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Docile Smart City Architecture: Moving Toward an Ethical Smart City

Sahil Sholla[1], Roohie Naaz Mir[1] and Mohammad Ahsan Chishti[1]

[1]*Computer Science and Engineering Department, National Institute of Technology Srinagar, Hazratbal , India*

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Abstract: A recent idea of providing better civic facilities to modern societies is the concept of the Internet of Things (IoT) enabled smart city. IoT seeks to connect all things to the global Internet. Though varied smart city architectures are proposed in literature, it is observed that they lack thorough consideration for the principal element of a smart city i.e. citizens. We opine that a technologically intensive city that provides modern citizen services is not a sufficient criterion for conferring a city to be smart. Sociological factors such as culture, legal system and ethics represent essential components of a healthy functional city. In this work, we propose Docile Smart City Architecture (DSCA) to address the pressing need of ethics in smart cities. The distinguishing feature of our architecture vis-a-vis other architectures presented in literature is that we include sociological and ethical considerations of a city within smart city architecture itself. Such development would promote smart city paradigm among masses and increase its marketability.

Keywords: Smart city, Architecture, Internet of Things, Ethics, Societal impact

1. INTRODUCTION

In recent times better facilities and civic amenities for modern societies is represented by the idea of smart city facilitated by the Internet of Things (IoT). IoT is a paradigm shift in our understanding of networking that endeavours to connect even ordinary things to the internet, sensing environment for subsequent data processing and application [1]. Increasingly societies are heading towards urbanization and at the turn of 2050, 70 percent of global population is expected to live in urban areas [2]. Smart city paradigm offers promising solutions for addressing the challenges of urbanization and many countries have already embarked on the mission to offer smart cities to their citizens including the US, European Union, Toronto, Paris and London. There is a general agreement among the researchers that smart cities utilise Information and Communication Technology (ICT) to provide better civic amenities like healthcare, transportation, communication, sanitation etc. Smart city leverages advanced technology to sense and process routine data of a city to provide solutions to the problems faced by citizens [3]. Apart from academia, smart city research has also attracted significant attention from many technological vendors [4]. Notwithstanding immense research effort, the definition of smart city has failed to achieve consensus resulting in varying architectures [5].

The architectures presented in literature primarily focus on infrastructure, technology and application whilst due attention is not paid to the recipients of such technology i.e. people. A three layer smart city architecture is proposed in [6] comprising of information storage layer, application layer and user interface layer. All smart city related data is stored in the information storage layer that is subsequently used by application layer to provide smart services to citizens. User interface layer adopts a variety of graphical interfacing mechanisms to facilitate interaction of people with the application services. A four layer architecture is proposed in [7] that consist of bottom tier, intermediate tier-1, intermediate tier-2 and top tier. The first layer is responsible for data collection, second layer manages communication technologies and third layer performs data analytics on the smart city data. Various smart city application services are provided by the top tier. Authors in [8] propose a five layer architecture. All the sensors used to collect smart city data are grouped into data acquisition layer and data are exchanged using communication infrastructure of the data transmission layer. Refining of the data is performed at data vitalization and storage layer and end-user services are provided by support service layer. Various smart city systems are integrated at domain service layer. Authors in [9] provide a detailed survey of smart cities, however

E-mail address: sahilsholla@gmail.com, naaz310@nitsri.net, ahsan@nitsri.net

social implications of such all-pervading systems have not been considered.

