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Ubiquitous Computing, Informatization, Urban Structures and Density

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We identify the major challenges to the development of cities over the next century and comment on the challenges to ubiquitous computing over the same period. We describe some ubiquitous computing work on intelligent buildings and on urban development. We describe the effects that the development of ubiquitous computing is having on the world economy and use Hardt and Negri’s description of informatization as a new mode of production to consider possible effects on urban development. We recognize the material limits of the process of informatization in the affective aspects of our lives and in the need for sustenance, clothing, shelter etc however they are delivered. We speculate about the consequences of the development of informatization as a mode of production on the shape, size and density of the cities of the future. We suggest that multi-disciplinary teams including experts in ubiquitous computing be organized to research the possible ways in which cities may be developed. We argue that this takes place against a backdrop of climate change and ecological crisis and needs to be addressed soon.

1. Introduction

Sponsored by the UN Habitat Group, the announcement of World Habitat Day 2006 indicated clearly some of the challenges and expectations of urban development during the twenty-first century.

> This year’s theme highlights the fact that the world is witnessing the greatest migration in its history of people into towns and cities. In 1950, one-third of the world’s people lived in cities. Just fifty years later, this rose to one-half and will continue to grow to two-thirds, or 6 billion people, by 2050. Cities are now home to half of humankind. As the world becomes increasingly urban, it is crucial that policy-makers understand the power of the city as a catalyst for national development. Cities have to be able to provide inclusive living conditions for all their residents. Rich or poor, everyone has a right to the city, to a decent living environment, to clean water, sanitation, transport, electricity and other services. How we manage this is arguably one of the greatest challenges facing humanity.

Over the same period, the development of computer networks (the Internet) reaching into work and domestic environments is giving rise to equally difficult challenges as the world becomes increasingly ‘informatized’ (see section 3 for a full discussion of this concept). By 2050, it is possible that the sum total of all human knowledge will be held on computers. This integration of computing into all facets of life is commonly called *ubiquitous computing*. If ubiquitous computing develops as expected, it will have a fundamental effect on the nature of human life and habitation. Central to this vision of ubiquitous computing is the fact that information and control need no longer be linked exclusively to physical location. This article explores aspects of the relationship between ubiquitous computing, urban structures and density.

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2. Ubiquitous Computing

Ubiquitous computing is the method of enhancing computer use by making many computers available throughout the physical environment, but making them effectively invisible to the user.

so said Mark Weiser in his 1993 *Communications of the ACM* paper that introduced Ubiquitous Computing (Weiser, 1993). Mark Weiser was the chief technology officer of Xerox Corp’s Palo Alto Research Center when, in 1988, he coined the term ‘ubiquitous computing’ which he used to describe computers that were ‘*so embedded, so fitting, so natural, that we use them without even thinking about it*’. Sadly, Mark Weiser died in 1999 but the technological developments he instigated have become part of mainstream computing. The notion of ubiquity simply means that computers have become all pervasive whereas that of being invisible can be both physical, i.e. they are microscopic in size, and cognitive, i.e. they demand little intellectual engagement from their users.

From a technical viewpoint, we create environments composed of numerous networked embedded-computers that are capable of sensing and coordinating their actions to support the needs of the people within the environment (Callaghan *et al*., 2005). Michio Kaku, professor of theoretical physics at the City College of New York (and co-founder of String Field Theory) described an extraordinary vision of ubiquitous computing in his 1998 book *Visions*. In this a computer generated companion (an intelligent agent) mediates between people and a bewildering ‘futurescape’ of devices that attend to every facet of people’s lives from work, through medical to social needs. He observes that, in the computer industry, it takes roughly 15 years from the conception of an idea to its entering the marketplace. He predicts that ubiquitous computing will come of age in 2010 and will dominate our lives by 2020, with the internet, and its dynamic myriad of servers, holding the sum total of human experience on this planet. In a previous paper we have argued that for there to be any meaningful exploration and habitation of our solar system, ubiquitous computing will be intrinsic to daily survival (Clarke *et al*., 2000).

2.1. Ubiquitous Computing and Buildings

Today ubiquitous computing mainly manifests itself in the form of intelligent buildings and digital homes which are formed by integrating networked computers into the building’s major sub-systems and using sensory networks to monitor the building and its occupants, thereby enabling the computers to regulate the building environment in a way that benefits the principal stakeholders of the building (Callaghan *et al*., 2001). In commercial buildings, ubiquitous computing is used commonly to automate building services such as security, lighting, elevators, power, safety, and HVAC which are crucial to a well-run building. Echelon, a leading company in the provision of technology for building automation cites some 400 examples of the deployment of their Lonworks building automation technology across the world including hospitals, schools, theatres, airports, hotels, banks and offices (Echelon, 2006).

