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Smart city as a smart service system: Human-computer interaction and smart city surveillance systems

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A R T I C L E I N F O

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A B S T R A C T

Smart city services, smart applications and smart devices form an ecosystem of tools and artifacts that challenge, and times even disrupt, conventions, norms, and rites of behavior, thus prompting diverse behavioral changes at the level of the individual, the group, and the society at large. In this view, smart city may be viewed as a – one of its kind – laboratory to query the complex human-computer relationship from a multi-dimensional perspective. By adopting this perspective, this paper queries the existing smart city surveillance systems to identify their key limitations and sources of frequently justified controversies. It is argued that to bypass these – *first* – the value of mesh-technology should be explored. It is also argued that – *second* – it is necessary not only to bring citizens back in the discussion on smart city, but also to highlight the mechanisms by means of which they might be involved in the co-design of smart city solutions and in urban decision-making. To bridge these two imperatives, smart city is conceptualized as a smart service system and, consequently, a wireless integrated mesh-technology enhanced (WIMTE) smart city surveillance system is elaborated.

1. Introduction

Smart city services, smart applications and smart devices form an ecosystem of tools and artifacts that challenge, and times even disrupt, conventions, norms, and rites of behavior, thus prompting diverse behavioral changes at the level of the individual, the group, and the society at large. In this view, smart city may be viewed as a – one of its kind – laboratory to query several dimensions of the complex human-computer relationship that pragmatizes in the process of the making and the functioning of the smart city on a daily basis. The reference to computer in this case denotes a broader approach to computer as the signifier, and the embodiment, of technology and its inroads in the fabric of the society. The examination of the human-computer interaction (HCI), the two-way information transfer between human and computer-enabled smart systems (Chang et al., 2018; Lytras & Visvizi, 2021), in the urban context requires therefore that several methodological and conceptual questions are addressed (Karvonen et al., 2019; Streitz, 2018). These include such questions as: how to systematize the variety of issues and processes that unfold at the intersection of the human-computer interaction, how to explore diverse aspects of the ecosystem in which this relationship unfolds, what hierarchy to apply to the multiple agents occupying and making the smart city space, how to validly put relevant research results together, and eventually, how to feed these results and findings in the decision-making process.

The objective of this paper is to address this composite research problem by taking a closer look at the frequently contested smart city surveillance systems. To this end, the argument in this paper is driven by two imperatives. *First (Imperative 1)*, considering that the scope of streaming video and data in conventional smart city surveillance systems is limited and, essentially, does not lend itself to active real-time monitoring and assessment of risks, threats, and infrastructure maintenance needs in cities, it is imperative that new solutions bypassing these limitations are sought (Cilfone et al., 2019; Parvin, 2019; Regazzoni et al., 2010). *Second (Imperative 2)*, considering the pace at which technology permeates the city space, thus fostering the process of cities transitioning to smart cities, it is imperative that the resultant human-computer interaction be rethought, re-examined and re-learned, in view of restoring the centrality of citizen in smart cities design,

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decision-making and policy-making.

To address the limitations of existing smart city surveillance systems (Imperative 1), the adoption of a wireless integrated mesh-technology-enhanced (WIMTE) security apparatus is proposed. WIMTE systems can help urban decision-makers in the management challenges, risks and threats in contemporary smart cities. Hence, a case for a geographically distributed but integrated, i.e., WIMTE smart city surveillance system is made. It is argued that the mesh technology-enhanced solutions allow for a simultaneous, rather than sequential, streaming of data to multiple clients. Therefore, within a specific geographical space endowed with a certain connectivity capacity, the geographically distributed, yet integrated, surveillance system subcomponents acquire the capacity to surveil, stream, and assess risks and threats in real time. This mesh-technology-enhanced streaming capacity coupled with integrated situational assessments of risks and threats across the integrated subsystems can be employed to develop the capability of unsupervised learning by each of the subsystems and the entire system. The situational assessment of risks and threats derives from, and is based on, a clear delineation, and thus accurate #tagging/#annotation capacity, of the concepts of risks and threats. The capacity to evaluate and recommend necessary response, both in terms of tools and policies, is ingrained in the system.

To explore the evolving human-computer interaction and to investigate the active role of citizens in contemporary decision-making (Imperative 2), smart cities are reread as smart service systems according to a socio-technical view that analyzes the impact of technology in the co-creation of economic, social and cultural value. It is argued that, on the one hand, the traditional top-down approach to the adoption of technology in the domains of safety and security creates valid concerns that civic rights and freedoms may be compromised. On the other hand, it does not promote either innovation, or increased efficiency, usability, and utility of smart city surveillance systems. To address this issue, collaboration between the end-users and the providers, i.e., citizens, vendors and the public sector/the municipality would be needed (Clarinval et al., 2020; Lytras et al., 2021; Lytras & Visvizi, 2018). Approaching smart city from the conceptual angle of the smart service system (Barile & Polese, 2010; Lim & Maglio, 2016; Spohrer et al., 2007; Maglio & Spohrer, 2008), allows to bridge and bypass these concerns Through the lens of service science, cities can be explored as complex systems in which the active engagement of people, through human-computer interactions and information sharing with organizations, can lead to the co-development of innovative solutions for the well-being of all the stakeholders in the system. The adoption of a systems perspective emphasizes the need to study how digitalization in urban contexts can improve not only the technological progress of a city but above all people's lives by employing a human-centric approach, as suggested in extant research on smart cities (Feher, 2021; Ho, 2017; Pali et al., 2020).

The remainder of this paper is structured as follows (see Fig. 1). Section 2 elaborates on the conceptual framework, in which smart city is depicted as a smart service system. In the following step, the caveats, challenges, and concerns relating to smart city surveillance systems are discussed. In section 4, the model solution designed to bypass the limitations of the existing smart city surveillance systems, i.e., WIMTE, is introduced. Section 5 elaborates on WIMTE system configuration. The discussion introduces a multi-layered framework that assesses how WIMTE can redefine citizens' attitude, interactions and behaviors. Conclusions follow.

2. Smart city as a smart service system

Smart service systems (Lim et al., 2016) are defined as the interconnection of people, technology, organizations, and information, which are synergistically integrated through so called 4Cs, i.e.,

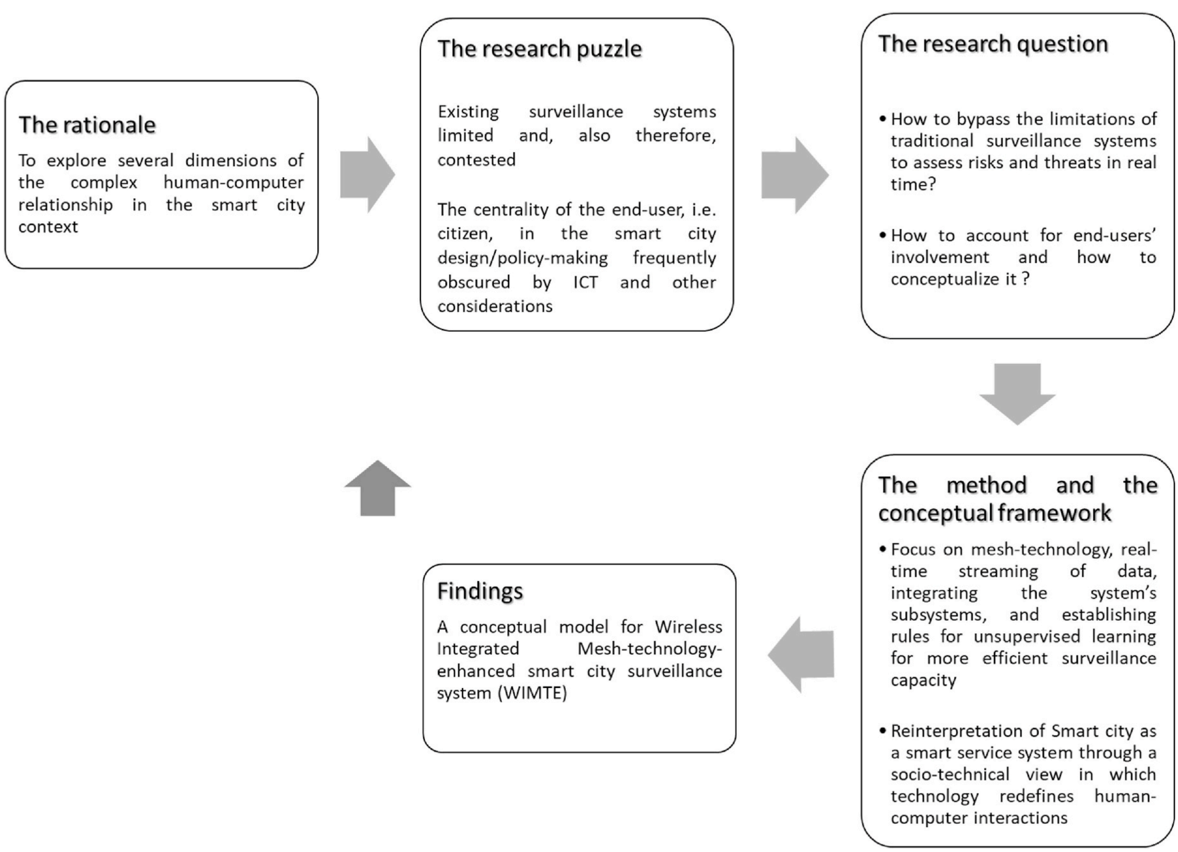

Fig. 1. The research model.