In our opinion, implementation of various advanced technologies is not a sufficient criterion to deem a city to be smart. Ethics, morality and culture represent essential vehicles for smooth functioning of any society. Ethics symbolise the collection of beliefs, values and morals of a given society that serve as guiding principles for amicable mutual coexistence. A sound set of social, cultural and ethical norms represent essential components of a healthy society that need to be taken into consideration when the technologies are implemented. An issue closely related to ethical complicity is the question of security ethics. As smart devices of the IoT are able to sense unprecedented amount of information, private user data needs to be handled in a secure manner, respecting the ethics of individual and society. Although different societies might view ethics differently, all across the board there is a common thread of universal human values that transcend space and time. The ever-increasing presence of technology has inevitably become an essential ingredient of modern societies and smart city vision would only bolster it. Thus, ethical connotations of technology cannot be undermined else wellbeing of the very people it seeks to benefit would be in danger. Since the notion of smart city aims to address the wellbeing of entire society, a holistic approach that takes ethics also into consideration is necessary.Not only should people be aware of ethics but we propose that ethics be coded into smart city architecture. Also, we outline a method that can be used to implement context specific ethics in smart devices to facilitate the development of ethical smart city.

2. Docile Smart City Architecture

We view smart city concept as an approach to ensure all-round development of a city rather than mere implementation of certain technology in a particular geographic location whilst being desolate of complex sociological factors. In this work, we propose Docile Smart City Architecture (DSCA) to address social and moral considerations of a smart city. The distinguishing feature of our architecture vis-a-vis other architectures presented in literature is that we include sociological and ethical features of a city within smart city architecture itself.

Docile Smart City Architecture (DSCA) shown in Fig. 1 comprises of five layers. Physical layer performs identification of real world things. Network layer hosts various communication infrastructure followed by data analytics layer that utilises various data mining techniques on smart city data. Transparency layer incorporates sociological parameters of a city and finally business layer provides various smart services to the citizens. Various layers of the proposed architecture are described below:

A. Physical Layer

In a smart city numerous sensors embedded all across the city would enable collection of immense data from the surroundings. These smart things would need to be identified to the Internet to facilitate global exchange of data. Various possible technologies that could facilitate addressing mechanisms of smart things are Radio Frequency Identification (RFID) [10], electronic product code (EPC), IPv6, ubiquitous code (ucode) [11], 6LowPAN [12] and named data networking (NDN) [13].

B. Network Layer

Smart cities are expected to connect a spectrum of heterogeneous devices and as such would involve an array of commutation technologies. Network layer would use a combination of past, present and future technologies to meet the networking demands of a smart city. Technologies such as RFID, Near field communication (NFC) [14], ultra wideband (UWB) [15] and WiFi [16] are promising for machine-to-machine (M2M) communication. Applications requiring small data rate e.g. various home appliances, HVAC (Heating, Ventilation and Air Conditioning) and healthcare devices would typically use Z-Wave [17]. Bluetooth Low-Energy (BLE) is expected to play a significant role in Intelligent Transportation Systems (ITS) [18]. LTE-A is another technology offering high data rate for mobile nodes [19].

C. Data Analytics Layer

Data mining for smart city entails non-trivial mechanism to unravel strategic information from data gathered by ubiquitous sensors [20]. Cloud platforms would be necessary for such colossal data to ensure storage and processing in a reliable, secure and scalable manner. Various data mining techniques would be applied on the gathered data to provide services to end users.

Collective data over a large range is expected to be more useful to understand the trend than data collected by a single sensor. Data analytics techniques serve to reveal such society-wide information as traffic patterns, environmental health, business trends etc. Sophisticated models representing various markets within a smart city could also be designed to guide decisions that would facilitate economic well being of a smart city.

D. Transparency Layer

Smart cities would have the ability to gather gigantic amounts of data regarding its citizens due to ubiquitous nature of sensors. In the absence of a sound ethical framework, the idea of smart city could infringe on the ethical rights of its citizens and lead to discrimination based on race, language or culture [21]. Concentrating on mere technological aspects ultimately ignores the beneficiaries of the technology. The idea of responsibility in technological advancement is a recent development that has been incorporated only after rigorous legal, religious and philosophical discussion [22].