In the domestic home arena, the application of automation extends to support a wider set of functions such as caring, entertaining, securing, socializing, education or work, based around items such as kitchen appliances, home theatre systems, security/safety devices, pool/spa systems and IP based telephony/media delivery. An interesting example

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of such deployment was undertaken, in the UK, by Cisco who cooperated with Laing Homes to build a number of what they called Internet Homes in Watford, in which networks and internet connectivity was as abundant as electrical power distribution . With the increasing proportion of older people in the Western world, care of the elderly in their own homes is rapidly become a driving force in building automation technology (Hine *et al.*, 2005).

Other prominent examples of home based enterprises include the ‘Integer House’ project which is a venture to encourage change in home building practices, particularly those that enable the creation of more environmentally friendly homes which, in some countries, can account for up to 50 per cent of CO_2 emissions (Kell, 2005). From its initial roots in Watford in 1996, where it built a single demonstration home on the Building Research Establishments site, it has grown to become an international project with sites in Ireland and China. Of particular interest to the focus of this paper is Integer’s Kunming Project which is located on the north-eastern fringes of Kunming City, in Yunnan Province, south-western China (see figure 1). The project comprises four prototype houses and is described as the first eco-town in southern China, with an emphasis on sustainable lifestyle, environmental protection and intelligent technology. The project aims to develop a sustainable housing and lifestyle model appropriate for the urbanization of the western region in China.

Figure 1 - Integer’s Kunming Project

2.2. Ubiquitous Computing and Urban Development

Urban areas can be regarded as concentrated collections of buildings linked by physical pathways for the movement of people and materials and sustained by power and other networks. In a world of ubiquitous computing, there are also networks connecting systems within and between buildings and providing full connectivity with the wider world for the possibly millions of people living there. Such systems will also cover the open spaces within the urban area so that the population has uninterrupted access to these systems throughout the day and night. The operational model of a city is intricate, involving millions of people interacting in complex social and professional relationships employing virtual, pedestrian and vehicular movement and the use of numerous differing environments and appliances. Urban areas are much more complex environments than buildings and present the biggest challenge to ubiquitous computing so far. Given its complexity, it is hardly surprising that urban design has not featured strongly in ubiquitous computing and there is a lack of theory, tools, established practices and even basic visions for designing ubiquitous systems that are integral to urban architectures and lifestyles. Currently, Broadband, WiMax and WiFi are key enabling technology underpinning the integration of ubiquitous computing with both urban and rural life and,

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as such, their deployment and performance are key issues that governments must address (White, 2006).

The majority of projects that have addressed urban technology issues have restricted themselves to relatively small areas and timescales and have generally not addressed ubiquitous computing as a facet of urban design nor have they solved the technical challenges of implementing urban-scale ubiquitous computing. Some notable projects are Equator, Mobile Bristol, Intel’s Urban Atmospheres, Cityware, SANE and TIME. By way of an example, the UK EPSRC funded Cityware project brings together Vodafone, Nokia, IBM and Hewlett-Packard Labs and Bath University to investigate people’s relationship with public pervasive technologies as well as find a way to implement long-term pervasive systems across the city of Bath which is one of the top three tourist destinations in the UK, with two major urban regeneration projects under way, and thus an ideal test bed (Kostakos *et al*., 2006).

SANE (Sustainable Accommodation for the New Economy) was an EU funded project that investigated the impact of the new informatization economy that ubiquitous computing can be argued to enable (see section 3). Based on extensive monitoring of space usage, the findings of the SANE project included a case for a distributed workplace model, both physical and virtual, distributing workplaces around cities in radically new ways by incorporating semi-public spaces such as hotels, serviced office centres, airport lounges and cafes into their work environment. (Harrison *et al*., 2003).

The annual Ubicomp conference includes threads that explicitly address the relationship of ubiquitous computing to the urban environment in relevant and useful ways, for example, it has reported on the TIME (Transport Information Monitoring Environment) project that uses the city of Cambridge as a testbed with the ultimate goal of developing novel traffic data monitoring, management and modelling systems (Yoneki, 2005). Ubiquitous computing can in itself be used as a driver for change. There are numerous examples where people have attempted to retrofit ubiquitous computing to regions and cities to act as drivers to alter its dynamics such as Blacksburg Electronic Village, Australia’s Nerang Electronic Village, Netville, a Toronto development, Virtual Ennis in Ireland, the Scottish Highlands and Islands Virtual University and public electronic networks (e.g. PEN in Santa Monica, SCN in Seattle, PTW in Boston, LatinoNet in San Francisco). Some of these have featured in composite case studies such as that by Jones (1999) that concluded ‘changes resulting from the introduction of networked technology has at least as great a dependency on choices made by government, community organizations, businesses, and grass-roots groups’ indicating any vision for change should be an integrated one.