connection, communication, collection of data, computation (see Fig. 2). In other words, smart service systems constitute networked groups of actors, including people and organizations, whose interactions are strengthened and intensified through the proliferation of points of contact, or technological channels, referred to in this conceptual approach as *things*. Information and communication technology (ICT) can boost the already existing multi-layered relationships (*connections*) between the so defined actors and between actors and technology (human-computer interactions) by enhancing the velocity of *information* exchange and the transparency and efficiency of *communication*. ICT-enhanced tools and solutions enable continuous collection of data (*data collection*), which if managed appropriately (Lytras et al., 2021), allows to extract information and new value from the data set thus collected. The concept of smart service systems (Barile & Polese, 2010; Lim & Maglio, 2016, Spohrer et al., 2007; Maglio & Spohrer, 2008) allows to explore the active engagement of people, who through human-computer interactions with organizations can co-create value and innovative solutions. In this way, the prospect and the capacity of fostering the system's innovation improve (Davis et al., 2011; Edvardsson et al., 2015).

Recent approaches to the study of the smart city suggest the value of viewing the smart city from a three-tiered perspective, i.e., as an analytical concept; as an artifact; and as a policymaking objective. In this reading, the smart city turns into the key venue in which information needs to be managed both efficiently and sustainably (Lytras et al., 2021). The process of managing information in the smart city efficiently and sustainably requires that the mechanisms that bring the city inhabitants, i.e., people/citizens and organizations (businesses and other), together – and allow them to engage in a meaningful and constructive/innovative ways – are identified and examined. Considering the multi-layered and networked nature of the smart city (Visvizi et al., 2018) as well as the salience of the 4Cs, i.e., relationships/connections, collection of data, information processing/computing, and information sharing/communication, for the functioning of the smart city, it is valid to conceptualize the smart city as a smart service system (Lim et al., 2016; Lim and Maglio, 2019). In this reading, a smart city represents a complex set of actors (people and organizations), each striving to accomplish different needs and interests, and each endowed with different capabilities. These actors are related to each other through ICT-supported smart city-specific infrastructure that enables the 4Cs through the development of complex human-computer interactions. Conceptualizing smart cities as smart service systems allows to shed light on the transformative role of ICT (Akaka et al., 2019) and information management (Lytras & Visvizi, 2021) in the regulation and coordination of interactions/relationships that unfold among the smart city actors. Moreover, by applying the lens of the smart service system to the study of the smart city directs the search light on the mechanisms that facilitate/hamper efficient ways of addressing emerging challenges and nascent threats that smart cities face (Visvizi & Lytras, 2019). Specifically, the smart service system approach highlights the key role of

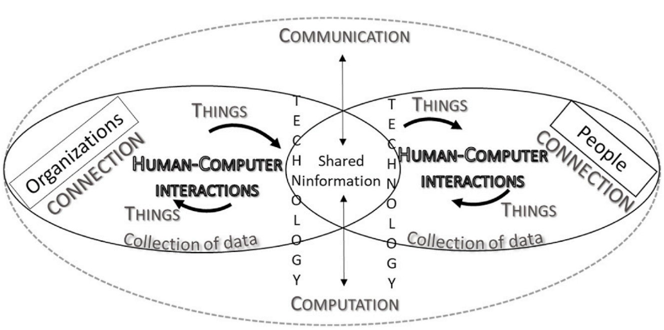

Fig. 2. Smart Service Systems: key dimensions (adapted from Troisi et al., 2020a).

data collection, information generation (computing), information sharing, and communication for the functioning of the smart city. However, it also suggests the necessity of investing in relationships' building and bottom-up modes of collaborations among organizations and people/citizens. It also suggests that diffused value creation strategies may trigger the creation of new knowledge, new communication modes and practices, and eventually, innovation (Azoulay & Jones, 2020; Rees et al., 2020; Malik & Janowska, 2018). The exploration of how technology redefines human-computer interaction in smart cities-reinterpreted as smart service systems-permits to identify the new forms of interactions that can be developed and co-developed within the city for future smart environments (McKenna, 2020). Smart cities are multidimensional systems that can transform themselves and generate innovation and social changes through bottom-up collaboration among users. The investigation of value co-creation is one of the emerging trends in smart cities literature. As noticed by Zandbergen (2017), over the last years European policy makers introduced the transition from top-down urban planning to co-creative city making in which citizens become active co-makers through the use of empowering technologies.

The systems perspective adopted in this study aims at exploring how the implementation of integrated wireless mesh technology can redefine human-computer interactions in smart cities considered as systems by enhancing user's decision-making and helping cities pre-empt risks, survive crisis and develop resilient attitude. The proposition of an integrated system based on wireless mesh technology in urban smart service systems can allow at investigating: 1) how WIMTE can activate human-technology interaction and enable diffused decision-making and bottom-up collaborations among users; 2) how collaboration and co-creation can lead to the development of innovative solutions in the city. Hence, the thrust of the argument developed in this paper is that the processes of bottom-up communication and collaboration are pivotal for the smart city sustainability. Sustainability in this context also implies safety, inclusion and resilience (Visvizi & Perez del Hoyo, 2021; Polese et al., 2021).

The implementation of an integrated set of technologies for safety and security based on multiple surveillance can introduce significant changes in human-computer interactions, in citizens' behavior and in the resources integration among actors by leading them to co-create new value and to co-develop new social practices, rules and meanings (Polese et al., 2020), by increasing social capital and improving sustainability.

Thus, the reinterpretation of cities as smart service systems allows at emphasizing the social factors embedded in urban ecosystem and to adopt a socio-technical view on smart city (Nam and Pardo, 2011) that seeks to overcome the technocratic reductionism that led extant research on smart cities to overestimate the role of technology in the creation of cities' well-being (Söderström et al., 2014).

Moreover, reframing smart cities through a systems perspective is in line with a participatory-centric approach (Borda and Bowen, 2019) that explores urban contexts through collective model in which technological advancements are explored as enabling factors enhance systemic capabilities aiming to enhance competitiveness, effectiveness, quality of life and sustainability and innovation and smart culture.

What follows is that by conceptualizing smart city as a smart service system allows us to bring the individual, the citizen and the society back in the conversation on smart city services. Therefore, it is also possible to validly claim that people/citizens should and may be involved in the development and functioning of smart city surveillance systems. While this section suggested how to reconcile this plea at the conceptual level, the following two sections highlight the technical, empirical ways in which this can be done.

3. Surveillance operations in cities: challenges and technological advancements

Prior to the current explosive growth of urban areas, streets and public spaces used to be manned by police personnel and neighborhood residents. At present, cities opt for Video Surveillance (CCTV: Closed Circuit Television) as an essential tool to augment police force and community watches. The visibility of surveillance cameras in public spaces, in and of itself, is perceived as a deterrent for aberrant behavior. Criminal behavior studies refer to this phenomenon as "situational crime prevention" strategy that psychologically heightens the odds of arrest for intending or would-be offenders (Clarke & Homel, 1997). CCTV networks are also employed to monitor irregularities in transportation channels, city roads, airports, water supply networks and various infrastructure components. They function as a "workforce multiplier" that extends government and law enforcement footprint, thereby reducing response time needed to tackle problems (Armitage et al., 1999). Crime rates have dropped significantly in the United Kingdom (UK) upon the adoption of CCTV systems in various cities (Welsh & Farrington, 2002). Research in both the UK and the US reported statistically significant crime reductions due to the visibility of surveillance video cameras in parking lots and public transit facilities (Cameron et al., 2008; Welsh & Farrington, 2004). However, sustaining the effectiveness of CCTV in surveilling public spaces requires massive city-wide deployment of fixed location cameras and unfailing vigilance of human operators to monitor and report incidents to first responders. Studies have cited various factors that may hinder the efficacy of CCTV systems such as information overload, partial visibility, distractions, and human fatigue (Knight, 2008).