In our opinion a city that efficiently uses technology does not fulfil the requirements of the idea of a smart city. For the smooth functioning of any city, ethical and legal dimensions must also be considered. We propose a separate transparency layer to tackle this important question. Transparency layer would possibly use a set of premises representing social values of city and ensure that services provided to citizens are consistent with ethical, cultural and legal expectations of a smart city.

It is expected that the notion of 'smart' city would vary amongst different societies as culture, ethics, morality and laws concerning them vary. Transparency layer would consider such differences to personalise the smart city for its citizens to facilitate social acceptance and increase the economic value of the model. Transparency layer represents a layer of strategic and economic significance because smart city concept will only enjoy public support if people's values, concerns and apprehensions are respected.

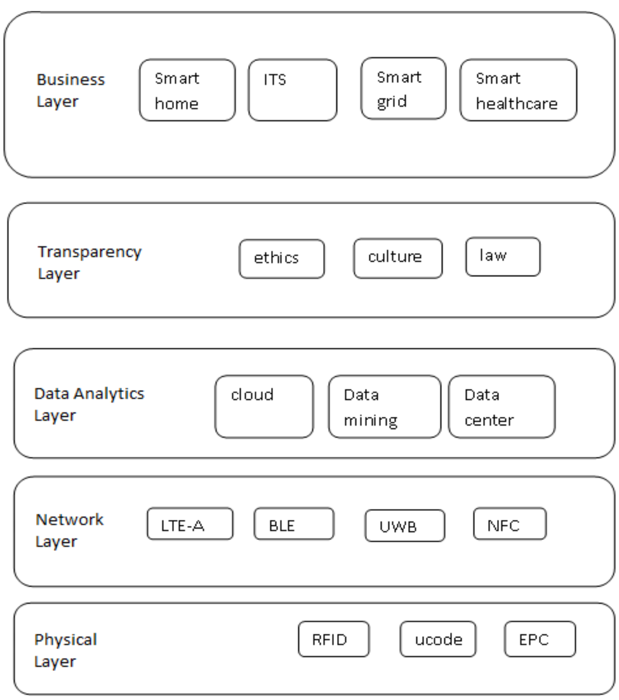

Figure1.Docile Smart City Architecture (DSCA)

E. Business Layer

Smart city would offer its citizens a plethora of user specific applications, limited only by imagination. Various technologies would be integrated to provide such services as smart healthcare, ITS, smart grids, smart homes etc. The services provided by smart city to individuals and organisations are expected to be a huge potential market [17]. Business layer utilises services of data analytics layer to understand economic model of the smart city so that profitable business markets are identified. Also, it would facilitate strategic smart city planning to help alleviate poverty and improve economic well being of citizens.

We have named it Business layer instead of application layer because services are adapted to smart city market to ensure businesses in the specific area flourish and are not adversely affected by rollout of modern technologies. Also, economic implications of introducing smart services are weighted so that daily bread of ordinary citizens is not endangered due to automation and their interests are not downplayed by smart city.

3. Ethics-Aware Knife

Usually working of a smart device only focuses on technical specifications for efficient design. Devices are treated as stand-alone systems disconnected from moral, ethical and legal context in which they operate. However, this may inadvertently result in situations that compromise essential human values or cause serious physical injury, even loss of life. The problem is exacerbated in the face of artificial intelligence enabled smart cities that use pervasive technology of the Internet of Things. In this section, we propose a method by which we can implement ethics in the ordinary things of a smart city that would eventually lead to the development of an ethical smart city. Also, we illustrate its working by designing an ethics-aware knife.