Other interesting examples include ‘Singapore ONE’, a national initiative which is an ongoing development of the IT2000 Masterplan to transform Singapore into an Intelligent Island where information technology is exploited to raise the capabilities of the population at home, work and play. There are two separate levels; the first is a broadband infrastructure level composed of high-capacity networks and switches whilst the second comprises applications and services that take advantage of the infrastructure. In 2002, South Korea has also embarked on a similar masterplan, ‘e-Korea’, that aims, by 2010, to deliver a core broadband network with a speed of 100Mbps by spending 2.1 trillion won (£1.06bn) to help Korea become the world’s ICT leader. Currently South Korea’s core network runs at speeds of up to 2Mbps and its citizens are among the most

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enthusiastic users of the net with about 11 million broadband connections (of a population of around 48 million).

Another interesting national ubiquitous computing development is the UK company BT's 21st Century Network (21CN). BT is investing around £10bn between now and 2010 to develop what it regards as a new approach to wiring cities and countries. 21CN will be an IP-based network, the only such national backbone in the world, with its most obvious difference being that voice will be carried over IP (VoIP) in a similar way to companies such as Skpe that were threatening the traditional telephone companies. IP has the advantage that it is a universal protocol that can operate at all levels from devices within the home and office to, potentially, international communication. It is being implemented in a way that enables users to configure the services to suit their needs. The International Telecommunications Union has produced a ranking of how 'connected' a country is based on measures that include the number of fixed/mobile phones per person, how fast broadband links are and the percentage of citizens who are net users. Sweden tops the list with South Korea fourth and the US and UK at twelfth and eleventh respectively!

Less developed regions of the world face particularly difficult challenges. For example, according to Han Jianbin, director of Pingliang Municipal Information Office in China's Gansu Province, there is a huge gap in the digital divide between west and east China (Jianbin, 2005). As they are starting from a base where there is widespread ignorance of IT, the major focus has been to educate people and make IT facilities available in the form of 'Information Homes for Farmers'; a facility equipped with a computer, printer, internet access and various types of information. In response to such issues a more unified initiative was launched by the Shanghai Municipal People's Government and the UN Department of Economic and Social Affairs to set up a forum on City Informatization in the Asia-Pacific Region (CIAPR). It has a set of guiding principles, collectively labelled the 'Shanghai Declaration' that specifically target underdeveloped regions which shares the Pingliang focus of improving IT literacy and making resources available through the mechanism of digital libraries, although in this case involving other countries such as Vietnam, Malaysia, Korea and Singapore (Bertucci, 2002). In support of this a Regional Cooperation Office for City Informatization (RCOCI) has been established in Shanghai (RCOCO, 2002).

In developed economies, informatization is also an issue as companies are keen to remain competitive. Christos Voudouris, Senior Technology Manager at BT Group plc technology office, argues that this new economy not only implies a movement in employment to knowledge-based jobs, but also a shift from traditional goods manufacturing to service based economies (see figure 2). However, for this to be effective other changes need to take place such as more investment in research and development (R&D) for services and the willingness and means for services to be exported as easily as goods. Currently, in the UK, the service industry accounts for 70 per cent of economic activity but only gets 20 per cent of the total R&D investment!

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3. Informatization – A New Mode of Production

The consequences of the computer revolution and the widespread adoption of and development of ubiquitous, pervasive and ambient computing described in the preceding section is argued by some at least to be intrinsic to the development of a totally new post-industrial mode of production (Hardt and Negri, 2000). In order for us to look at the impact that this new mode of production might have on urban structures, we need to be able to characterize it suitably and look at the general implications for social and cultural processes. We are going to use the description of this new mode of production as developed by Hardt and Negri in *Empire* to provide us with a specific guide to the various drivers involved. We recognize that this model is not universally accepted (Balakrishnan, 2003; Passavant and Dean, 2004) but it has the virtue of being based on the recognition and acceptance of the many and deep changes that we believe the wholesale acceptance of ubiquitous computing will bring, many of which we have discussed elsewhere (Clarke *et al*., 2000; Callaghan *et al*., 2001).

