

Smart Cities of Tomorrow

Paul Budde

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Abstract Tomorrow's digital cities will be the product of today's dreams. The world presently faces numerous challenges, many of which can only be overcome by changing the way we do things. We are now at a turning point and our future will be shaped by the way in which we respond to today's problems, and how successfully we can move into the digital world.

An important element of these developments lies in the creation of Smart Cities, consisting of cohesive and open telecommunication and software architecture, which will underpin the smart, citizen-centric applications that will abound. These applications will also be applied in areas of national interest and social need, such as e-health, smart energy and e-education. For this occur a trans-sector approach is needed, along with strong government leadership – a more horizontal system of collaboration which combines the knowledge and resources of different sectors.

The building blocks upon which smart cities will be created include smart and renewable energy; next-generation networks; smart buildings; smart transport; and, extremely important, smart government.

1 Digital Cities: Digital Dreams?

Half of the world's population are already city-dwellers, and the trend towards increased urbanization is accelerating rapidly. The future of the majority of the world's citizens is undeniably urban – 70 % will live in cities by 2050 – but exactly how that city of tomorrow will look, and how smart living will be implemented and experienced remains largely uncertain.

P. Budde (✉)

BuddeComm, 5385 George Downes Drive, Bucketty, NSW 2250, Australia

e-mail: pbcbudde.com.au

We are already seeing some directions for the future emerging: public transport will become more efficient and predictable; cars will drive and park themselves; carbon emissions will be reduced as electric vehicles replace current models; and houses will be more energy-efficient. Tele-conferencing and video-conferencing is beginning to replace some business travel and e-health and home automation is offering higher quality smart health care and will eventually enable more elderly people to stay at home; smart governance will reduce costs whilst increasing safety and efficiency.

Eventually, perhaps, we will see self-cleaning carbon-neutral buildings tapping into an array of renewable energy sources and sending power back to the smart grid, and electrical appliances automatically switching off in response to demand. Smart cities will be green cities with e-generators routing power efficiently in response to demand.

The potential of smart applications is boundless – personal health applications fixed to clothes or beneath the skin sending back constant streams of data to medical centres and providing real-time alerts or diagnoses; biometric identity devices; always-on mobile access to social networks; and people-to-object digital connections. Smart education will empower the educationally disenfranchised through e-learning and m-education; devices and services will be targeted at the elderly and disabled to increase their inclusion.

The digital dreams of today will become a reality – not just in the privileged developed world but in the developing world also. Ubiquitous, universal broadband access can be achieved in a number of ways: through spectrum management to free up this increasingly scarce resource in a progressively data- and video-hungry mobile world, or the creation of a new investment model based on infrastructure-sharing; or next-generation wireless technologies. The early collaboration of all stakeholders from industry, government, regulators, urban planners, research companies and civic society alike is vital.

The city is essentially a form of cooperation. We can do nothing completely in isolation, but together we can do, make and accomplish anything.

These metropolises are being hit hard by the current stress, and so it would make sense to explore what city communities can do to survive, and even thrive, in the changing environment.

The infrastructure systems used in these cities to manage water, energy, food supply, transport, communication, economic and social structures are faltering. Cities are also the major polluters as they generate the vast bulk of CO₂ emissions.

At the same time, ever since cities started to emerge, they became the centre of knowledge, innovation and social and economic interaction. They contain a vast pool of human capital that can be tapped into for solutions.

Focusing the national search for solutions within cities will also create a grass-roots environment that could assist in addressing many of today's problems. And cities are in a better position than national governments to investigate trans-sector approaches – looking for more horizontal levels of collaboration by combining the knowledge of different sectors to address the shared problems we are experiencing.

The building of smart cities in a Greenfield environment will be difficult enough; managing the transformation of a Brownfield environment is a much more difficult problem, and unless the cities and their citizens become directly involved in working on solutions we see little hope for success.