We hold the opinion that human beings regardless of religion, ethnicity, race, region and society share a rich reservoir of ethics that should be considered for inclusion within device functioning. However, we do not concern ourselves with the philosophical debate surrounding the question. The objective of the proposed method is to implement a given set of moral, ethical or legal considerations applicable in the context of a smart device regardless of the philosophy that motivates such considerations. In general, the proposed method works as follows:

We refer to the collection of sociological, ethical, legal or religious parameters relevant to the context of a particular machine as Ethics of Operation (EOP). First we express the EOP in the form of propositional statements (whether related to input or output). With the help of propositional variables we identify various scenarios that may result between the smart device and its context. The scenarios could represent normal functional behaviour, malfunction, ethical behaviour as well as ethical breaches. Various combinations of the propositional variables and the meaning implied by them is indicated in the context table. Then, EOP is used to design appropriate ethical response. For each scenario in the context table corresponding ethical response is expressed in the manners table. The mapping from context table to manners table enables the machine to exhibit ethical behaviour.

Such incorporation ensures essential human values that invariably come into play in the context of smart device functioning are upheld. We illustrate our method by implementing two ethics theories on the knife that we call *Ethics-Aware Knife: A Knife that does not hurt!*

The ethics-aware knife in the context of kitchen will function normally while cutting vegetable, fruits etc. However, if sharp edge of the knife crosses threshold distance with a human, it goes into protect mode.

Let us consider the following two ethics theories to be implemented in the knife:

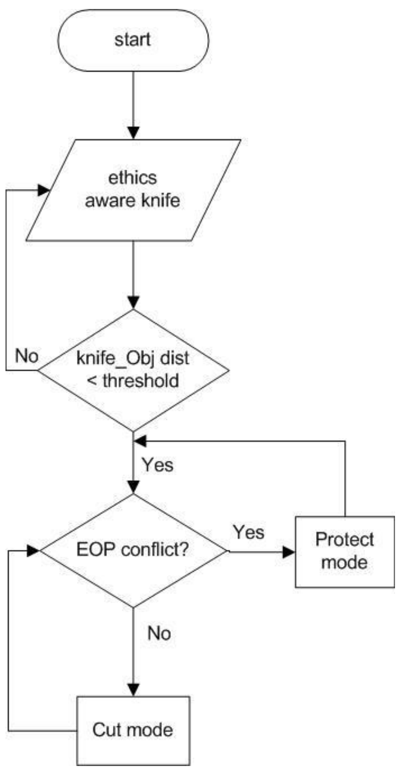

Figure 2. Flowchart Ethics Theory A

Ethics Theory A: The knife may not harm (cut) a human. It is however permissible for it to remain sheathed/unsheathed when not in use (no object under sharp edge). The flowchart for ethics theory A is shown in Fig. 2.

Ethics Theory B: The knife may not harm (cut) a human. Also when not in use (no object under sharp edge), it should remain sheathed.

Under ethics theory A, the sharp edge of knife is permitted to remain sheathed or unsheathed when not in use. As the knife is brought close to an object (e.g. vegetables), sensors within the knife detect presence of an object and microprocessor embedded within the knife calculates if the distance between the knife and the object (vegetable) is less than some carefully chosen threshold distance value. If the distance is greater than threshold, the knife may remain sheathed or unsheathed, as the manufacturer desires. If however, the distance is lower than or equal to threshold value, the knife is unsheathed to expose sharp edge to perform normal cut operation. However, if the object detected is human, an EOP conflict occurs and the sheath is enabled even when threshold distance is crossed to protect the human.

Ethics theory B represents a 'nobler' version wherein the knife functions in a similar manner but with the additional constraint that sharp edge of the knife is by default protected by a sheath for greater safety. Ethics theory serves as judgment criteria on the ethical status of a scenario that can occur between ethics-aware knife and its context. The two theories A and B are motivated by common understanding of how a knife is expected to function in a kitchen scenario without regard to any specific philosophy. In general, ethics theory to be implemented on a given device in a specific social context should be prepared in consultation with thinkers, ethicists, jurists, religious scholars etc. in order to protect the well being of masses.

A. Implementation of ethics theory A

We represent the ethical theory A in terms of propositional variables h, t and s where :

h: a human is detected under sharp edge

t: distance of object less than threshold

s: enable sheath covering the sharp edge

Using these propositional variables, we construct a table to represent ethical theory A that we call context table. The propositions can take either true (T) or false (F) values that we denote by 1 and 0 respectively. The meaning implied by various codes and corresponding ethical status is shown in Table 1.