Hardt and Negri argue that the move from the domination of industry to that of services and information is a process that they call *informatization*, a term with which we are already familiar. They also argue that the informatization of production as the new dominant mode of production is already in full swing and that this shift has already taken place in the dominant capitalist countries and particularly in the United States starting in the early 1970s through the migration from industry to service jobs. For them the notion of services covers a wide range of activities from health care, education and finance to transportation, entertainment and advertising. These jobs are for the most part highly mobile and involve flexible skills. More importantly, for our consideration of ubiquitous computing, they are characterized in general by the central role played by knowledge, information, affect and communication. They suggest that this 'post-industrial economy' is an information economy. According to Hardt and Negri, those of the dominant capitalist countries that have embarked on the project of informatization one group – the USA, the UK and Canada – have gone for a *service economy model* involving a rapid decline in industrial jobs and a corresponding rise in service sector jobs, in particular, the financial services that manage capital have come to dominate the other service sectors. While another group – typified by Japan and Germany – have gone for an info-industrial model where industrial employment declines more slowly than in the service economy model and more importantly the process of informatization is closely integrated into and serves to reinforce the strength of industrial production. Both of these strategies, they argue, are meant to help manage and gain advantage during the economic transition and both move

Figure 2- The trend is for the service industry to grow quicker than manufacturing in most developed economies.

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resolutely in the direction of the informatization of the economy and the heightened importance of productive flows and networks. But according to Hardt and Negri, any large country with a varied economy like India or Brazil can simultaneously support all levels of productive processes – information-based production of services, modern industrial production of goods, and traditional handicrafts, agriculture and mining production. However, all forms of production exist within the networks of the world market and under the domination of the informational production of services. i.e. within the existing world order.

The wider consequences of this move into a new mode of production are significant not just at the economic level but, as they argue, informatization today marks a new mode of becoming human, because today information and communication have come to play a foundational role in production processes. This has led to a change in the quality and nature of labour. A characteristic of much of this activity is the production of immaterial goods like a service, a cultural product, knowledge or communication and this leads to the idea of ‘immaterial labour’ which operates at two distinct levels: one involved with the use of computers and communication to provide symbol manipulation and analysis for problem identifying and solving, the other being strategic brokering services that live off the back of low-value low-skill jobs of routine symbol manipulation such as data entry and word processing.

So, the computer has become the central tool, through which all activities must pass. However, as far as Hardt and Negri are concerned the model of the computer can account for only one part of the communicational and immaterial labour involved in the production of services. The other aspect of immaterial labour that is essential to the model is the *affective labour* of human contact and interaction. This affective production, exchange, and communication is generally associated with human contact, but they argue that this contact can be either actual or virtual, as it is in the entertainments industry. Affective labour is therefore immersed in the corporeal, the somatic, but the effects it produces are nonetheless immaterial. What it produces, they argue, are social networks, forms of community, biopower.

This analysis leads Hardt and Negri to propose three types of immaterial labour that drive the service sector at the top of the informational economy. What we argue is that these three types of labour which drive the informationalization of the global economy will be drivers for or against the development of urban structures and density. The three types of immaterial labour are:

1. Involved in industrial production that has been informationalized and has incorporated communication technologies in a way that transforms the production process itself.

2. The immaterial labour of analytic and symbolic tasks, which breaks down into creative and intelligent manipulation or routine symbolic tasks.

3. Involves the production and manipulation of affect and requires (virtual or actual) human contact, or ‘labour in the bodily mode’ as they call it.

Hardt and Negri are keen to point out that cooperation is inherent in each of these forms of immaterial labour and they argue that today productivity, wealth, and the

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creation of social surpluses take the form of cooperative interaction through linguistic, communicational and affective networks.

They go on to consider the wider consequences of the development of this new mode of production on drivers that will directly affect urban living. First and most significantly is the potential for a dramatic decentralization of production. The informatization of the economy combined with the development of widespread high-speed networks has meant that the reasons for large-scale factories have disappeared. Quoting Bill Gates, Hardt and Negri argue that if Gates’s vision were to be realized, then networks would tend to reduce all distance and make transactions immediate. Sites of production and sites of consumption would be present to one another regardless of geographical location. So while the development of high-speed networks connecting everything to everything else instantaneously would encourage the distribution of production, the decentralization and global dispersal of productive processes and sites, this is balanced by a tendency towards the centralization of control over production. However they fear that the control of labouring activity can potentially be individualized and continuous in what they call ‘the virtual panopticon’ of network production, where the employer can monitor whatever the employee is doing no matter how remote they may be physically. This centralization of control, however, is even clearer from a global perspective. They assert that the geographical dispersal of manufacturing has itself created a demand for increasingly centralized management and planning, and also for a new centralization of specialized producer services, especially financial services. They suggest that at the level of the city the decline and evacuation of industrial cities has corresponded to the rise of global cities, or what they call ‘cities of control’.