And if we are going to use our cities as the spearhead in this battle we will need to make sure that they are operating effectively and efficiently – and at present this is often not the case.

2 Smart Cities Based on Three Pillars

Fascinating developments are already taking place towards smart city development. What is needed is for the concept and its many elements to be better communicated to the ordinary citizens. Very significant information and communication processes need to be put in place to support these communities as they work to transform themselves.

In essence, a smart city is built on three pillars:

1. To make quality of life an excellence hub, to deliver services tailored to the citizen;
2. To promote sustainable development through harmonised management of public services, which will increase productivity and generate savings on energy;
3. To work on economic development, so that the city remains an essential lever in the development of new services and the creation of innovative businesses and activities.

The smart city therefore relies on cohesive and open telecom and software architecture, which is the foundation for developing citizen-oriented applications. In particular, this includes:

- Access to superfast fixed and wireless broadband networks;
- A network based on machine-to-machine (M2M) sensors, data collection and storage/archive devices;
- Harmonised and open management of Big Data, and access via service platforms;
- A cohesive, citizen-centric information system.

Once these building blocks are in place it becomes easy to create and/or sustain applications that will make the most of the city's resources, assets and positioning.

It then becomes possible to develop a long-term view for the cohesive integration of the building blocks of the smart city's architecture (telecom and software infrastructure, data centres, network of sensors, etc.) and the short and medium-term sector-specific initiatives (e-health, e-transportation, etc.).

Cities need to be especially vigilant about integrating the following in their plans:

- The conviction that the smart city is geared to a close understanding of its residents and customising services;

- The understanding that the interplay between private and public initiatives, in the areas of both networks and applications, incorporate open innovation as a central tenet;
- The systematic review of those elements that are managed internally and those that are outsourced, and this for all layers of the architecture;
- The integration of new business models, which consider public information as an essential resource in drawing the maximum benefit from a city's actions.

3 Smart Cities Have Key Components

A smart city must address the following issues and may be made up of the following components:

3.1 *Smart Energy*

Many countries are in the grip of escalating energy prices and to a certain extent this is paralysing the debate regarding sustainability, renewable energy, energy efficiency, industry transformation and so on.

In analysing that situation it became clear that it is actually not the price of energy that is causing these increases. As a matter of fact, energy is still very cheap and in general we have plenty of it from many different sources – the traditional fossil fuels, uranium, geothermal etc. Furthermore there are sun and wind generation opportunities, so there is no reason to fear heavy cost increases due to a fundamental shortage of energy.

We also have to be realistic about the fact that India and China are opening up new coal-powered generators every week. Whatever the rest of the world is doing regarding clean energy is negated by this reality. An encouraging development is that these countries are moving towards using gas for new generators, and while that still has a significant CO₂ footprint it is much better than coal. China is also already the world leader in solar energy technology and their investments in Renewables overtake the investments made in many of the developed economies.

Of course, the million dollar question will be: “Do we have enough time? Is this relentless increase in the use of fossil fuels – for at least the next decade – going to affect our planet's climate?”

The scientists are very clear on this. They say it will have a devastating effect on the world as we know it. The frightening situation, however, is that it is unlikely that any significant reduction in CO₂ emission is going to happen as long as the developing countries are adding new fossil fuel generators to their energy infrastructure at the current rate. Just as similar developments were essential for building the western economies over the last 100 years, the same now applies to the developing economies. Their prosperity is dependent on access to cheap energy.

3.1.1 Renewable Energy

Everybody agrees that the best solution is to move as soon as possible towards renewable energy, despite the fact that these technologies have not yet matured and that it will take a long time to change over. But if we pursue this course, and if we have some luck with the climate change developments, we might still make the switch over to renewable in time. The truth, however, is that the scientists are very sceptical about our ability to respond in a sufficiently timely manner.

So what have smart grids to do with all of this?

