Content list available at ICONSMAT

Journal of Construction Materials

Journal homepage: www.iconsmat.com.au/publication

Article history:
Received 02 April 2020
Received in revised form
10 April 2020
Accepted 13 April 2020
Available online
2 July 2020

Influence of 5G and IoT in construction and demolition waste recycling – conceptual smart city design

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Abstract

The emerging 5G network as a controversial technology is well known to finally show case the concept of smart cities. In the context of environmental urban development, this study focuses on the main components of a fully automated construction and demolition waste recycling protocol. Autonomous trucks, smart roads capable of wireless charging of electronic vehicles, use of image processing in the recycling process, and also essential regulatory bodies had been considered in this study. A comprehensive political and economic review is being projected in the essence of data transparency and employment. Pitfalls and solutions to the arisen issues caused by the implementation of 5G network is also being discussed.

DOI: 10.36756/JCM.v1.4.1

Keywords

Smart city; Recycled aggregate; 5G; IoT

Introduction

5G is referred to as the backbone of IoT and the crucial component for the implementation of smart cities. Many definitions exist for what constitute a smart city. The collocation of all the definitions however, refers to an integrated system of interaction between the element of a city, such as health system, power management[1, 2], education, waste management[3], etc. in a smart way based on ICT infrastructure. The definition, of course, changes as new technologies emerge. One might define the concept of smart city in 2020 in a way that triggers 5G technology[4, 5]. Nevertheless, the importance of social welfare and hygiene in human communities remains the same.

When it comes to digital communication between the elements of smart cities, ICT requirements can be classified as followed:

- High capacity mobile network in the scale of Gbps
- High volume integration of IoT
- Ultrareliable communication system with latency down to 1 ms node-to-node.

Above-mentioned ensures that the connectivity of the devices deployed as elements of smart city is utmost. Waste management systems and traffic control systems are amongst the clusters subject to influence of ICT integrated cities. As an example, a smart city embraces the utilization of connected street lights in order to increase the efficiency of traffic control measures during the day i.e. in a cross section at midnight the duration for a red light should vary based on the traffic density. In the same context of smart traffic control, with the emergence of electric cars, the utilization of road lanes capable of charging the vehicles on the go is one of the hottest research topics. Graphene reinforced concrete pavements are known to be the promising solution for such technology. In another example for waste management systems (and particularly in construction and demolition waste recycling), waste collection trucks once equipped with GPS tracking systems can bring governance control in order to battle illegal dumping of waste in landfills. In a broader more advanced scale, autonomous waste trucks can benefit from 5G sensors.

Prior to gain a proper understanding on the benefits of 5G integrated smart cities, the current existing barriers need to be identified first. As a beginning, governments claim that the privacy issues, health risks due to the high frequency of waves, uncertainties about the way humans interact with robots, and lack of the required infrastructure are some of the main drawback reasons. The privacy issue mainly arises as a high level of detailed data is being transferred via the 5G technology. To name a few simple examples of highly detailed data, the angel of mobile phones which they make with horizon (gyrospcopy) and geolocation of electronic devices are amongst to most sensible ones. Data privacy becomes important since due to the high level of details, a minor interruption in the system caused by any possible reasons such as failure in a router or a cyber-attack, can cause a massive corruption in the urban environment. The short wave lengths and high frequency ranging in 24 – 86 GHz show alarming health risks that may cause to be accelerating cancer cells, and irreversible symptoms. Noteworthy, more investigations are being conducted on

the health matters related to the use of 5G network. On the other side, social interactions will be affected once the presence of robots becomes more prone. To clarify more in the case of autonomous vehicles while the trend is still in transition from all human-driven vehicles to a complete autonomous streets, the chances of collisions are high. Sudden interruption in a street, say, a kid running after a ball, will confuse drivers and autonomous vehicles. In fact, making eye contact between drivers is an important aspect of roads safety. In terms of social interactions it is good to be mentioned that humans, however, are adapting their behavior as the emergence of wearable devices, full immersive 3D experience and augmented reality had already proved their influence. At the end, it is said that network operators require a 3-7 year period to fully upgrade the existing infrastructure to 5G.

5G is operating in the range of 450 MHz – 52.6 GHz. Noteworthy, high frequency bands above 30 GHz are also being called as mmWave bands[4, 6]. In the mmWave bands, although a shorter transmission time interval can be used because of lower frequency selectivity, cell coverage would be limited because of higher path loss, which would inevitably lead to the use of small cell sizes. In turn, small cell sizes would cause issues for mobility management and control signaling overhead (Figure 1).