Currently, security and emergency operations in most cities depend on disconnected communication networks that include landline, cellular and mobile radio networks. During emergencies, these networks get overloaded and become unable to provide adequate services especially that physical infrastructural components can be compromised by natural or man-made events. Bandwidth and overall functionality of conventional networks could be impacted and may not be sufficient to process intensive multi-media applications such as high-resolution video sharing amongst security and recovery personnel. Automation and integration of auxiliary devices with CCTV would improve the detection and deployment of the necessary resources. Hence, the following part of this paper examines a range of high-tech solutions that integrate fixed/mobile surveillance instruments and wireless web-based technologies that potentially enhance situational awareness, access control, analysis, and decision-making process by intensifying human-computer interaction (HCI).

The keywords that define smart surveillance networks are: effective data aggregation, seamless integration/transmission across wired and wireless channels and meaningful data analytics. Effective aggregation refers to the network ability to receive live and recorded video streams from multiple sources, which may originate from either fixed location cameras or onboard vehicle cameras. Seamless integration/transmission signifies the capacity of the networks to deliver bits of data from different sources across wired and wireless nodes with consistent roaming at high speeds. Meaningful data analytics automate the process of identifying the nature of incidents, analyze contextual parameters and interpret findings into useful information, based on which first responders could effectively identify and deploy required resources. Various cities around the world have established the infrastructure and gradually but surely adding the building blocks of smart surveillance networks (Valera & Velastin, 2005). The city of Nice, France, has pioneered a smart parking pilot with a four-layer architecture. The first layer consists of sensors and networked devices. The second layer includes data receptors and processors distributed at different points across the city. The third layer accommodates central data repositories and analytics. The fourth layer provides the wireless mesh network that streams all kinds of data across the entire system (Mitchell et al., 2013).

Smart surveillance networks help synchronize public agencies and law enforcement decisions in command centers with real-world emergencies to improve preparedness and effectiveness in tackling problems. They include a network of nodes and transmitters that consistently stream video and data from node to node at high speeds. Using artificial intelligence capabilities that overlay real-world and stored data in command centers repositories, video and data analytics platforms automate the process of analyzing and identifying resources needed to tackle emergencies. The latter processes culminate in sending such interpretive and meaningful reports to first responders who could effectively proceed to deploy resources required to deal with problem area, crimes and/or emergencies (Fadel et al., 2015). Thus, smart network components must include an intense multisensory capacity through a large number of fixed and mobile surveillance sensors, wireless mesh networks and video/data analytics platforms (Fig. 3).

The understanding of the different surveillance solutions as an integrated system (see Fig. 3) based on fixed/mobile surveillance instruments and wireless web-based technologies can shed light on how contemporary cities should reframe urban layout to comply with the demands of the technological evolution. Adopting a system view to identify the new surveillance enabled technologies contributes to explore the role of citizens' participation and bottom-up innovation in smart cities safety and security.

Extant research identifies a series of integrated systems to fight Covid-19 through advanced systems for surveillance that not only enhance public security and well-being but boost human-computer interaction in real-time. For instance, the combination of infrared cameras and the facial recognition system is able to detect any individual with high temperature and whether or not the person is wearing a mask (Chun, 2020). Robots equipped with AI have been developed in China to reduce the potential risk of exposing authority to Covid-19 while conducting manual measurement of body temperature. Through 5G, high-resolution cameras and infrared thermometers these self-driving robots can scan the temperature of 10 people simultaneously in 5 m. The system warns the authority when a person with fever or without a mask is detected (Pollard, 2020). First, faces in the video are detected through a detection algorithm and, secondly, the face will be searched in the data center. This system can detect, extract features, and recognize a face from inputs taken by camera or video automatically (Inn, 2020, p. 841; Moorthy et al., 2020). In this way, the communication of government and health agencies with citizens is boosted and accelerated, by reducing costs and time and increasing the possibility to receive medical care immediately.

Moreover, AI is employed in the optimization of transportation operations, which can not only help the monitoring and management of traffic flow in cities but can also enhance connectivity. For instance, smart intersection technologies can include areas of high traffic that leverage connectivity and AI-based automation to monitor and manage traffic flow based on real-time data to reduce the time wasted by road congestion. Connectivity will enable smart traffic management platforms to gather data directly from vehicles, rather than relying on traditional traffic actuation methods. Consequently, the intensification of HCI and of stakeholder collaboration can enable the integration of various automotive services into smart traffic management, by providing enhanced convenience for vehicles by using smart parking services. In this way, technological, economic and relational benefits can be gained.

Moreover, a wireless mesh architecture can support decision-making during crisis by enhancing information flows and improving disaster recovery communication. The interconnection of multiple devices that increases the real-time interactions between different stakeholders can help monitor public safety and detect incident (Portmann and Pirzada, 2008). The multiplication of information sources permits to provide timely information on public safety. However, despite the proposition of a series of advanced systems to improve smart surveillance, previous contributions on smart cities calls for further investigation on the redesign of the relationships between people and technologies (Kuzmann, 2020) and on the identification of new strategies to involve citizens in diffused decision-making and policy-making (Costa & Peixoto, 2020).

To account for these issues, this paper views the smart city as a smart

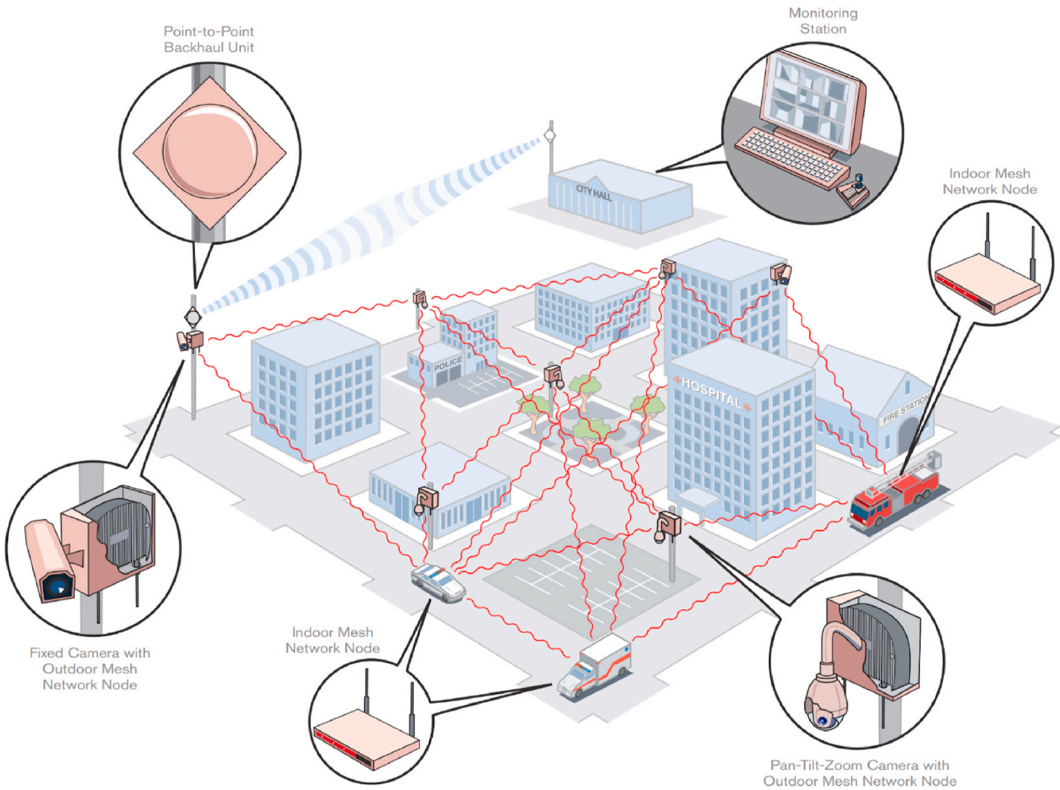

Fig. 3. Smart municipal video surveillance system (BearCom 2010).

service system. This approach allows to shed light on the question of how the development and acceptance of innovative solutions in the domain of smart city surveillance can be co-created and fostered through the active collaboration of each actor in the system. The conceptualization of smart cities as smart service systems allows detecting the different kinds of technologies and human behaviors (intentions, attitude, citizens' digital competencies and willingness to use technology) that can act as key enablers for the creation of new rules to coordinate exchanges and interactions and for the transformation of crisis into opportunities, innovation, and social change.