TABLE 1. CONTEXT TABLE FOR ETHICS THEORY A

Scenario	h	t	s	Meaning	Ethical Status
1	0	0	0	human not detected, threshold not crossed, sheath disabled	permissible
2	0	0	1	Human not detected, threshold not crossed, sheath enabled	permissible
3	0	1	0	Cut mode (no human, threshold crossed, sheath disabled)	obligatory
4	0	1	1	system malfunction (no human, threshold crossed, sheath enabled)	permissible
5	1	0	0	Human detected, threshold not crossed, sheath disabled	permissible

6	1	0	1	Human detected, threshold not crossed, sheath enabled	permissible
7	1	1	0	EOP conflict (Human detected, threshold crossed, sheath disabled)	forbidden
8	1	1	1	Protect mode (Human detected, threshold crossed, sheath enabled)	obligatory

The context table depicts various scenarios that can occur between the knife and its surroundings. It indicates various ethical choices that can be made, ethical breaches that can occur as well as captures system malfunctioning.

We define propositional functions H (h,t,s), T(h,t,s) and S(h,t,s) on propositional variable h, t and s that provide ethics compliant values for h, t and s to ensure that the knife performs its functions in agreement with ethical theory A. For simplicity we represent the functions as functions H, T and S.

Then we construct a table called Manners Map that maps scenarios in the context table to corresponding ethically compliant scenarios in the manners table as shown in Table 2.

TABLE 2. MANNERS MAP FOR ETHICS THEORY A

h	**t**	**s**
0	0	0
0	0	1
0	1	0
0	1	1
1	0	0
1	0	1
1	**1**	**0**
1	1	1

Context table

H	**T**	**S**
0	0	0
0	0	1
0	1	0
0	1	1
1	0	0
1	0	1
1	**1**	**1**
1	1	1

Manners table

In the above table the possible ethics breach (110) has been handled as per ethics theory A i.e., corresponding to output 111, shown in bold in the manners map. We keep system malfunction (011) as such and do not take any action as this is ethically permissible. However, for constructing fault tolerant systems such error condition can trigger automatic troubleshoot request, customer complaint etc. For each column of the manners table, we focus on the rows that are set to '1' and consider corresponding rows in the context table to evaluate propositional functions.

The Boolean equations corresponding to functions H, T and S are:

$$H = h\bar{t}\bar{s} + h\bar{t}s + ht\bar{s} + hts$$

$$H = h$$

$$T = \bar{h}t\bar{s} + \bar{h}ts + ht\bar{s} + hts$$

$$T = t$$

$$S = \bar{h}\bar{t}s + \bar{h}ts + h\bar{t}s + ht\bar{s} + hts$$

$$S = \bar{h}s + hts + h(t \oplus s)$$

We observe from the equations of H and T that there are no changes in the values of h and t, respectively. This is because the parameters h and t cannot be changed by the knife in this example and as such remain unaffected. The equation S, reflecting ethical behaviour of sheath is however dependent on all three variables h, t and s.

B. *Implementation of ethics theory B*

The implementation of ethics theory B is done in a similar manner. Here the permissible scenarios 1 and 5 corresponding to ethics theory A are both forbidden. Also, permissible scenarios 2 and 6 of ethics theory A are both obligatory, rest of the scenarios remain the same. Assuming the same propositional variable h, t and s as in ethics theory A, the modified context table is given by Table 3.