Smart grids form one of the bases of smart cities. There has been a global underinvestment in utility infrastructure. It is dumb, outdated and in desperate need of an upgrade. The latest development is the concept of smart grids – an intelligent IP overlay over the electricity grid, with sensors and other equipment. This will allow utilities too much better manage their network, limit electricity loss, prevent outages, load-shed and provide customers with in-house information and tools (smart meters) to better manage their own energy use. In addition, utilities will be able to reduce their carbon emissions, which will offer interesting opportunities on the carbon trading market. Paul Budde

Much of the reason for the recent price increases relates to the cost of the networks and systems needed to carry the energy in an efficient way to the users. Therefore from a cost perspective it is most certainly very relevant to look at the grid in relation to the price increases. But perhaps we should not do that in a linear way, extrapolating from the past to the future.

As more and more people are putting photovoltaic (PV) systems on their roofs we need to start looking at distributed energy systems, enabling streets and neighbourhoods to become energy producers. While some are describing this development as ‘Off Grid’, we would like to describe it differently. We do need to reposition the grid and review the investments in the grid in order to ensure that it becomes an interconnected system that can play a central role in distributed energy – like exchanges as we know them in telecommunications and internet services. Initially the distributed use of this system will be limited; however over time this becomes more significant, and eventually that could well become its main role.

What this means is that the value of the grid is not only the delivery of centrally produced energy (basically funded by a component of that energy price) but that its value becomes its intelligent network functions. This network will be shared by many applications such as:

- Managing distributed generation;
- Arbitrage of renewable energy;
- Managing electric vehicles;
- Extending network intelligence into homes and businesses;
- Providing data collection and data analyses in real time and making that (commercially) available to authorised users;
- Value-added network services in relation to billing, network management services for the new parties involved in energy generation and so on.

This means that the business model for grid operators will evolve from simply selling and delivering energy to the more sophisticated role of managing energy. Any new smart grid developments will need to be pursued with that future in mind.

There are now several countries that are putting smart infrastructure central to their energy policies, as they see this as the key to linking together the various policy and innovation developments. Germany, the Netherlands and the Scandinavian countries are among the thought leaders in this field and Germany has invested heavily to make this happen. In this country, the total cost of their energy investments amounts to around one-third of the country's Gross Domestic Product (GDP).

3.2 Next Generation Telecoms/National Broadband Networks

The second key component of a smart city involves telecoms infrastructure. Global telecom networks are undergoing extraordinary changes, with increasing investments in All-IP Next Generation Networks (NGNs) and National Broadband Networks (NBNs) based on fibre – in order to meet burgeoning consumer demand for high-bandwidth applications.

E-health, e-education, media and sustainability are also the key reasons developed nations need NGNs. IP is at the core of NGNs as it facilitates affordable triple play business models and seamlessly integrates voice, data and video. A proper inventory of national infrastructure assets is required if we want to establish an efficient and economically viable national broadband structure for these services. In the developing markets, next generation telecoms will primarily take the form of wireless NGNs (i.e. LTE/WiMAX).

The most critical element to the success of NBNs will be the infrastructure company that will run the network. They will have to make the critical architecture and design decisions for the open wholesale-only services which will form the basis of this new infrastructure for at least the next 25 years. Essential here will be for the network to facilitate the vision laid down by governments, which includes multiple use of the network by other sectors such as healthcare, education, energy, etc. At the same time the company will need to ensure that it remains an infrastructure company and doesn't become another telco.

Australia was the first country to get the national purpose vision right, thanks to government leadership. The USA soon followed and is now showing real leadership as well. The Netherlands, New Zealand and others are also on the right track. Economic and trans-sector innovations are now key items on the political agenda of these countries. There is no silver bullet and each unique situation generates its own alternatives, which in turn inform others involved in similar national projects. The vision gives rise to the creation of social and economic strategies that need to be taken into account in the design and architecture of the infrastructure.

