorpe, one of the project leaders, was contacted via email. We learned that the US Dept. of Transport withdrew their funding in order to concentrate research on driver assistance, saying that automated systems would take longer to build. He was unable to answer any questions on feasibility of either system as their research was terminated too early.

7.2. Social Impact and acceptance:

As the number of vehicles on the road increases, our roads are becoming increasingly congested. The possibility of automation may reduce this by allowing cars to form convoys and therefore increase the capacity of roads by removing individual driving habits and allowing cars to travel faster with smaller distances between them. This may be the most cost effective and environmentally friendly method of relieving congestion in the long term, the alternative being to construct more roads. In addition to reducing congestion, automated transport would leave the ‘driver’ free to do other tasks or just relax.

Most accidents are due to driver error. People are unlikely to accept that a computer could control a car more effectively if the change is rapid. However, if the extra functionality were added slowly this would not be a problem. This is what you would expect from a “disappearing computer”. Initially there will be scepticism about the technology but eventually people will become accustomed to it, in much the same way as cruise control or even the biro. Possible systems may include such things as cruise control with automatic distance keeping, such as Mercedes ‘Proximity-controlled cruising’, which may go into production soon. A lane-keeping system would have great benefits. Advanced steering, braking and acceleration systems will all be making their way to the market over the next ten years as demand grows, and radar, communications and other systems become cheaper.

7.3. Moral Implications:

There are environmental benefits to an automated driving system: as well as relieving the need for more roads to be built there will be better fuel consumption due to more constant speeds. There will be less time spent with motor running and not moving.

Any system designed to improve driver and passenger safety is obviously a moral one, and many such systems such as ABS and airbags have already been developed and are now important features of many production cars.

7.4. Health and safety:

Health and safety is one of the most important factors in determining the success of automated car technology. Systems need to be developed to handle obstacle detection and avoidance. These systems would have to be quite advanced so as to predict the motion of any obstacles and take the necessary action, which may be emergency braking or swerving.

8. Conclusions:

Pervasive computing will undoubtedly become very important over the next few years and for the foreseeable future. There are many business, medical and leisure applications for it as the research shows. Some of these applications are unfeasible, some almost a certainty. The feasibility of specific products and areas have been discussed in the preceding sections and this conclusion will draw upon this research and experience to draw some general ideas on pervasive computing as a whole.

8.1. TECHNOLOGY:

One of the features of technological advancement is that of miniaturisation. One of the implications of this is that a powerful microprocessor can now fit into a very small area. For instance, the biochip, capable of analysing complex telemetry, is small enough (in the nanometer range) to be implanted inside the human body.

The idea of pervasive computing, that everyday objects will have some degree of intelligence or computing power, relies on miniaturisation since many of these objects will be small and portable.

While miniaturisation may offer more flexibility in the design of these ‘intelligent’ objects, size reduction should not necessarily be the dominant factor influencing the design choice. For example, some applications will require easy to use interfaces, and this will determine the optimum size.

The phenomenon of ubiquitous computing will be a progression to an intelligent environment; a network of computers embedded in everyday objects, each communicating with each other and the user to exchange information about their environment etc. to enable them to perform the most useful tasks, or make more intelligent decisions. Thus, some of the most important technologies of which pervasive computing can make use will be wireless communication systems, such as Bluetooth technology, and sensor technology to link virtual space to physical space. The need for both of these can be seen in the automated car, where navigation and obstacle avoidance relies on information from both internal sensors such as radar, and via wireless communication links with other vehicles.

After highlighting the main technologies enabling pervasive computing, future technologies will be discussed. From viewing ubiquitous computing in terms of a network, it seems that a user moving from network to network should be identifiable so that information about him/her can be passed to the network. Therefore security issues concerning information should be addressed and this may require the introduction of some new technology. Also, in order to maximise the potential of these embedded systems, standard protocols will need to be introduced. Each device may need a unique identity. There are many other issues which may need to be addressed, but these will not be clear until these systems begin to develop.

8.2. SOCIAL IMPACT AND ACCEPTANCE:

Social impact is hard to gauge before the technology has been introduced. It depends on many factors such as marketing, acceptance, government legislation and moral and health factors. There are many ways in which pervasive computing may impact on society. For example, pervasive computing may lead to work becoming more pervasive if it becomes possible to take all your documents with you in electronic form, on a storage card or similar device. This could lead to an abandonment of traditional family values, and our notion of the working environment.

Isolation by technology is an important issue, and it depends on the notion of pervasive computing as to whether this would be a problem. As discussed in section 3.1.4, if pervasive computing develops according to the 'tool outside of perception' it will be an improvement over today's desktop computer, which inevitably takes a users whole concentration to use. The danger is that pervasive computing will become a simile for laptop computer – a device that you interact with in the same way as you would a computer now, but is more portable.

Acceptance of technologies such as those described here will also vary greatly. In the same way as some groups of people today refuse to embrace internet and email technologies, it seems likely that there will be certain groups of people in the future who will be hostile to these pervasive computing technologies. There are many reasons for this. There are sentimental motives for holding onto many things that could be replaced, such as books. It is easy to imagine an electronic pad, easy to use, that was linked to a central library of electronically stored books, which could be called up by anyone at a moments notice. However, many people like the idea of actually owning the book, being able to touch it and look at it upon a shelf, and there will be resistance to anything which replaces that.

8.3. Moral Implications:

The move to ubiquitous computing will consequently lead to development of new technologies or new applications of existing technologies. The introduction of this technology, however, may conflict with moral values.

Due to the fact that pervasive computing involves networked computers embedded in everyday objects exchanging information with each other and with users, it can be seen as a threat to an individuals privacy; personal information about a person could be accessed by persons unknown to him/her. The Active Badge system discussed in 3.1.4 and 6.2 are examples of this. In the extreme case, a Nineteen-Eighty-Four-type scenario could be imagined, where people are monitored constantly and privacy ceases to exist. Pervasive computing technology has this kind of potential, but it is likely that the public will reject the use of technology at this level. However, if the potential is there, it may be possible for organisations to implement this without people knowing.

During the research, no reports or discussions of ethical or moral issues were found. This may be due to the fact that research in this general area is still embryonic, or that the issues mentioned above are not considered relevant to those groups involved.

8.4. Health and Safety:

There will be different risks and benefits associated with each separate device. However, there may be resistance to new technology if it is not fully understood by the public, especially since the revelations concerning radiation emitted by mobile phones.

8.5. Possible Guidelines for Introduction of Pervasive Computing Environments:

In our opinion the report shows that the following points should be considered when developing pervasive computing devices:

1. Freedom of information: resistance is likely to be lower if people with no technical knowledge can easily understand the operation of devices.
2. Ensure that devices are application specific; limitation of functionality, by law or otherwise, would limit the possibility of misuse.
3. To ensure acceptance of the product by society moral issues like the privacy of the individual and the Data Protection Act should be considered and upheld.
4. As most products will start off being a luxury product or a gimmick, for them to be successful they must have the potential to become a key element of our everyday life, just like the mobile phone.
5. These new computing devices should enhance our everyday life, but using them should be optional and care should be taken to not replace existing systems but to add to them.
6. A computer’s abilities should be limited, so that it will always assist but not rule its human superior.

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