4. A wireless integrated mesh technology-enhanced (WIMTE)

The reconceptualization of the city as a smart service system should

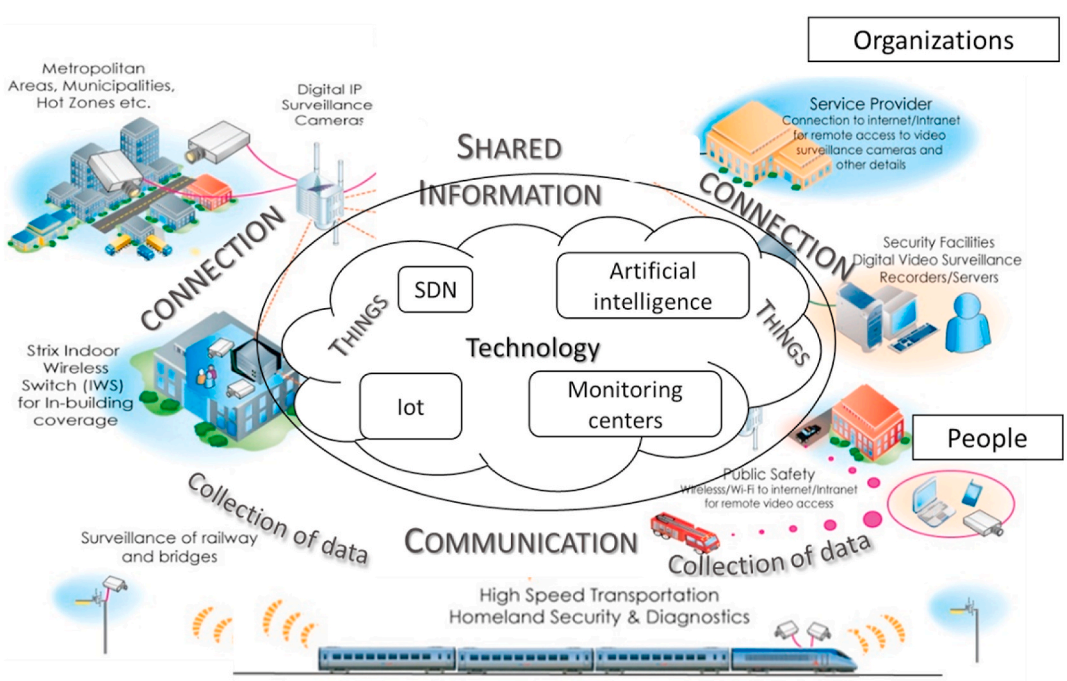

Fig. 4. An integrated model for WIMTE: smart cities as smart service systems (adapted from: Strix Systems, 2020).

be seen as a response to the pace at which technology permeates people's lives and the imperative to make cities inclusive, safe, resilient and sustainable. Service science can be used as an interpretative lens to ascertain: 1) the integrated set of technologies that can enhance safety and security in cities through key tools, such as multiple surveillance systems and wireless mesh technology; 2) the transformation introduced in human-computer interaction (HCI) and the improvement of communication; 3) the impact of these transformations on individual and organizational behaviors.

Starting from the integrated perspective introduced in the previous paragraph, a wireless integrated mesh-technology-enhanced (WIMTE) security apparatus can be proposed (Fig. 4). With the enhanced connectivity and system intelligence, WIMTE will enable city authorities to effectively deal with the quantitative and qualitative shift in challenges, risks and threats that cities and their inhabitants face today. The inherent diffused decision-making process afforded by WIMTE can result in societal transformations and enhanced sense of collective and personal responsibility amongst urban citizenries. The development of WIMTE, which by definition is a participatory framework, can guide decision-makers toward the implementation of faster decisions, policy-makers towards a more effective planning of smart cities and citizens towards the participation in the co-development of innovative solutions. Through the creation of a multi-leveled network the dialogue between public actors can be established to reach consensus on social issues, build commitment, share the management of urban planning, design and policy-making and to empower individuals to address problems and to set priorities. In this way, through interaction, negotiation and partnerships each actor in the system can share its viewpoints, make more informed judgments and commit to public decisions by co-creating the development of mutual learning in the city.

The exploration of the key enablers for a real technological change in cities infrastructure can be addressed through the lenses of Service Science. In particular, the concept of smart service systems seems to be suitable for an in-depth investigation of how innovative solutions for citizens security and safety can be pursued systematically using new technologies and enhanced information flows that, by means of learning-based mechanisms and diffused communication and decision-making, can encourage social innovation and enhance cities' resilience.

The conceptual model for WIMTE introduced in this work encompasses three interconnected operational stages: 1) to detect, record, and transmit a wide range of video and audio signals in addition to other critical sensory information such as temperature, smell, and smoke; 2) to collect information from video, audio, and other environmental sensors to be sent to central station servers that perform high-level data aggregation, computation and analysis. The automated video analytics performed in the second stage represent a major breakthrough in data fusion and integration of information from different sources. Events are analyzed in real time to help with crime prevention and mitigation in addition to the commonly performed post-event video forensics; 3) to build a communication network that ensures timely and reliable transmission of information to first responders and other security personnel involved in public safety and crime control. The objective of such sophisticated security apparatus is not only to apprehend offenders but rather to deter and prevent crimes from happening in the first place. WIMTE as envisioned in this research will provide a versatile and expandable service system at manageable infrastructure resources. It will offer incrementally expandable platform that could respond to the challenging demands of security operations in large metropolitan regions.

Effective governmental interagency communication is critical for WIMTE, which aims to connect various stakeholders (public and private) via high-tech surveillance technologies to create a smart service system that not only enhances security and public safety but contributes to infrastructure management and infectious disease control (Sayogo et al., 2020). The essence of WIMTE as a geographically distributed but wirelessly integrated mesh system is to facilitate real-time access to location-based data such as high-resolution maps, floor plans, and infrastructural assets at incident sites. Situational awareness could be tremendously heightened by the ability to send and receive live video streams and other critical data that help analyze and reconstruct events. Detection, tracking and pursuance could go hand-in-hand in order to mitigate the negative impact of crime and disasters. WIMTE can offer tremendous potential in the mitigation and control operations during infectious diseases' outbreaks. Here the case of Covid-19 suggests that more flexible and more efficient solutions are needed if risks to public health are to be preempted and threats to citizens' health addressed swiftly. Consider this: biometric sensors in city public spaces would help in identifying, tracking and contact-tracing pandemic clusters. With the help of embedded intelligence about the nature of infectious diseases in the analytics servers, reports and mitigation strategies can be shared using wireless mesh networks in real-time with command centers, hospitals and first responders. The incremental buildup and interconnectivity of network clouds in shopping malls, worship centers, transportation venues, hospitals, industrial facilities, office parks, etc. would help in the detection of virus outbreaks, transmission of notifications/warnings and deployment of medical emergency/control resources.

And yet, despite the incorporation of some high-tech applications in cities today, the existing surveillance solutions are somewhat fragmented and do not offer real time data aggregation/integration needed to tackle infrastructure services and security risks/threats in cities. As a result, they do not learn, even if they could. If they could learn, the possibility of identifying risks and preempting them would increase. Hence, safety would be enhanced. The question is how to make it happen. On the one hand, there is the technical issue, i.e., how to connect the geographically distributed neural, but very real, networks. On the other hand, how to synchronize the real input of citizens and decision-makers to ensure that unsupervised learning follows some rules? The answers to these critical questions provide the impetus for the WMITE system configuration detailed below.

The integrated WIMTE model for surveillance depicted in Fig. 4 exploits the opportunities offered from interactive technology for situational awareness, real-time access and for the intensification of human-computer interactions. Multiple surveillance and sensory instruments could be integrated into comprehensive networked systems that allow wireless real-time viewing and communication, video analytics, and automated response/action capabilities. As opposed to fragmented high-tech applications in cities today, smart information solutions, dubbed as Internet of Things (IoT), aim to advance scalable networks that gradually but surely embed intelligence into city physical spaces. With the help of multisensory capacity, AI (Artificial Intelligence) evolving cognition capabilities and wireless real-time/broadband connectivity, the proposed WIMTE will not only enable smart cities to deter/reduce crime rates (Hassan et al., 2021), but also optimize transportation operations, enhance infrastructure services and improve city resiliency in the face of infectious decease pandemics. AI can facilitate real-time epidemiological data collection, risk-assessment, decision-making processes, and design/implementation of public health interventions. Moreover, AI-based tools can enhance the recognition of specific diagnostic and prognostic features and the identification of already existing drugs/discovering new molecules by fostering the development of healthy, smart, resilient cites and designing new standardized protocols for sharing data and information during emergencies (Bragazzi et al., 2020; Xiao et al., 2018). When AI and machine learning merge with distributed cloud, practical blockchain, system software automation, and AI speech recognition, the health monitoring systems enable the creation of a reliable remote monitoring system between patient and doctor.