Open networks also provide the possibility to create a multiplier effect. The infrastructure can be used for a range of smart community applications (healthcare, education, smart grids, media, etc.). Open networks are the next step in the evolution of telecoms infrastructure as it gives users full control of the services and applications that are made available over high-speed broadband infrastructure. Open networks also means a democratisation of the telecoms infrastructure. The topology and the architecture of the open network should be such that infrastructure, service and content providers can all offer higher quality and different 'premium' products and services. Paul Budde

Pragmatic solutions need to be developed to maximise the use of existing infrastructure and other resources. Un(der)served areas need to receive priority and local communities and councils can play a key role in this. Wireless broadband can play a major role as well. These early projects could also be an ideal testing ground for trans-sector applications.

3.3 Smart Government

The infrastructure above requires the governments around the world to modernise outdated infrastructure and implement new strategies and processes to meet the needs to the community. Governments taking a smart approach are heading in this direction which is referred to as Smart Government. It is an emerging area and a key element to the success of smart communities. One study by Pike Research estimated the global smart government technology market to be worth \$706 million in 2011 and would grow to \$2.5 billion by 2017. Between 2011 and 2017 cumulative investment in this area would total \$4.8 billion worldwide. Pike Research identified North America to lead these developments during this time, with Europe and Asia Pacific not far behind.

In 2013 the future use and management of Big Data is becoming a key focus for governments. In addition, mobile services are being incorporated into service offerings and cloud computing is becoming integrated to network development. The impact of the Internet of Things (IoT) and M2M developments are also a key consideration for this sector.

3.4 Smart Buildings/Homes

In many cities around the world, high density living is the norm and attention is now turning towards making this style of living more sustainable. Technological innovations include water harvesting and re-use, solar collection and energy-efficient appliances including heating and cooling. Sustainable urban transport systems are also on the agenda for many governments.

Exhibit 1: Smart Homes

Smart homes such as ‘habitat control’ or ‘intelligent home’ type networks are equipped with devices that possess an amount of integrated intelligence required to manage and exchange data.

Though home automation systems being offered in the past were heavily marketed as devices that enhanced lifestyle, in recent times, security, energy and access control systems have gained increased prominence and usage. The market is also displaying signs of maturity as the demand for integrating home automation systems with the internet is on the rise. In fact, even the current demand for simple applications has prompted broadband service providers to include home networking products in their installation packages and even go to the extent of integrating them with the existing systems at home free of charge.

Smart home functions include: entertainment, communications, energy and climate control, security, alternative energy and energy neutral applications, lighting and robotics. Facilities for tele-working are another important element in smart home designs.

Increasingly the definition of smart homes is also beginning to include ‘zero-energy’. These buildings have zero net energy emissions. Carbon emissions generated from on-site or off-site fossil fuel use are balanced by the amount of on-site renewable energy production. This can also include carbon emissions generated in the construction of the building and the embodied energy of the structure.

(Source: BuddeComm 2013)

3.5 Smart Transport

Smart transport systems or intelligent transport systems (ITS) encompass a range of wireless and wired communications-based information technologies that can be integrated into transportation infrastructure and vehicles.

Traditionally road network infrastructure has been built and then maintained, with little active management of how it is used. Investing in intelligent infrastructure allows for road managers to be more aware of how the network is being used, and how it can be used more efficiently.

Smart transport developments also include smart vehicles, which can communicate with each other and the transport network, and take action to improve safety and efficient operation. Smart vehicles include not only cars, but also trucks, trains, trams and buses.

Smart vehicle technologies are not something of the future. Almost all of us would be familiar with anti-lock brakes, where the vehicle thinks and then acts

to brake more safely than a human can. Of course, there are even more advanced technologies already available, such as adaptive cruise control that can keep vehicles at a safe following distance, and dynamic navigation systems that receive data to calculate the best route home.