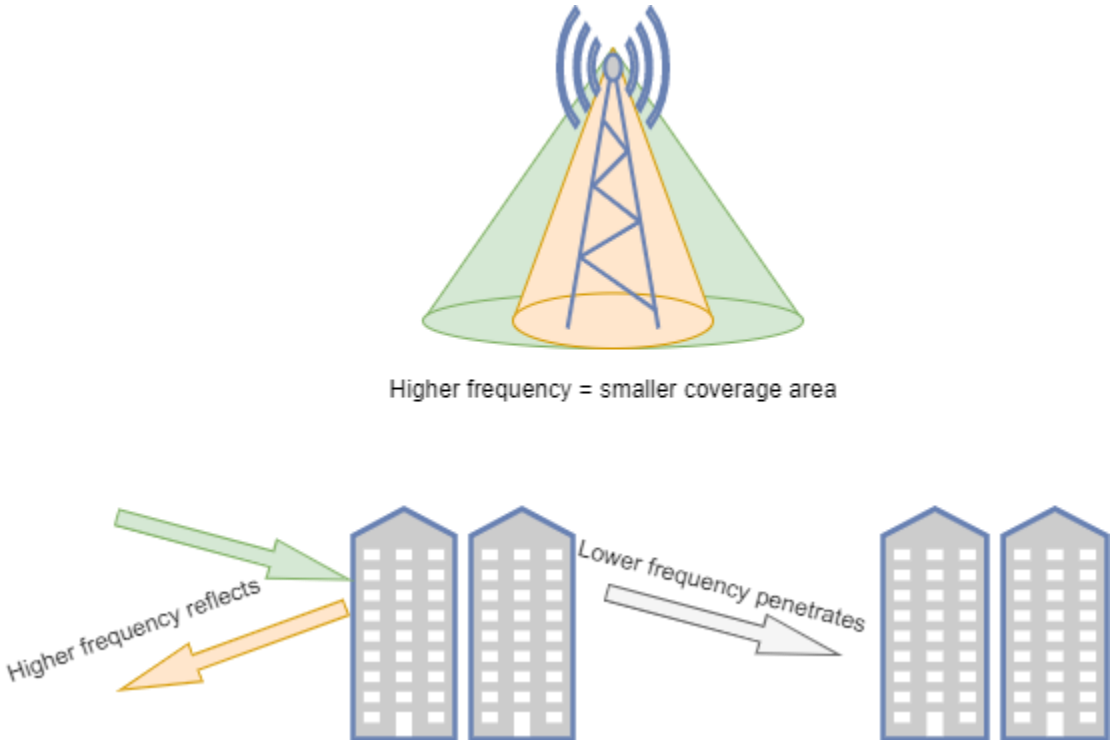

FIGURE 1 SCHEMATIC ILLUSTRATION OF PENETRATION AND COVERAGE ISSUES

One may consider investigation on the suitable types of construction materials in terms of 5G wave passage. What looks obvious is that lightweight materials due to their lower density may compromise a lower reflection rate[7].

Traffic control systems

In the context of smart cities, smart materials need space to perform. Graphene as the noble prize winner in 2010, compromises unique combination of superior properties clears the path for disruptive technologies. Electrons in graphene move 100 times faster than in silicon. Two of the key areas of application in the context of smart urban development are graphene-induced concrete roads capable of charging electronic vehicles, and, increased performance based properties of supercapacitors used in electronic vehicles. An Australian based research and development entity had introduced a highly conductive road pavement induced with graphene. The graphene reinforced concrete pavement introduced by this entity had reported a low 0.05 Ohm.cm of electrical resistance compared to the typical cement mortar which has a high 1,000,000 Ohm.cm resistance. In such range, wireless charging of electronic vehicles is not far reaching (Figure 2). However, concerns might arise regarding the safety of roads when high voltage electricity is passing underneath.

One of the major drawbacks in the inducement of graphene in concrete roadways is the high cost of production associated. In a study recently published, a new cheap mass production method had been introduced using electrochemical exfoliation of graphene oxide. An average unit price of graphene oxide is currently about $190 per gram, while the so-called method drops the price to about half[8-12].

FIGURE 2 GRAPHENE INDUCED CONCRETE ROADWAYS ARE CAPABLE OF CHARGING ELECTRONIC VEHICLES ON THE GO.