As an integral component of broadband internet applications today, wireless mesh network (WMN) is structured as a topological mesh of large number of nodes with ad hoc combinations of smart two-way transmission devices. The latter could be fixed, portable and/or nomadic stations (desktops, laptops, handhelds, video devices, sensors, etc.) as well as a system of routers and gateways that create a wireless broadband mesh cloud with connective versatility across multiple networks such as worldwide web, cellular and other radio frequency-based devices (Redwan & Kim, 2008). In some mesh configurations, user nodes of WMNs double as both hosts and routers, which provides the network with a high level of redundancy and mobility. Software protocols are rapidly evolving and will allow the WMNs to host unlimited number of clients without loss of efficiency and/or time delays. As more users (nodes) are connected over the network, the reliability, coverage and bandwidth of the mesh cloud increase; the users' devices themselves are the network (Fig. 5).

WMNs host a wide array of stationary and/or roaming client nodes over multi-level connectivity platforms that include point to point inside/outside buildings, neighborhoods, and cities (Blais, 1996). Nodes of the wireless mesh have the capability to sense the presence of other nodes in the same coverage area and automatically create bigger networks. Data hops from one device or node to another until it hooks with a destination node. The network can expand at will and adapt to ad hoc increments of nodes with unique self-organizing capabilities. Integrating cellular and web technologies with WMNs provides unlimited application potential (Akyildiz et al., 2005). By tapping into a variety of networks and platforms with readily available infrastructure resources (towers, cables, satellite connections, etc.), WMNs can be employed in a wide range of emergencies, disasters infrastructure and pandemic control programs (Jun & Sichitiu, 2003; Seth et al., 2010; Portmann & Pirzada 2008). The mesh architecture is configured in three types: infrastructure, client and hybrid. The infrastructure mesh (Parvin, 2019) (Fig. 6a) incorporates passive client nodes that communicate through Ethernet interfaces connected to mesh routers. Conventional client nodes (e.g., phones, desktops, laptops, PDAs, etc.) and the mesh router optimally operate under the same radio range. In the case of different radio frequencies, client nodes use the Ethernet to reach mesh routers via an intermediate communication with the base server station. The second WMN configuration is based on peer-to-peer connected client nodes. Each and every node in the network acts as a host and transmitter with no mesh routers mediating the reception/transfer process of data packets. The third WMN type offers a hybrid architecture in which the mesh clients act as both hosts and routers and together form the backbone of the entire operation (Parvin, 2019) (Fig. 6b). It is simply a large network of smaller networks with a routing function that transfers data packets between the different networks. As a way of example, the devices inside command centers form a network of nodes that host/route data packets internally and use dedicated mesh routers to connect externally to other networks of handhelds in the possession of field operators and first responders. The research on wireless mesh networks is rapidly developing the cryptosystems and security parameters required for resolving confidentiality and privacy issues (Cilfone et al.,

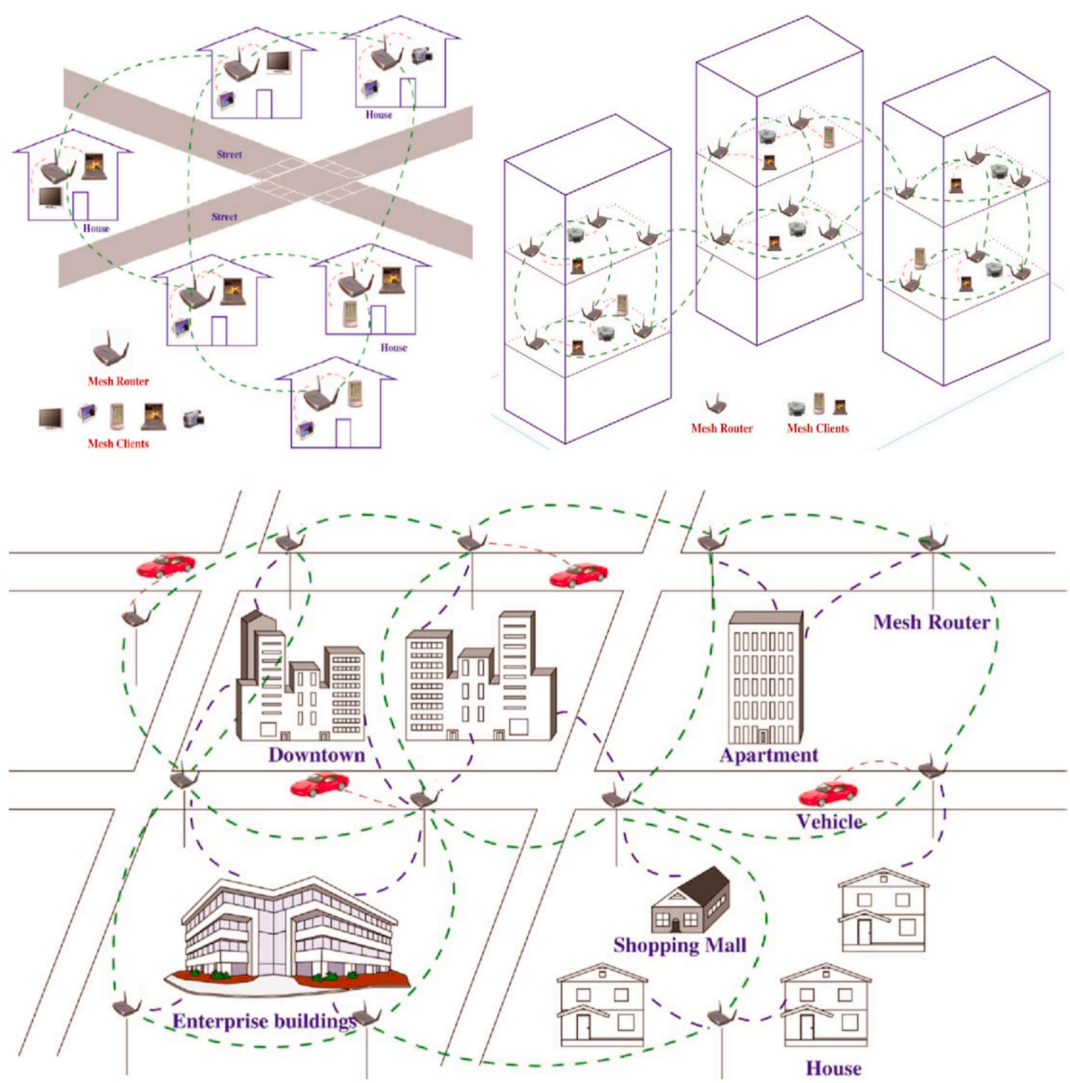

Fig. 5. WMNs infrastructure for Community, Enterprise and City-Wide (adapted from: Akyildiz et al., 2005).

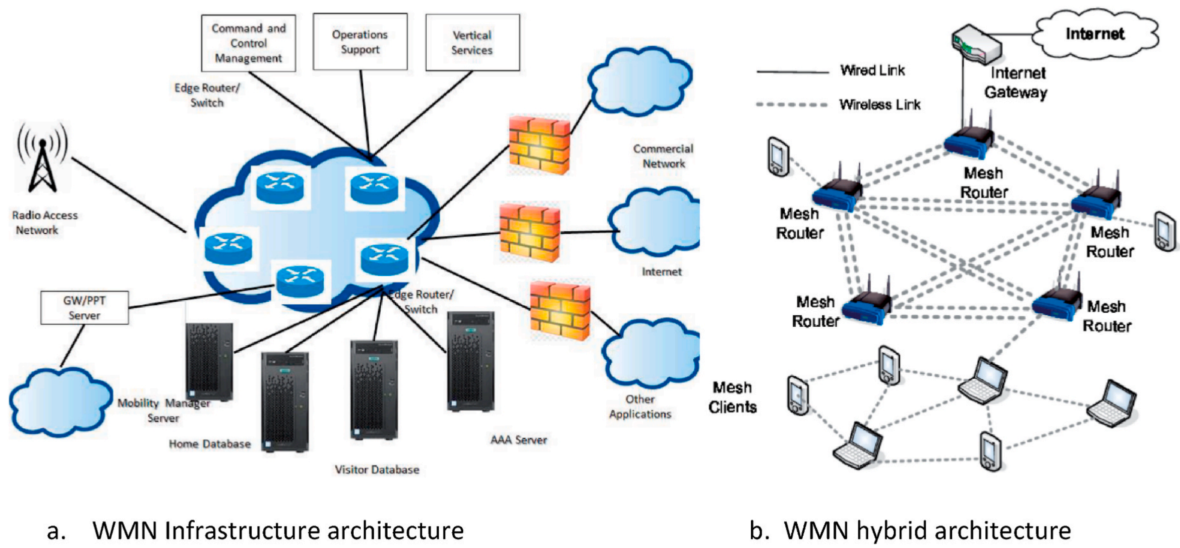

Fig. 6. WMNs architecture configurations (adapted from: Parvin, 2019).