3.1. Locus of Control

So, one aspect of this mode of production leads to the development of at least two different drivers, what Hardt and Negri call a ‘democratic’ and an ‘oligopolistic’ mechanism. For them the democratic network is a completely horizontal and deterritorialized model, an indeterminate and potentially unlimited number of interconnected nodes communicate with no central point of control and all nodes, regardless of territorial location, are connected to all others through a myriad of potential paths and relays. This is the Internet. On the other hand the oligopolistic network model is characterized by broadcast systems, by which they mean that the broadcast network is characterized by its centralized production, mass distribution, and one-way communication. It is a tree structure that subordinates all the branches to the central root. They argue that the networks of the new information structures are a hybrid of these two models. Thus they argue that the new communication technologies which hold out the promise of a new democracy and a new social equality, have in fact created new lines of inequality and exclusion, both within the dominant countries and especially outside them.

This argument about the locus of control and the difference between a properly decentralized horizontal network versus a centralized and hierarchical one is a familiar problem from within computer science and indeed essential to the whole process of developing robust ubiquitous and pervasive systems. In computer science, centralized systems dominated the early period of computer deployment as they were simpler, easier to understand and programme; cheaper, fewer processors and consequently less

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programming; more efficient to manage, less anarchical, facilitating data mining; more supportive of commercial ends, social research etc. However, more recently there has been a strong movement towards computational distribution as distributed systems are more reliable, because there is no dependency on a single processor or machine; have fewer connections; and the whole system is less susceptible to disruption etc. Distributed systems also provide better performance through concurrent processing, are more scalable so that processors and physical resources expand in tandem and are thus well matched to *dynamic computing environments*, e.g. mobile and nomadic ubiquitous computing. Distributed systems also provide a better fit for systems with spatially dispersed control needs like dispersed organizations, and finally entail fewer wiring and bandwidth demands because the communication control is closer to the processor.

In many ways the architecture and management of a computer system can be seen as analogous to that of laying out and managing urban areas. Processors can be seen as politicians, people, buildings, institutions and organizations, anything with autonomous decision-making power; connections are analogous to roads and communication channels, anything that conveys real or virtual entities; and plans are akin to the programs the processors execute. A particularly important lesson from ubiquitous computing is that it is essentially a non-deterministic environment due to the intractable number of components and the highly dynamic nature of the environment which is made up of non-deterministic elements such as people and physical phenomena. For such environments the implications from computer science are that whilst distributed systems are more difficult to design, they are more scalable and more robust.

3.2. Informatization and Density

Taking the three different aspects of immaterial labour into account, then we can see that within this new mode of production there are a number of drivers that might affect urban density. The democratic network would encourage the geographical distribution of all production and services and thus mitigate against the development of dense urban spaces. The oligopolistic aspect would encourage the growth of 'cities of control' though it is not at all clear that these would need to be any larger or denser than existing cities. This leaves the affective form of immaterial labour which can again be divided into two, the actual and the virtual. To take the virtual first, in relation to the control aspects of production, this corresponds to a situation that would or could have within it a driver akin to that of oligopolistic control and the production and distribution of virtual affective services might well look little different from that of the control aspects of immaterial labour. Thus we might have Los Angeles (Hollywood), Hong Kong, Bollywood (Mumbai) etc as the 'cities of control' of the immaterial production of affective labour in the entertainment industry. This leaves the actual production of affective services to be considered as a driver for urban density.

While human beings are naturally social, there is a limit to their capacity to handle large numbers of people on a face-to-face basis and since evolutionary psychologists have estimated that a network of a maximum of about 150 people is a common upper limit to natural face-to-face social groupings there is thus no intrinsic affective driver for large and dense cities. It may be that there are certain overall population requirements for supporting specific sorts of affective labour but we doubt that they are major drivers of

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absolute size or density within an urban settlement. If it could be shown that unless an urban settlement exceeded a specific population it could not support some specific and crucial activities of an affective nature then one should discount it as a driver for greater density in urban areas. Most importantly, it seems to us that the domain of real corporeal affective relations includes the very reproduction of people in a way that is unlikely to ever be replaced by computers however ubiquitous. The world of emotional attachment to kith and kin within family and social structures that produce the personal self that we recognize and value as essential to human culture is crucial to the very reproduction of the social order however sophisticated and ephemeral the mode of production has become at the level of informatization.