TABLE 3. CONTEXT TABLE FOR ETHICS THEORY B

Scenario	h	t	s	Meaning	Ethical Status
1	0	0	0	EOP conflict (human not detected, threshold not crossed, sheath disabled)	forbidden
2	0	0	1	Human not detected, threshold not crossed, sheath enabled	obligatory
3	0	1	0	Cut mode (no human, threshold crossed, sheath disabled)	obligatory
4	0	1	1	system malfunction (no human, threshold crossed, sheath enabled)	permissible
5	1	0	0	EOP conflict (Human detected, threshold not crossed, sheath disabled)	forbidden
6	1	0	1	Human detected, threshold not crossed, sheath enabled	obligatory
7	1	1	0	EOP conflict (Human detected, threshold crossed, sheath disabled)	forbidden
8	1	1	1	Protect mode (Human detected, threshold crossed, sheath enabled)	obligatory

The manners map for ethics theory B is shown in table 4.

TABLE 4: MANNERS MAP FOR ETHICS THEORY B

h	t	s	H	T	S
0	**0**	**0**	**0**	**0**	**1**
0	0	1	0	0	1
0	1	0	0	1	0
0	1	1	0	1	1
1	**0**	**0**	**1**	**0**	**1**
1	0	1	1	0	1
1	**1**	**0**	**1**	**1**	**1**
1	1	1	1	1	1

The corresponding Boolean functions for H, T and S are:

$$H = h$$

$$T = t$$

$$S = h + \bar{h}\bar{t} + \bar{h}ts$$

In a similar fashion, the EOP defined for the knife could be enhanced to incorporate additional constraints e.g. knife may only be allowed to cut objects of a certain type (say vegetables), children may not be allowed to use the knife, a knife should function only in the kitchen of its owner etc. Under such cases the knife evaluates if the object near its sharp edge is of type it is authorized to cut and if there is no violation, then the sheath covering the sharp edge is disabled and person is able to cut (vegetables). However, if there is an EOP conflict, like the object near the sharp edge is a wire, or person handling the knife is a child, or knife is not in the kitchen of its owner etc. then an EOP conflict occurs and sheath is not disabled even though distance is less than threshold distance.

In a similar fashion, an ethical car can be designed that prevents the dangerous situation of infants getting locked inside. A propositional variable would be used to determine if the car is locked or not. Another variable identifies if a child in inside the car. A third propositional variable would determine if emergency SOS is to be sent to the parent. If a person tries to lock the car with an infant inside, EOP conflict occurs, the lock is disabled and emergency SOS is sent to the parent.

Likewise, a camera that protects life by disabling selfie at a potentially dangerous location. A propositional variable would be used to determine if selfie mode of the camera is enabled and another variable would be used to verify if the place has been flagged as dangerous. A third variable would be used to decide if the camera is to be enabled or disabled. In case a person attempts to take a selfie at a potentially life threatening location, EOP conflict occurs and the camera would be disabled.

The method outlined above can pave way for many applications like ethical gadgets, ethical toys, ethical smart home, ethical smart city etc. The method is a promising approach to address the questions of social implications of technology by designing smart products that are affable to human ethics.

4. DISCUSSION

Since the idea of smart city encompasses multiple areas of societal welfare, interdisciplinary work would be necessary to materialise it. Although, we have sketched a possible solution for incorporating ethics in a smart city, considerable research effort would be needed to realise a full-fledged implementation of transparency layer. Integration mechanisms would need to be designed to interface the transparency layer with existing systems. Given the System of Systems nature of IoT, device ownership and consequently ethical responsibility of a device may be not well defined. This area would need active participation from legal experts to decide the ethical purview of each stakeholder in the IoT world. Ethical requirements from the government, law enforcement, industry and people using the technology could be combined carefully by establishing precedence and removing ambiguities to form unified device EOP. After all precaution has been taken, situations may still arise when a smart device faces conflicting ethical requirements. To address such concerns, a negotiation mechanism to resolve conflicts may be needed at the transparency layer. Moreover, security of ethics would also need to be addressed.