Waste management systems

Carbon tax had been introduced a couple of years ago to set price on the amount of carbon footprint each individual entities leaves behind their industrial activities. To an extent, the Act had become reluctant due to the claims for impracticality. In fact, monitoring those responsible for carbon emission was a big challenge that led the government set back from further implementation. However, this is understood that these days with a wider access to information and also the acceptability of life cycle assessment tools, particularly in the construction industry, such as BASIX which is regulated by the NSW state government in order to track the environmental properties of construction projects, monitoring such aspects are much easier than before. With the emergence of 5G network, an instantaneous monitoring system can be implemented in such a way that tracks the environmental hazards caused by the construction projects. This expands, also, to tracking the use of known non-environmental materials such as cement and other materials that had not passed through at least one recycling procedure. As an example, during the lodgment of construction development envelopes, the manger if urged to provide information about the materials used in that project, then the computer program such as BASIX can evaluate whether or not the envelop had considered the environmental impact of construction. Of course, in order to do so, the life cycle assessment system needs to be enforced with data on the type of materials which are being considered as environmental in this context.

Life cycle assessment, in general, is a well-known tool evaluating the inputs and outputs of a protocol which ultimately produces a report on the level of hazard and environmental properties. In the shade of 5G network, the carbon footprint of any construction activities can be tracked in a dynamic way. Assume the number of cycles a dirt truck takes in order to dump the construction waste in the recycling plant. An installed GPS in the truck may send signals to the server, which allows the real time environmental assessment. Such system can also be used for tax claims as well i.e. online automatic log book technology.

Waste segregation by image processing is another area under the influence of 5G network system. Construction and demolition recycling plants are currently struggling with the sorting process. It is well known that the major pitfall to recycled aggregate is the lack of heterogeneous properties due to the variety of particle types in a sample. Brick, concrete, glass, plastic, etc. are found in a sample of recycled aggregate that cause uneven distribution of loads across the cross section, making it unsuitable for structural applications. Experts suggest that an automatic sorting process leads to a better quality of aggregates and less uncertainty in regards to mechanical performance of this environmental construction material. In another studies conducted by the Institute of Construction Materials, an advanced image processing technology had been developed which showed promising results in the small laboratory scale. The technology is capable of distinguishing different particles based on their color code with an above 85% accuracy rate. This module in conjunction with other functioning modules such as robotic arms can form a complete automatic system. This is in fact where the 5G network comes into play.

The concept

Central operation room is the core to this concept. In Western Sydney, as an example, there are 4 recycling plants taking over the demolition wastes. Councils on the other side, are the entities authorizing the demolition certificates which means that they have access to valuable information about the size, materials and the destination of generated waste. Autonomous dirt trucks and smart rsoads are another playmakers in this concept. A central operation room is where all these component are being tracked and controlled. The advantage of this centralized operation room over the current existing practice is that it requires less number of humans to operate, faster control system, and a more reliable respond to the ever increasing demand for environmental construction.

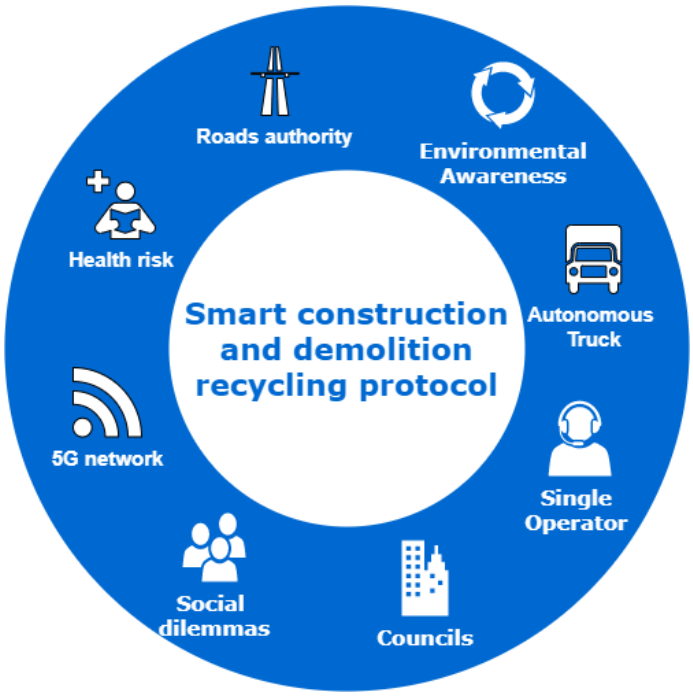

FIGURE 3 THE COMPONENT OF THE SMART CONSTRUCTION AND DEMOLITION WASTE RECYCLING PROTOCOL.