It is also worth noting at this point that the informatization of significant aspects of the economy does not mean that the dependence upon real material throughout society has been diminished. We will all still need to eat, clothe ourselves and build this new urban fabric out of something more substantial than information. The more we can service these needs from local resources the lower the costs of transportation and the greater control we have over these essentials to the efficient reproduction of daily life we will be.

3.3. New Economies

This discussion has been carried out with reference to the development of the currently dominant economies and we need to look in some detail at what is currently underway in economies that are not yet dominant but which are themselves aware of the informatization of production and already planning and working to become dominant players within this new mode of production. The rapid development of China and India in recent years and the move by the Far Eastern ‘Tiger’ economies to bring themselves into the forefront of the information revolution needs to be looked at in this light since these are economies that might move rapidly into the new informatized mode of production being relatively unencumbered by heavy investment in industrialization and fixed plant.

This is also the point at which current drivers for urban density, in particular the move from the countryside to the city, need to be addressed. Without a concomitant change in the basis of the economies within which these countries operate, cities will remain drivers of urban density because they represent loci of wealth and opportunity in a poor economy. At the same time certain cities like Hong Kong which are geographically limited have become both high density and also extremely wealthy.

Ubiquitous computing as the cornerstone of the new informatized mode of production opens the way for far greater democratization and distribution of immaterial goods and thus militates against urban concentrations and increased densities. However, because of the oligopolistic aspects of the control of production, affective and informational, there is a tendency for concentrations of people involved in specific sorts of enterprise to gather together in ‘cities of control’. These cities need not be either massive or dense *per se* and it may be that some of the extensive plans for producing wired cities in the Far East are blue prints for our own future.

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4. Consequences

Photographer Michael Wolf’s beautifully taken pictures of (Wolf, 2005, 2006) capture one aspect of urban density (see figure 3) in striking contrast to the more serene vision of an proposed by artist Angela McNiece (figure 4).

The problem of how to build viable cities is as old as the founders of Western civilization, the ancient Greeks. According to Leonidas C. Polopolus (Polopolus, 2001) an emeritus professor at the University of Florida specializing in Food and Resource Economics, they are the first civilization to have raised the question of the optimum size of a city-state and both Plato and Aristotle addressed this problem in different ways. Aristotle insists on the existence of a minimum population as well as a maximum size and gives emphasis to the public function of cities: ‘It is vital that the citizens know one another’. He was also worried about the problems of security when cities become too large. Plato states that the ideal republic would have 5,040 citizens, i.e. heads of households. This figure implies an optimum size population of about 20,000 people. Plato linked his optimum size of city to the need for communications among citizens insisting that the city remain sufficiently small to permit the holding of public meetings with all of the citizens present. Athens was the largest Greek city-state, approaching a population of approximately 100,000 by 500–450 BC. The other Greek city-states rarely had populations of as many as 40,000 people. As a general rule, as soon as a city approached a population of 20,000 to 30,000, it decided to found a new city rather than to continue the original city’s development. The ancient Greeks understood the constraints to excessive urban development. These constraints involved the limited productivity of the soils to produce food and the increasingly high cost of transportation to the central part of the city from the hinterland. Thus, the ancient Greeks knew that the cost of urban growth became prohibitively high at certain levels of population.

Figure 3 - High-rise living in Hong

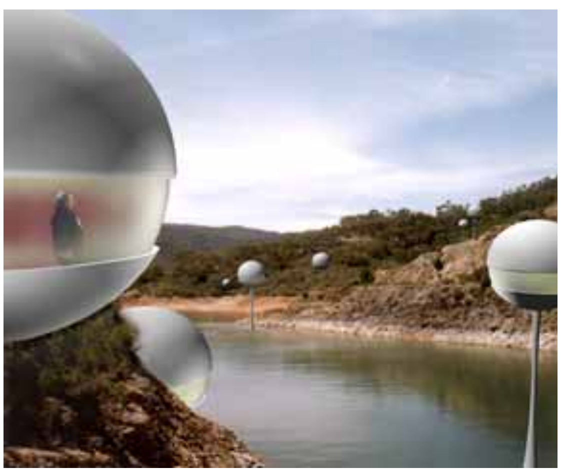

Figure 4 - Futuristic Homes and Communities

4.1. Countryside to City

The mass movement of people from the countryside to the city that accompanied the first industrial revolution is being repeated during this, the information revolution. China provides a good contemporary example as it has two mega cities (populations over 10 million), Beijing and Shanghai, and is expecting some 400 million people to move to cities from the countryside over the next 30 years. Modern city life is notoriously demanding on natural resources with modern cities such as Shanghai having an ecological footprints of 7 hectares per person in contrast to their rural counterparts which have a figure of 1.6. It is interesting to note that a sustainable and equable division of the world's resources amongst its inhabitant gives a figure of 1.8 hectares per person (Pearce 2006*a*). Returning people to a rural environment is not a practical proposition so it is necessary to find ways of making cities and other urban structures more eco-friendly.