2019).

A flexible communication between nodes boosts the architecture of wireless mesh networks that can collect and extract data automatically from different interconnected sources, that range from monitoring centers to healthcare organizations to citizen's personal devices and public transportation systems. In this way, the enhanced connectivity between the actors in the system through a set of interrelated touch-points can improve the sharing of information and the transparency of communication within the entire city. The creation of a network of interactions between actors and technology (HCI) and among diverse groups of actors can offer multiple benefits to the various stakeholders: 1) to government, that receives real-time information on the evolution of pandemic and on citizens' acceptance of technology and restrictions; 2) to citizens, who can be always in touch with public administration and with other citizens to share relevant information on the evolution of pandemics and on contagion; 3) to private and public organizations, that can find more easily the people who need assistance, medical cares or general services. The constant connection between the stakeholders in the city, the transfer of information in the digital networks and the creation of a real-time system for prompt and transparent communication can increase citizens participation to the public space by involving people in decision-making (Mainka et al., 2016) and encouraging, in this way, the emergence of bottom-up innovation and of co-created solutions. In this way, it can be noticed that co-creation can lead to the attainment of multiple economic, cultural and societal values (such as actor's commitment and attitude, Akterujjaman et al., 2020). The continuous collection of data in WMNs permits not only to monitor users' and citizens' behavior but to orient people's attitude toward technology and willingness to use technology and to improve the compliance with the governmental guidelines dictated by the Pandemic.

5. The reinterpretation of WIMTE in smart service system

The conceptual model introduced in Fig. 4 is obtained from the integration of the key enabling factors for value co-creation and innovation in smart service systems and the main stakeholders and technology for smart cities surveillance in WIMTE system. The *actors* in the system are: 1) service providers (*organizations*): offer cloud storage environment for large scale data storage to run complex video analysis algorithms and to adapt the system dynamically to user and computation needs; 2) public space, hospitals, and transportation system (*organizations*): channels, city roads, airports, water supply networks and various infrastructure components that work as a "workforce multiplier" that extends government and reduce potentially the response time needed to tackle problems; 3) users (*people*): final users that collect and examine the data offered from providers; 4) citizens (*people*), whose behavior in the smart city public space is observed. The smart city-reframed as a service system-can be viewed as a set of technologies, people and shared information and resources interconnected with multiple relationships, which occur at three different levels (Vargo et al., 2015): 1) *micro-individual level*: set of individuals with given intentions, attitudes, cognitive processes, value perception, skills and resources; 2) *meso-relational level*: networks of relational and social connections between groups of actors; 3) *macro-collective level*: the general community (public administration, institutions, legal system, etc.) in which the co-created value can be translated into new meanings, social practices and culture. Hence, value co-creation and the co-development of new value, new practices, innovation are dynamic processes arising from the combination of multi-levelled transformations at individual, relational and collective levels of exchange (Polese et al., 2020).

The *connection* between people and organizations is ensured through *things* such as security facilities that simultaneously process real-time information communicated from innumerable sensors and integrate them with batch data stored in diverse locations. The enhancement of connections between actors can boost human-computer interactions by emphasizing the influence of technology on individuals (users-people), organizations (service providers), and society (public space and citizens). The creation of an interconnected technology ecosystem for surveillance permits the development of new interaction techniques for supporting user tasks, providing better access to information, and creating more powerful forms of communication. The intensification of HCI involves the general improvement of input and output devices, of the interaction techniques that use them, of how information is presented and how the computer's actions are controlled and monitored, of the tools used to design, build, test, and evaluate user interfaces. Moreover, wireless technologies allow the creation of a system of routers and gateways that create a wireless broadband mesh cloud with connective versatility across multiple networks such as worldwide web, cellular and other radio frequency-based devices. The constant connection between people and organization and the establishment of a real-time integrated system for transparent communication increase actor's engagement in the public space and in decision-making by involving people in the dynamics of urban government. In this way, not only users' and citizens' behavior can be monitored but people's attitude toward technology, changes and the entire cities and their intention and willingness to use technology and to comply with the governmental guidelines dictated by the Pandemic can be observed.

Technology consists of a set of creative and integrated high-tech systems that aids in access control, intrusion detection, and warning/notification systems for various kinds of problems. Fixed and mobile surveillance instruments could be integrated into comprehensive networked systems that allow wireless real-time viewing and communication, video analytics, and automated response capabilities. The application of wireless mesh technology can foster the creation of smart solutions in various cities across the globe. Instruments like Iot (Internet of Things) and SDN (Software-Defined-Networking) foster dynamic and programmatically efficient network configuration in order to improve network performance and monitoring, through a series of mobile devices and content and the cloud services. Artificial intelligence systems can boost the analysis of audio and images from video surveillance in order to recognize humans, vehicles, objects and events and can provide and tools that allow analytics platforms to gather data and realize deeper and smarter decision-making that analyze and predict object/human behavior changes. AI can have a great potential for the management of Covid-19 and other emergencies, since it can track the spread of the virus in real time and plan public health interventions, monitor their effectiveness, identify potential vaccine candidates and improve the response of communities to the ongoing pandemic. These emerging approaches can be exploited together with classical surveillance: if the latter enhances data analysis and interpretation, the former uncovers hidden trends and can be used to build predictive models.

Together with AI, machine learning can generate, capture, store and analyze data using algorithms to detect and prevent the spread of the pandemic, diagnose cases and monitor vaccine development (Alimadadi et al., 2020). Smart city is included in an interconnected urban society; hence, collecting data continuously from several embedded devices can permit cities to effectively work with machine learning during the pandemic. Machine learning techniques produce useful insights to help smart cities decision makers to take preventive measures. In New York hospitals, for instance, to speed up the decision of the medical staffs, machine learning system is developed to provide support to triage patients (Spectrum, 2020). In China, the embedded intelligent systems process data and track people's location through video surveillance. Information is stored in a central database in which the machine learning algorithms runs the data to estimate the possible social interaction of the person that leaves the residential building (Dingli, 2020). These algorithms range from traditional shallow approach (neural network, decision tree, Naive Bayes, K-nearest neighbor) to more sophisticated algorithms such as Convolutional Neural Networks, Deep Generative Modeling.

Shared information synthesizes information from multiple sources and effective two-way live streaming of events and summative analytical reports. Users can transmit live and recorded video data across various fixed and mobile ends. Secured data repositories in the service provider network ensures that event details and reports can be retrieved and shared via different wireless communication channels.

Data collection permeates the entire system, in which analytics software coordinate the video/audio streams and sensory data and generates aggregate situational awareness reports to be conveyed via real-time multichannel *communication*. The receiving ends of such reports include fixed monitoring stations in offices or other mobile communication devices in the field (laptops, phones and other digital transmitters).

The dynamic combination of the dimensions of smart service systems can give birth to the co-creation of innovation and growth for the entire city by spreading in the system a constant innovative tension for social change, re-configuration and proactive co-evolution. Therefore, detecting the technological changes introduced by Pandemic in the relational modalities and the interactional patterns among people mediated by technology allows at identifying the enablers for the management of sanitary emergency.

The model depicted in Fig. 4 permits: 1) to analyze how the different combination and remodeling of actors, interactions and relationships due to the different use of smart technologies for surveillance can enable cities, conceptualized as service systems, to challenge "emergency"; 2) to detect how the readaptation of real-time communication and interactions between users in the systems can lead to the co-creation of innovative solutions to foster social changes and enhance the acceptance of the transformation caused by the Pandemic. The integration of technology and people (intended as human attitude and intentions at an individual level) can challenge social crisis and pandemic through the readaptation of interactions between users that can lead to the emergence of societal transformation and social changes in citizenship behavior through diffused decision-making (collective level).

6. Discussion: the impact of WIMTE on citizens' behavior

By adopting smart solutions and service systems, smart cities can bolster competitive advantage and living standards for their residents. To sustain economic growth, social cohesion and responsibility, and a reasonable level of equity amongst citizens, city governments and concerned organizations should invest in nourishing their human/social capital (Feher, 2021), natural ecosystems and provide rich opportunities for participatory governance (Ciasullo et al., 2020). Actors, stakeholders, and people at large, should be involved in the decision-making process as well as implementation and maintenance of smart city technologies. With a deep understanding of citizen concerns and needs, cities should offer a high level of transparency and technical skill training that allows different individuals with varying educational and cultural backgrounds to embrace the new technologies. End users should have some latitude in customizing smart applications according to their needs and objectives. The overall objective of smart systems should be to involve people not only as product consumers, but also contributors to the innovative powers of the smart city.