An estimation on the number of new jobs created in a 5-6 year period in Australia because of the emergence of 5G network, within the cluster of construction and demolition waste recycling, needs to be outlined. A new role will be introduced for a 5G technician (group) to physically install and maintain the connectivity of electronic tucks with the road elements. The operation room designed to control/overlook the recycling process consist of 2-3 personnel. An agent in each of the corresponding councils will be responsible to navigate the data required from the development/demolition plans to the operation room. Also, since currently there has been so

many concerns arisen due to the effect of high frequency waves on the human body, it is most likely that a research program would be initiated. In the nutshell, 4 separate cohort of new skills will emerge subsequently. But, it is also important to consider the number of jobs lost as a consequence. In the worst case scenario two major skillsets become reluctant because of the automation. Truck drivers will find their job reluctant. The number of manual plant operators will drop however the opportunity of working in the centralized operation room would still remain open for a few of those with outstanding computer skills.

Despite the numerous promising benefits that the concept of smart recycling brings about, there are of course a few disadvantageous encountered as well. Political and economic drawbacks such as resistance against transfer of data between organizations and loss of employment opportunities are amongst the few.

From the political perspective and particularly data accessibility, depending on the constitutional structure different scenarios can be proposed; whether be hierarchical as in capitalist and communist societies or be socialistic societies where communities decide about their own future [13](figure 4). In hierarchical constitutions, the leader/prime-minister/king/president must initiate an order to facilitate data transparency between corresponding organizations in order to facilitate the path to smart cities. On the other side, where socialist constitutions are in place, the principles of game theory can be deployed in order to share the long term gain between the organizations in a fair manner. Game theory via the means of a two well-known mathematical models, allocates the wealth generation between the organizations/participants. The two methods are based on the intrinsic rules of the game whether be a competitive game or a collaborative game instead[14].

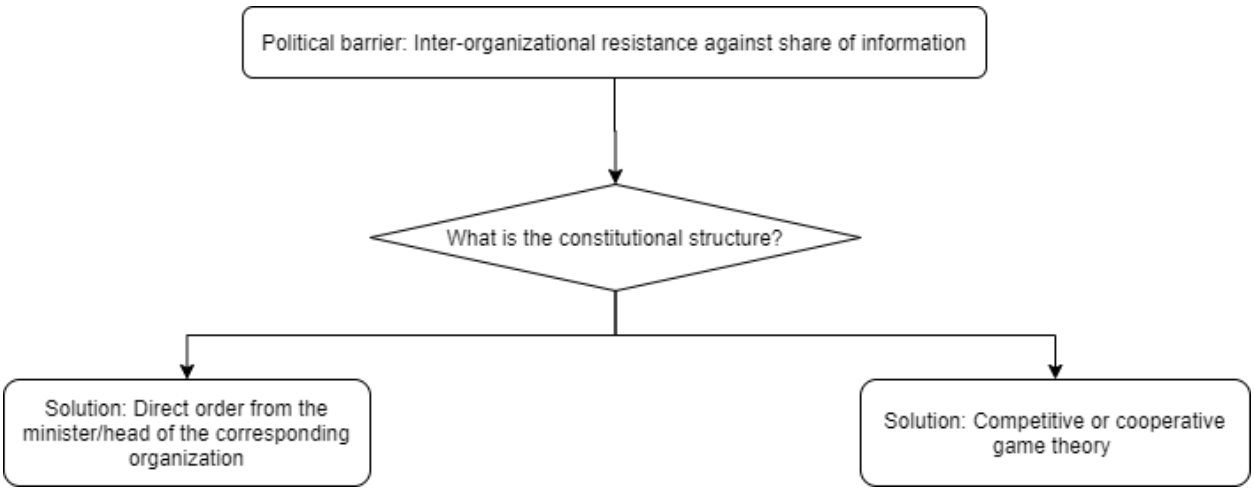

FIGURE 4 GOVERNMENTAL ENTITIES MAY RESIST IN PROVIDING CRUCIAL INFORMATION. DEPENDING ON THE CONSTITUTIONAL STRUCTURE, TWO POSSIBLE SOLUTIONS CAN BE SOUGHT.