Of the current approaches to this, the minimization of dependency upon personal means of travel seems to be the most promising and to open up possibilities of designing towns and cities with an eye to public transport rather than the car. Ubiquitous computing is able to help reduce the need for travel for example, with the development of virtual presence approaches which range from teleconferencing through distance learning to remote controlled processes by experts such as surgeons. A major current application of ubiquitous computing is intelligent buildings and vehicles, so energy in buildings can be adjusted to minimize waste, and journeys, if they are made by car, could be made more efficient not only by the elimination of congestion by smart traffic management but also by some forms of car pooling and intelligent deployment of automated vehicles so the personally-owned car shades imperceptibly into a fully fledged public transport system at a finer grain than is achievable today. Living without the car may, however, be the biggest challenge to the West in any case.

4.2. Density

Density is a function of the size and concentration of people in an urban environment so, for example, it is possible to have small and dense urban areas or large and sparse urban areas. Between these extremes, there are a number of interesting possibilities. On the one hand cities might develop much as they are at the moment, increasing in size until they suffer inefficient infrastructure or over pollution and so become self-limiting. Ubiquitous computing can move this limit by making infrastructure more efficient or it could diminish pollution by reducing energy consumption.

Ubiquitous computing also offers the potential to make a highly distributed lifestyle possible, principally by virtual presence, teleconferencing and access to internet based knowledge. However, this model might still require a fair amount of physical travel for face-to-face socializing and jobs involving specific physical locations. An interesting compromise between these two extremes is that of small urban developments on the pattern of the Chinese plans for the Western region perhaps where in effect these local regional nodes enable effective decentralization whilst maximizing the local effective use of the manpower and resources. If this sort of urban development is combined with the idea of everyone being both agent and patient to the sum total of human knowledge, centres of both consumption and production, this sort of connectedness might enable people to participate more fully in the decision-making process without intimidation because done within the privacy of their own homes. Thus a real transformation of urban living combined with ubiquitous computing could be feasible. It might be possible in the future to live in relatively small and self-sufficient urban areas linked by efficient public transport and connected to the rest of the world through both efficient public transport

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and ubiquitous connections to the internet. This would allow anyone to affiliate to and cooperate with people on any or all of the continents and participate in intellectual, political, cultural and artistic endeavours and only occasionally, or maybe never, actually meet (think of the MySpaces generation at an international level). The actual sensible size of such small urban villages could be, say, 15,000 people made up of a hundred groups of 150 people, something like the old Saxon political and economic unit of the *hundreds*.[1]

4.3. Fragmentation

An alternative possibility is the fragmentation of large cities into networks of ‘satellite’ towns. A notable example of this in current planning for the future is Shanghai where ten satellite towns have been built, four of which focus on different specialties. There is a harbour city based on sea related industries, a motor city currently based on car manufacturing but which could be changed to provide public transport, a university city and an Eco-City (Dongtan). This model combines the virtues of decentralization with proximity to major industry. China, like much of the world, would like to find a way of creating ecologically balanced cities and Dongtan, on Chongming island, designed by British engineers Arup with Peter Hall as planning advisor, aims to create a city with an ecological footprint of only 2.2 hectares per person which is less than a third of its neighbour, Shanghai (Pearce, 2006*b*). Part of this strategy is to reduce the use of cars, whilst other ideas include low-rise blocks of just 6–8 storeys high with natural ventilation in an environment comprised of parks, farms, lakes and leisure facilities. A century after the garden cities it seems that the time is right for architects and planners to begin to think again about the form of urban living appropriate to a century in which information rather than industry will dominate.