In 2013 there are many exciting ITS projects taking place around the world and Electric Vehicles, or Smart Cars, have become a reality with hundreds of thousands in operation. Recharging solutions are now under the spotlight, with developers attempting to find ways to power the cars based wireless and grid technology. Currently the infrastructure to facilitate this development is not in place. There are very few charging stations, and the electricity grids are incapable of handling any volume of smart cars. More coordinated smart infrastructure policies are required in order to move forward.

Exhibit 2: Learning from E-cars

It is interesting to note that the e-car is not new. In fact the first 30 years of the car industry was dominated by e-cars. The first e-cars began to emerge as early as 1897. They were mainly used as commercial vehicles, and taxis in particular ran on electricity until well into the 1920s. Some of the commercial e-cars lasted into the 1940s.

With the arrival of the combustion engine the reach of cars could be expanded, and one could drive into the country. There was already a well-established gasoline distribution network for household purposes (mainly stoves) and the first private cars were used purely for leisure, so a trip into the country was high on the list for those early drivers. At that time electricity was still a novelty outside the cities.

The residential mass market quickly discarded the e-car and soon after WWI most private vehicles were petrol-driven. After the oil crisis in the 1970s e-cars received renewed attention but the car and oil industries – while paying lip service to the development – never seriously threw their support behind them.

A very promising initiative was taken in California in 1990, which saw the arrival of modern well-designed e-cars. However, once again the American car and oil industries were able to undermine the project and eventually the last e-car was literally ‘destroyed’ in 2005.

In the meantime Japan continued its e-car development. Learning from the history of the e-car it is clear that there isn’t a one-size-fits-all solution and a balanced approach is essential to make sure this is not another false start.

(Source: BuddeComm)

4 Strategies for Smart Communities

The concept of smarter homes, communities and cities encompasses a range of policies and strategies that need to be developed parallel to each other.

Smart infrastructure is needed for communications, energy, transport, etc. The key element in ‘smart’ is its ability to gather data, analyse it and provide intelligent feedback. These developments are referred to as the Internet of Things (IoT) and comprise elements of M2M processing; real-time data and Big Data management.

Communications is an essential element in all smart activities. Currently all the silo-based sectors operate separate and independent infrastructure, which of course creates significant financial waste and a lack of interoperability.

Without sound government policies to actually direct the various sectors to share utilities-based infrastructure nothing ‘smart’ will happen in the near future. At BuddeComm we call this the trans-sector approach.

Leadership from the top is needed to direct the sectors to work together, share infrastructure and provide a seamless service for the customer. This involves:

- People – and empowering them to take control over, for example, the management of their energy use, e-health requirements, e-education, etc.; and
- Things – as in sensors and devices that collect data and process this in real time. The combined data from, for instance, the weather bureau, the transport authorities, energy companies, local authorities can then be analysed (also in real time) to supply instant information to users. This can be in relation to natural disasters, traffic jams, energy prices, energy efficiencies of buildings, personal healthcare information and so on.

Currently most of this information is collected and stored in silos, often on incompatible systems and most of the time not shared with others. It is highly unlikely that these sector-based silos will readily agree to work together. They will all take cover – rightly or wrongly – behind security, privacy, reliability and so on. Only a leader at the top (President, Prime Minister, Emir etc.) can provide the overall leadership that is needed to create a trans-sector policy that will bring together the various infrastructures and application policies.

Once the foundation is established, industry will jump on board, operating in accordance with clear policies, guidelines and regulations. Governments can promote this further with policies that will see some budget redirection from the various sectors (healthcare, education, energy, environment, transport) towards the development of e-services.

Through positive incentives private industry will develop strategies and come up with most of the investments needed for the building of these smart systems.

Trans-sector thinking will be required to guide us through the next stage of human evolution. We are drawing attention here to the importance of looking across sectors to create synergy. BuddeComm has previously discussed at length the opportunities within the ICT industries of utilising new telecoms networks for e-health, e-education, smart grids, etc. A new way of thinking has emerged which also applies across infrastructure projects – looking at the potential synergies between the building of roads, sewerage systems, water and gas pipe networks as well as telecoms and electricity networks. Paul Budde

4.1 Greenfield Communities

The culmination of trans-sector thinking will be the evolution of smart connected communities.