The proposed method of implementing ethics needs human assistance to design manners map from a given EOP. For smaller examples this could be easily achieved as illustrated for the ethics-aware knife. However, as situations become complex, large number of propositional variables would be needed to sufficiently express EOP. This would increase the possible number of scenarios to be handled exponentially and possibly need complex Boolean analysis. A mechanism that is able to automate the generation of the truth tables from a given EOP would be necessary in such situations. Focussing on context specific ethical requirements may also fend off the problem to some extent. Although, smart things of the IoT are expected be endowed with some processing power, analysing massive exponential scenarios may not be feasible, particularly in real-time situations. Under such circumstances, fog and cloud computing platform solutions may need to be explored.

5. Conclusion

In spite of the large scale research effort, smart city architectures do not give adequate consideration to ethical aspects of a smart city. In this work, we have proposed our Docile Smart City Architecture to address the question of ethics of a smart city. DSCA comprises of five layers. Physical layer performs the role of identification of smart things, Network layer contains technology for communication followed by Data analytics layer that employs data mining. Transparency layer incorporates social and ethical dimension and business layer provides end user services. By employing transparency layer, sociological requirements of a smart city are addressed, social acceptance facilitated and economic value of smart city increased.

Also we outlined our method that is able to implement context specific ethics or EOP in smart devices. EOP expressed in terms of propositional variables are mapped to ethically consistent values in the manners map. The method was illustrated by considering an ethics-aware knife. The knife detects the presence of human and if distance with the sharp edge is less than threshold, a protective sheath is enabled to safeguard the human. By extending similar approach to other smart devices, we can ensure that smart devices function in a manner congruent to ethical expectations of the society. We hope this work would further the research effort toward incorporating complex social variables within smart city architecture.

References

[1] Smart Networked Objects and Internet of Things, white paper, Association Instituts Carnot, Greece, 2011

[2] J. Jin, J. Gubbi, S. Marusic and M. Palaniswami, "An Information Framework for Creating a Smart City Through Internet of Things," IEEE Internet of Things Journal, 2014, 1(2): 112-121.

[3] R. Wenge, X. Zhang, C. Dave, L. Chao and S. Hao, "Smart city architecture: A technology guide for implementation and design challenges," China Communications, 2014, 11(3): 56-69.

[4] L. G. Anthopoulos, "Understanding the smart city domain: A literature review," in *Transforming City Governments for Successful Smart Cities*, Springer, 2015, pp. 9–21.

[5] Caragliu A, Del Bo C, Nijkamp P, "Smart Cities in Europe", Proceedings of 3rd Smart cities in Central European Conference in Regional Science. October 7-9. Košice, Slovak Republic. 2009: 45–59.

[6] N. Komninos, "The Architecture of Intelligent Cities," 2nd Int. Conf. Intell. Environ., pp. 13–20, 2006.

[7] M. M. Rathore, A. Ahmad, A. Paul, and S. Rho, "Urban planning and building smart cities based on the Internet of Things using Big Data analytics," Comput. Networks, vol. 101, pp. 63–80, 2016.

[8] W. Rong, Z. Xiong, D. Cooper, C. Li, and H. Sheng, "Smart city architecture: A technology guide for implementation and design challenges," China Commun., vol. 11, no. 3, pp. 56–69, 2014.

[9] A. Gharaibeh et al., "Smart Cities: A Survey on Data Management, Security, and Enabling Technologies," IEEE Communications Surveys & Tutorials, vol. 19, no. 4, pp. 2456-2501, 2017

[10] D. Yang, F. Liu and Y. Liang, "A survey of the Internet of Things," Proceedings 1st ICEBI, 2010 : 358–366.

[11] N. Koshizuka and K. Sakamura, "Ubiquitous ID: Standards for Ubiquitous computing and the Internet of Things," IEEE Pervasive Comput., 2010, 9(4): 98–101.

[12] N. Kushalnagar, G. Montenegro and C. Schumacher, "IPv6 over Low- Power Wireless Personal Area Networks (6LoWPANs): Overview, assumptions, problem statement, and goals," Internet Eng. Task Force (IETF), Fremont, CA, USA, RFC4919, vol. 10, Aug. 2007.