Personal data privacy and security is of paramount significance to accelerate the rate of people acceptance of smart systems. Through the effective deployment of "Blockchain" technologies in smart applications, individuals can be assured of the confidentiality and safety of their information (Lia et al., 2017). It will be necessary to maintain an equilibrium between total reliance on technology and people real needs and concerns. New rules and polices that regulate smart cities should consider issues of safety (perceived or real), citizens involvement in urban action and access to technological resources. Raising people awareness of the fine line between sharing and abusing private data of others is imperative for successful implementation of smart systems. Enhanced accountability measures of the digital realm can help individuals and groups to embrace smart systems as a significant contributor to quality of life. The degree of city smartness should be reflected in the long-term well-being of citizens and reduced negative implications of disruptive technological changes. Various cities across the world have initialized the deployment of mesh networks and utilized video analytics and multiple-sensor surveillance to improve safety and security. HP and Motorola have offered video surveillance solutions that avail of improved speed and technology of IP (internet protocol) and fastest 4G/5G wireless networks. Due to the widespread mobility of handhelds and enhanced display of devices, their solutions are gradually fulfilling the promise of integrated mobile video surveillance systems. HP/Intel VSS incorporates the analytical logic required for synthesizing information from multiple sources and effective two-way live streaming of events and summative analytical reports. Users can transmit live and recorded video data across various fixed and mobile ends. Secured data repositories in the service provider network ensures that event details and reports can be retrieved and shared via different wireless communication channels (Intel, 2009). Effective integration of these smart technologies in city services requires public and private partnerships, regulatory frameworks, government transparency regarding risks, threats and confidentiality of users' data and state-wide alliances between universities, research centers and citizen groups. Technological spinoff products of smart solutions include but not limited to utility robots, high-tech wearables and gadgets, self-driving vehicles, augmented and/or extended reality functionalities that will penetrate various social, economic, and cultural aspects.

The adoption of an integrated system of smart solutions for surveillance and the application of WIMTE in smart service systems can foster the redefinition of users' attitude (at an individual level) of human-computer interaction (at an intersubjective level) and of citizens' culture and behavior (at a collective level). Thus, as discussed in paragraph 5 with reference to the identification of the individual/relational/collective levels, the reinterpretation of smart cities as service system enables the adoption of ICT-enhanced smart city solutions that can monitor, predict and orient individual behaviour (intentions, attitudes, beliefs), intersubjective behaviour (citizens' digital competencies, interactions with technology and willingness to use technology) and citizen's collective behaviour (digital culture and adhesion to a smart mentality).

As Fig. 7 shows, the implementation of the conceptual model proposed in this work can enable: 1) the reframing of individual's orientation and attitude and the enhancement of users acceptance of technology (*orientation and attitude*); 2) the creation of new interactional and relational modalities based on social distancing through new technological solutions that can give birth (through *resources integration*) to the co-creation of new digital mind-set and to the enhancement of social trust (*co-creation of new culture and social praxes*). In line with the socio-technical view of smart cities adopted in this study, the conceptual model introduced below suggests that the smart city as a smart system not only can reproduce the social order, but also can produce new social categories (Pali et al., 2020).

At an individual level, the creation of an integrated systems for WIMTE can contribute to remove the traditional obstacles of technology acceptance and can strengthen, in turn, users' readiness to accept and use technology. From a psychological standpoint, users are encouraged to develop a positive attitude toward new technologies through the reduction of technology anxiety and privacy concerns about the misuse of personal data. In this way, the fear and uncertainty that lead actors to activate resistance to technological changes can decrease. The improvement of individuals' personal attitude toward technology (Hollands, 2008; Mora et al., 2017) and of their propensity to change their lives through human-computer interactions and social distancing can be intended as the key enablers of a wise application of smart technology and of a proper management of unexpected phenomena (Kunzmann, 2020) such as the global emergency dictated by Covid-19 Pandemic. Moreover, resistances to accept and use technologies can be removed through the enrichment of digital culture at a personal level by enhancing users' perceived usefulness of new technologies.

The dynamic resources integration between citizens and organizations is enhanced by human-computer interactions, which can allow the development of new interactional modalities between human and computer that encourage the co-creation of new social praxes and of a new digital culture (Troisi et al., 2020b). As the confidence in their ability to use technologies rises, citizens show a positive digital attitude, characterized by a great sense of belonging to the community and a high degree of trust in the opportunities offered from a shared use of smart tools.

Hence, the conceptual model supports the identification of the derivers of culture co-creation, which is described as one of the most critical factors that foster the achievement of economic growth and social cohesion (Hudson et al., 2017).

Social inclusion and the ability of government to involve citizens in the use of technologies by removing the obstacles to access infrastructure can enhance the general sense of belonging and the social trust in the bottom-up use of technology. In this way, an inclusive smart city can be realized to boost participation and bridge the digital divide by enriching the digital skills of both citizens and managers through the engagement of stakeholders and a diffused decision-making. The development of digital culture at a collective level (lack of diffusion of digital competencies from the government or unproper management of economic resources) can generate users' trust in technology infrastructure, in data use and above all in the collaboration between people through human-computer interactions. In this way, citizens can not only increase their perceived ability to use technology but are encouraged to adopt a collaborative mind-set based on the trust in data sharing and people's mutual support. The sharing of a cohesive digital culture within the entire smart city (both in providers and users) can stem from the bottom-up diffusion of technological tools, which can influence citizens' attitude and behavior toward technology and foster the acceptance of technological changes (Blignaut et al., 2002; Ramanathan et al., 2014). The support of cities management in the use of technology can reinforce citizens' positive perception of technology and improve its usability and adoption.

7. Theoretical and managerial implications

The study analyses how the different combination and remodeling of actors, interactions and relationships due to the different use of smart technologies for surveillance can enable cities, conceptualized as service systems, to challenge emergency situations, such as the spread of Covid-19. The investigation of the changes introduced in real-time communication and interactions between users in the systems can lead to the co-creation of innovative solutions to foster social changes and enhance the acceptance of the transformation caused by the Pandemic. Thus, the case study contributes to detect how collaboration, diffused decision-making and the development of co-created innovative solutions for security can help citizens overcome and accept the changes introduced by contemporary social, technological and cultural evolution and can meet

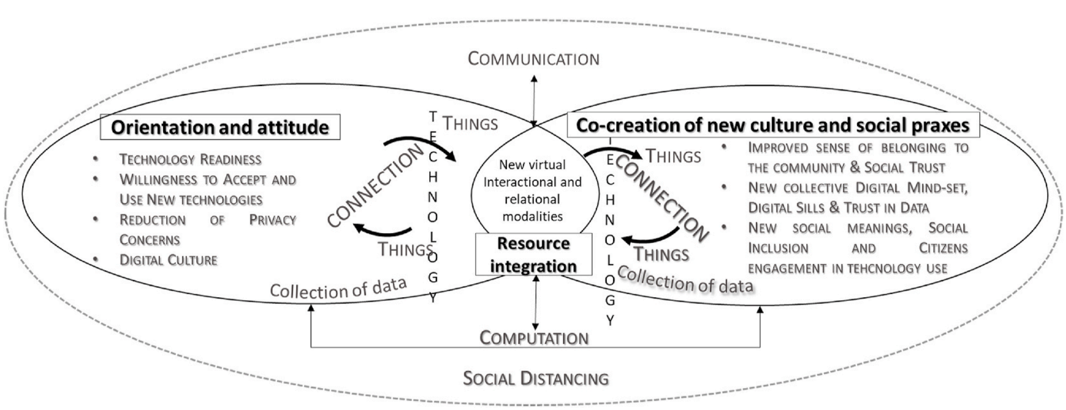

Fig. 7. The impact of WIMTE on the redefinition of users' attitude, interactions and behaviors.

relevant social challenges.

Critical configurational issues remain unresolved especially as it relates to privacy and confidentiality of data transmission in mesh networks. As discussed in this paper, reliance on technology and cutting-edge developments in telecommunications and computing has become a necessity rather than a choice. The study provided an overview of smart cities vulnerabilities related to confidentiality and privacy of users' data and susceptibility of service systems to software bugs, hardware glitches and malicious cyberattacks. Software engineers and specialists are actively working to deal with such issues and rapidly developing protocols and software architectures that will ensure data security and resistance to hacking. This paper advocates the principle of "design smart systems with security in mind," which requires embedding the smart preventive and mitigation strategies in the initial design of smart systems. Components' design will have to consider risks and threats as integral to smart service system configuration and deployment. Predictive modeling, demonstrations of system vulnerabilities and emergency response scenarios are crucial to viable smart service systems. The use of data extracted from social media such as family history and lifestyle, clinical, personal and travel data can provide accurate prediction but can involve privacy concerns (Obeidat, 2020). Security, privacy, computation and reliability issues are the major challenges facing Wireless mesh networks, especially during routing. To address these challenges, protocols must ensure confidentiality, integrity, privacy preservation, and reliability in the network. Effective point-to-point security scheme for mutual authentication, perturbation, and pseudonym can help overcoming security and privacy issues (Olakanmi and Dada, 2020). However, rather than focusing on whether to use personal data source, future research can analyze how data can be employed wisely and effectively without violating ethical issues. Hence, if technologies are implemented through a transparent process (Mello and Wang, 2020), through citizens' involvement and through trustworthy public communication that shares and justifies the decisions taken, not only the value of data can be exploited efficiently and strategically but policy-makers can strengthen citizens' trust in the government's strategy.