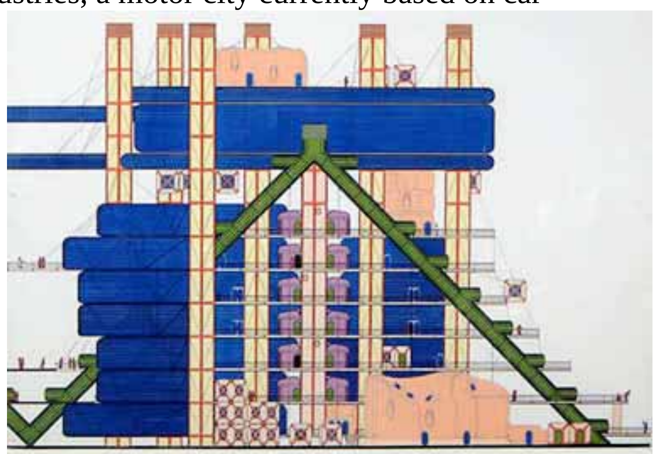

Figure 5 - Archigram’s ‘Plug-In City’

For the effective integration of ubiquitous computing into cities, we need new cities (and buildings) but this takes time. Retro-fitting existing cities with ubiquitous computing, such as cable operators in the UK attempted, is always going to be a difficult and probably ineffective enterprise, though a new layer of ubiquitous computing might be applied to existing cities using wireless technology. New cities (and

Figure 6 - Yona Friedman’s ‘Spatial City’

less so new buildings) take years in the planning and building and the technology available when the design is fixed will have been enhanced considerably by the time the city is built. Consequently any major new buildings/cities should integrate ubiquitous computing into their design and functioning and leave the options open for upgrading this aspect of the design until the last minute. The drivers for distributed systems where everyone is connected equally should make the development of smaller scale urban environments much easier.

The centralizing tendency as it relates to centres of control and current broadcast media/entertainment might come under attack by changes in the whole process whereby cultures are reproduced and develop. When and if films become totally generated by computer this process can, in theory at least, be decentralized. Combine this with the tendency for self-publishing that the internet encourages and you have what might become a new force for distribution within what is seen as a centralizing process i.e. everyone as their own centre of production/broadcast. At the structural level an alternative to conventional planning may emerge where you sow the seeds of an urban structure by providing an underlying scaleable technical community infrastructure, and let that attract and guide people into building their own cities (cf. 1960s visionary proposals for just such an infrastructure e.g. and which might now be technically realizable).

5. Conclusions

Affective relationships will remain at the core of human development and care but do not have within them any necessity for great urban density. Power, political and economic, control of industrial and informational processes, land and materials will remain key determinants of power relations globally. National plans for the development of urban landscape will continue to be the key to any move towards informatization on a wide scale in the short term. This is more likely to take place in currently developing countries like China and India where the move from the countryside to the city is going to be one of the major drivers of urban development. By the time that urban solutions that truly integrate ubiquitous computing systems are developed (2020 at the earliest) many of the cities now on the drawing board will have been built.

We argue that research into self-contained, self-regulating intelligent environments, from the room to the urban settlement, is the key to developing the full benefit from integration of ubiquitous computing into everyday life (Hirsh *et al.*, 1999). There are also concrete material constraints on these processes no matter what degree of informatization is achieved. Short of a Startrek 'replicator,' we will need to produce and distribute material goods, food, clothing, building materials etc. Ideally this would be done within the local community but it needs to be planned every bit as much as the rest of the urban area. There is a special piquancy to all of this as it is taking place against the backdrop of a world facing severe climate change and its consequences which could nullify all these plans. There is a general consensus within the scientific community that these changes are real and that unless we can devise ways of radically reducing carbon emissions then regional catastrophes of one sort or another will generate stresses on the international community which will prevent long-term solutions for the benefit of all to be developed.

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In the most dire scenarios, like those developed by James Lovelock in his *Revenge of Gaia* (2006), there is only a small chance that we can avoid a massive population crash globally, the knock on effects of which are incalculable.

Buckminster Fuller once described architects as ‘comprehensive anticipatory design scientists’. It seems to us that all the professionals who concern themselves with the design and development of new cities, towns, suburbs, communities, buildings – the architects, planners, urban theorists, economists and now ubiquitous computing specialists – need to form multi-disciplinary groups to address the problem of urban design and living in the twenty-first century on Fuller’s model. The brothers, Paul and Percival Goodman, put together a book called *Communitas: Means of Livelihood and Ways of Life*, first published in 1947 but rewritten and reedited issued in paperback in 1960, in which they described a number of different solutions to the problems of our living together in communities. Lewis Mumford said it was ‘… a wise book; for it deals with the underlying values and purposes, political and moral, on which planning of any sort must be based’. It seems to us that we need a new attempt to think through and develop our own set of alternative approaches to urban design facilitated by the development of ubiquitous computing but with an eye to a world in which the limits on our use of energy and resources are now much clearer and in a time frame where global warming and climate change are making every moment precious.

NOTE

1. Introduced by the Anglo-Saxons, a ‘hundred’ was an area of land large enough to support 100 households or 100 tithings – a tithing was derived from ‘ten householders’, each of whom lived on a ‘hide’ of land.

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