[13] Lixia Zhang, Alexander Afanasyev, Jeffrey Burke, et al., "Named Data Networking", ACM SIGCOMM Computer Communication Review (CCR), 2014

[14] R.Want, "Near field communication," IEEE Pervasive Comput., 2011, 10 (3): 4–7.

[15] R. S. Kshetrimayum, "An introduction to UWB communication systems," IEEE Potentials, 2009, 28 (2): 9–13.

[16] E. Ferro and F. Potorti, "Bluetooth and Wi-Fi wireless protocols: A survey and a comparison," IEEE Wireless Commun., 2005, 12 (1): 12–26.

[17] A. Al-Fuqaha, M. Guizani, M. Mohammadi, M. Aledhari and M. Ayyash, "Internet of Things: A Survey on Enabling Technologies, Protocols, and Applications", IEEE Communications Surveys & Tutorials, 2015, 17 (4): 2347-2376.

[18] R. Frank, W. Bronzi, G. Castignani, and T. Engel, "Bluetooth low energy: An alternative technology for VANET applications," Proc. 11th Annu. Conf. WONS, 2014: 104–107.

[19] A. Ghosh, R. Ratasuk, B. Mondal, N. Mangalvedhe, and T. Thomas, "LTE-Advanced: Next-generation wireless broadband technology [InvitedPaper]," IEEE Wireless Commun.,2010, 17(3): 10–22.

[20] Han J, Kamber M, " Data Mining: Concepts and Techniques", San Francisco: Morgan Kaufmann, 2000.

[21] D. Bianchini and I. Avila, "Smart Cities and Their Smart Decisions: Ethical Considerations," IEEE Technology and Society Magazine, 2014, 33(1):34-40.

[22] C. Mitchan, "Os desafios colocados pela tecnologia à responsabilidade ética", Análise Social, 2006, 41, 4 (181): 1127-1141.

Sahil Sholla, is pursuing his PhD at the department of Computer Science & Engineering, National Institute of Technology Srinagar, India. He has done bachelors in Computer Engineering from University of Kashmir and masters in Communication and Information Technology from National Institute of Technology Srinagar, India. He is Member of the International Association of Computer Science and Information Technology (IACSIT) Singapore and International Association of Engineers (IAENG) Hong Kong. His research focuses on technology ethics, security and Internet of Things.

Roohie N Mir, is a professor in the Department of Computer Science & Engineering at National Institute of Technology Srinagar, India. She received B.E. (Hons) in Electrical Engineering from University of Kashmir (India), M.E. in Computer Science & Engineering from IISc Bangalore (India) and Ph D from University of Kashmir, (India). She is a Fellow of IEI, IETE, a senior member of IEEE, member of IACSIT and IAENG. She is the author of many scientific publications in international journals and conferences. Her current research interests include reconfigurable computing, mobile computing, security and routing in networks.

Mohammad Ahsan Chishti, has done his Bachelor of Engineering and M.S. in Computer and Information Engineering from International Islamic University Malaysia with specialization in Computer Networking. He has received his Ph.D. from National Institute of Technology Srinagar, India. Presently he is working as Assistant Professor and Head of the Department of Computer Science & Engineering, National Institute of Technology Srinagar, India. He has more than 50 research publications to his credit and 8 patents with two granted International Patents. He is a Young Scientist awardee from Department of Science & Technology, Government of Jammu and Kashmir for the year 2009-2010 and IEI young engineer awardee 2015. He is Senior Member-Institute of IEEE, Member IEI, Life Member CSI, and Member IETE. He is a certified White belt in Six Sigma by Six Sigma Advantage Inc. of USA (SSAI).

E-mail address: sahilsholla@gmail.com, naaz310@nitsri.net, ahsan@nitsri.net