From the economic point of view, the initiation of smart cities will cause a dramatic loss of employments as one of the objectives in this concept is to lessen the degree of human interaction. One can say such concept is more in the benefit of the manager than the employees. In the periods of high unemployment governments usually introduce stimulus packages in order to decrease the harsh consequences of homelessness and poverty. This approach, injecting cash in the economy, usually decreases the value of money and results in inflation, if not hyperinflation. Property prices hike in the medium run as more cash is now being circulated in the economy. In this article, in order to avoid such undesirable consequences, more focus on the education/training section is being proposed before economy leads to a disaster caused by the integration of smart cities. To discuss the Microeconomy of construction and demolition recycling, a number of factors has to be identified those are helpful in creation of new jobs. The geolocation of operation rooms, corresponding maintenance entity, number of trucks, and government plans on new development are some of the most important factors affecting the creation of new jobs. Noteworthy, all of the aforementioned aspects requires a highly skilled workers in the field of IT. A pitfall that currently is facing the construction industry is that a negligible credits are allocated for computer programming units in the relevant university faculties. Undergraduate programs in the relevant schools teaching construction students, are not structured to equip the young with computer skills. Rather, these modules are mostly designed to train on-site labours. The graduates from these schools will be amongst those are going to be jobless once the concept of smart cities had come into reality. Thus, it is necessary to have a reform in the education system. Once university modules had been changed to a more suitable structure addressing the future demand, the graduates can expect to find a job in the operation or the maintenance entity related to the proposed smart recycling concept.

Conclusion

The article had projected a perspective on the fully automated construction and demolition recycling protocol powered by 5G network. Compromising technologies had been introduced including the intrinsic properties of 5G signals, graphene induced roadway for wireless charging of electronic vehicles, and image processing as part of the recycling procedure. A critical view had also been discussed on the political and economic aspects of this protocol. The proposed smart system creates more job opportunities and embraces a faster and more reliable network of environmental construction.

Conflict of Interest

The authors declare that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

References

[1] A. Gharizadeh, F. Sartipi, E. Ayoubi, and A. Severino, "The chemical reactor design configuration of CO2 concrete green solution," *Journal of Construction Materials,* vol. 1, pp. 2-5, 2020.

[2] A. Todhunter, M. Crowley, F. Sartipi, and K. Jegendran, "Use of the by-products of post-combustion carbon capture in concrete production: Australian case study," *Journal of Construction Materials,* vol. 1, no. 1, 2019.

[3] F. Sartipi, "Automatic sorting of recycled aggregate using image processing and object detection," *Journal of Construction Materials,* vol. 1, pp. 3-3, 2020.

[4] S. K. Rao and R. Prasad, "Impact of 5G technologies on smart city implementation," *Wireless Personal Communications,* vol. 100, no. 1, pp. 161-176, 2018.

[5] C.-X. Wang *et al.*, "Cellular architecture and key technologies for 5G wireless communication networks," *IEEE communications magazine,* vol. 52, no. 2, pp. 122-130, 2014.

[6] P. K. Agyapong, M. Iwamura, D. Staehle, W. Kiess, and A. Benjebbour, "Design considerations for a 5G network architecture," *IEEE Communications Magazine,* vol. 52, no. 11, pp. 65-75, 2014.

[7] M. Sartipi and F. Sartipi, "Stormwater retention using pervious concrete pavement: Great Western Sydney case study," *Case Studies in Construction Materials,* vol. 11, p. e00274, 2019.

[8] A. Abdelkader, A. Cooper, R. Dryfe, and I. Kinloch, "How to get between the sheets: a review of recent works on the electrochemical exfoliation of graphene materials from bulk graphite," *Nanoscale,* vol. 7, no. 16, pp. 6944-6956, 2015.

[9] S. Chuah, Z. Pan, J. G. Sanjayan, C. M. Wang, and W. H. Duan, "Nano reinforced cement and concrete composites and new perspective from graphene oxide," *Construction and Building Materials,* vol. 73, pp. 113-124, 2014.

[10] M. Gamil, A. Ghari Zadeh, and F. Sartipi, "A review on graphene reinforced cement composite: technical approach for ecofriendly construction," *Journal of Construction Materials,* 2019.

[11] F. Sartipi, A. Ghari Zadeh, and M. Gamil, "Electrical resistance of graphene reinforced cement paste," *Journal of Construction Materials,* 2019.

[12] P. Yu, S. E. Lowe, G. P. Simon, and Y. L. Zhong, "Electrochemical exfoliation of graphite and production of functional graphene," *Current opinion in colloid & interface science,* vol. 20, no. 5-6, pp. 329-338, 2015.

[13] A. Todhunter, M. Crowley, and F. Sartipi, "Construction productivity indices in socialism compared with capitalism," *Journal of Construction Materials,* 2019.

[14] F. Sartipi, "Organizational structure of construction entities based on the cooperative game theory," *Journal of Construction Materials,* vol. 1, no. 2, 2020.