Based upon the formation of a community based on FttH networks, a number of technologies and services can combine to create an enhanced-value opportunity for residents of these communities.

Smart homes that are connected to these networks can utilise a range of technologies such as:

- Smart grids, which will enable the management of renewable energy, including e-cars;
- Smart meters connected to smart grids, which will communicate intelligent data about power and energy usage;
- Environmental monitoring meters, which will allow for real-time collection of data via an in-home display to show potable water, non-potable water, power, gas and waste water usage;
- Community portals, which will provide a gateway to community-based information, government services, health services, education services, etc.;
- Home automation technology, which will allow control of energy and resource-saving devices such as photovoltaic cells, window shading, lighting, cooling, heating, garden irrigation, security monitoring, etc.;
- Home entertainment systems, which utilise internet-connected systems for audio and video;
- High-speed broadband capabilities that will support tele-working to allow workers to work from home using voice, data and video conferencing. This will significantly reduce carbon emissions normally associated with travel to a place of work.

To date the easiest path to incorporating these concepts into a smart community has been with the development of 'Greenfield' residential communities. These projects essentially start with no existing legacy utility infrastructure, and involve the construction of new dwellings which are capable of incorporating a range of new technologies.

While these Greenfield developments represent only a small percentage of the total population they provide a valuable opportunity to easily introduce FttH and to build services and capabilities into the community using this infrastructure within a relatively short space of time.

Therefore it is our recommendation to use Greenfield development sites as the test bed for new smart community and smart home concepts, which will accelerate the adoption of new technologies and will lead the way for other existing communities to follow suit.

5 Changes are Starting to Drive Action

Interestingly, we appear to be arriving at a turning point. People are now being confronted directly with environmental, energy, healthcare problems; they need no further convincing and are now starting to react out of a 'survival instinct'. It has become obvious that we need to do something about the problems ourselves.

In addition, the world's population is quickly growing from around seven billion to nine billion.

This obviously is causing stress in virtually all of our global systems. While it is essential that we address the causes of these problems, the reality is also that some of these issues, like over-population, which are causing the stress, are virtually unstoppable and we cannot alter this trend in the foreseeable future. While these problems need to be addressed in the longer-term, it is imperative that we focus on alleviating some of the stress now, so as to win some time to address the long-term problems.

So let us acknowledge that the world is facing a significant number of challenges. The key problem associated with these challenges is a lack of smart government policies based on integrated solutions that cross sector boundaries. Political leadership is needed to address these issues. Over the last few years citizens all round the world have indicated that they are ready for change. We have seen this in relation to climate change and the use of new and modern means of communication.

BuddeComm has argued that we can solve the challenges at hand, but we will have to do things differently. There is not a linear way forward – lateral solutions are needed. Over the last 60 years or so we have created a world of specialists who operate within silos. These silos need to be demolished and new horizontal structures established in which all sectors and disciplines work together.

Leadership from the top is needed if this is to be achieved. It is called the trans-sector approach, and (Information and Communication Technology) ICT is the glue needed to build more horizontal collaborative structures. Whether we are talking about smart cities, smart transport, smart grids, smart buildings or e-health – what is needed is useful data that can be analysed in real time, allowing people and/or machines to make instant decisions in relation to energy efficiency, traffic situations, weather activities, and personal health issues, as well as commercial decisions. These developments are referred to as machine-to-machine (M2M) or IoT and are the cornerstone of the smart developments of the future.

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5385 George Downes Drive, BUCKETTY NSW 2250 AUSTRALIA

Telephone: +61 2 4998 8144, Fax: +61 2 4998 8247

Email: pbc@budde.com.au, Web: www.budde.com.au

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