The conceptual model introduced identifies: 1) the main technological drivers for smart surveillance to redefine smart cities infrastructure to challenge epidemic; 2) the complex process of redefinition of actor's interactions and communication modalities between actors; 3) the key determinants of social change as a result of the transformation of citizens attitude toward technology and behavior. Thus, from a managerial standpoint the study helps cities management identify the main enabling factors (according to smart service systems: people-organizations, technology, shared information, communication, computing, data collection) to address crises, such as the global emergency of Covid-19 and, secondly, how these elements can be harmonized to attain systems continuous re-adaptation that fosters social change conducive to sustainability. Moreover, the proposition of a model for smart cities research that integrates complex systems based on artificial intelligence, machine learning, cloud computing and distributed data warehouses can help the identification of the drivers to collect, organize and exploit heterogeneous data to assist policymaking, by increasing interoperability, safety and security. The proposition of a systems framework for smart city can provide a detailed view of the enabling factors of cities' growth and can guide future research in the development of a multi-layered typology of smart cities (Vanolo, 2014) in which the different stakeholder's roles can be defined by classifying the relevant decisions and the most proper policies that can be implemented in each layer.

The identification of the enablers of societal changes in smart cities and the revealing of the new interaction modalities and main strategies to challenge the pandemic can help scholars and practitioners to shed light on the key drivers to overcome social and economic crisis. The elaboration of a model that examines how technology can redefine humans' interactions and can foster social changes in smart cities can address a gap in literature related to the absence of studies exploring the role of ICT in reframing traditional cities management and social innovation (Lytras & Visvizi, 2018). Moreover, the discussion of the findings introduces significant advancements on the classification of the psychological, cultural and social determinants of citizens attitude and behavior that can reduce users' resistance to technology in smart cities (Lytras et al., 2021). Identifying the drivers of citizen's behavior and technology adoption can contribute to enhance public managers' and policy-makers' understanding of the most proper strategies to engage citizens in diffused decision-making, manage efficiently the economic, social and technological challenges posed by pandemic and enhance the co-development of innovation.

The integrated WIMTE framework proposed in this study contributes to shed light on how ecosystems can challenge social and economic crisis through the integration of technologies with human attitude and individual intentions (individual level) to detect how the readaptation of interactions between users (relational level) can lead to the emergence of innovation and well-being (collective level). At the end of the process, the co-creation of culture and citizen's adoption of a "digital culture" can create a new cultural status accepted collectively and based on new routines and rules for the human-computer interactions and for the general use of technology and the reshaping of social structures. The new smart mentality shared in the city can change significantly the way in which people act and take decisions by reframing the attitude of citizens, policy-makers, institutions that seek to challenge collaboratively the Pandemic through the adoption of new and accepted technological solution and to address the evolving social needs through continuous co-learning process.

The creation of a cohesive culture in cities can help co-developing social capital and reframe the traditional human-computer interactions by turning the technological tools employed to implement smart working, distance learning, e-government and e-public services into new way of delivering services, routines and consolidated social practices (Rihova et al., 2015). Through a deep understanding of citizen concerns and needs, cities can offer technical skills training that improve citizens' access to technology and allow individuals with different educational and cultural backgrounds to embrace the new technologies. The overall objective of governance should be to engage people as end-users, citizens and as contributors to the innovative strength of the smart city.

The categorization of the enablers that can foster citizens-organizations acceptance of technology can enable the identification of the key features to manage strategically smart cities infrastructure and to classify the main drivers to monitor, manage and challenge users' technology anxiety, to increase their acceptance of technologies and predict citizens behaviour and to manage the technological tools for transactional citizenship (distance learning, smart working, electronic provision of health service, etc.).

8. Conclusion

The increasing digitalization requires companies, public institutions and non-profit associations to adapt to a digital and remote way of doing business which is changing dramatically people's daily experiences (Palmieri et al., 2016), interactions with other people and with technologies, and participation to public life. The readaptation of urban infrastructure in digital era requires cities to redesign their spaces, to refocus their strategies, to redefine the interactions and the relational modalities between stakeholders (Ivanov and Dolgui, 2020). In the light of most recent restrictions and regulations of public life, high-tech and ICTs solutions are needed to sustain mobility, transportation and safety, by deterring aberrant behavior and improving first responder communication and action.

Therefore, the recent global events raised many questions about the proper implementation of ideas and insights for the use of smart technology in urban planning and design (Abusaada and Elshate, 2020) and about the building of an integrated infrastructure to detect and mitigate potential outbreaks in smart cities (Costa and Peixoto, 2020). Through a data-driven restructuring of cities, the timely detection of emergencies can be made ensured. The multiple technological points and their real time ability to collect and share data can significantly improve well-being and quality of life, by strengthening citizens' involvement in policymaking and generate added value and sustainability for the cities (Ciasullo et al., 2020; Lytras et al., 2021).

Against the implications of the Covid-19 pandemic, it is expected that situational intelligence and automated targeted responses can increase the safety of global public health. By means of a coherent set of data-driven services provided by IoT devices, such as IP surveillance, cameras, sensors, and actuators, sophisticated surveillance systems can be implemented to estimate and prevent the negative implications of pandemic (Shorfuzzaman et al., 2018), to monitor systemically and systematically social distancing, mask wearing (Kunst et al., 2018) and to locate individuals for safety or health reasons (Hossain et al., 2020).

This paper conceptualized the essential ingredients of a high-tech, state of the art, smart city surveillance system (WIMTE) that can enhance smart cities' safety and security and doubles as a critical tool for infrastructure management and infectious disease control. As a geographically distributed but wirelessly integrated mesh system, WIMTE facilitates real-time access and transfer of information across a wide array of actors/stakeholders in the decision-making process. The integration of multi-sensor technology with wireless mesh networks will eclipse the conventional wireless surveillance solutions, which utilize network fragments and do not offer real time data aggregation/integration needed to tackle infrastructure services and security risks in cities. The effective deployment of WIMTE requires enhanced broadband width and coordinated/seamless communication across public and private domains. Mobile multi-sensor surveillance, video analytics, and wireless mesh ingredients of WIMTE discussed in this paper promise a better alternative to current surveillance operations. They facilitate situational awareness and real-time access to location-based information with the ability to send and receive live video streams and other critical data that help analyze and reconstruct events. Embedded artificial intelligence in the WIMTE architecture allows the system to think, learn and relearn as streams of data are analyzed and synthesized to create automated responses that can be shared real-time with command centers, first responders and a host of other involved stakeholders. Detection, tracking and pursuance go hand-in-hand in order to mitigate the negative impact of security threats and other emergency situations.

With the rapid urban growth and unprecedented rate of infrastructure deployment, cities should avail of the new surveillance technology and build a cutting-edge metro-wide surveillance and security operation. The most important components of the proposed WIMTE network would be: (1) a city-wide network of multi-sensor, IP-based surveillance hardware (video, audio, and envirometrics) with built-in video analytic capability, (2) command centers with both human and high level algorithmic analytics for video, audio and other sensory information and (3) a versatile wireless mesh network with a high degree of interoperability and connectivity with all existing internet, cellular, local area (wired and wireless) and radio-based networks. The IP-based sensory capacity would deliver enhanced functionality and connectivity to already existing data communication infrastructure. Deployment of sensors, analytics and mesh technologies would provide a powerful data cloud that allows the transmission of high-resolution video and other bandwidth hungry applications from campuses, to shopping malls, to public works and traffic systems to stationary and handhelds of first responders and police personnel. The existing wireless networks in cities across the globe would provide some of the IP backbone needed to transmit data from stationary and on-board vehicle cameras to laptops and mobiles at locations metro-wide. Routers and gateways would enable the distribution of live and recorded videos as well as video analytics to first responders anywhere within the cloud coverage. The network will provide on-scene "eyes," "ears" and advanced sensory analytics to operatives in the field and commanders in headquarters. Live as well as recorded videos, audio and other information analytics can be relayed along with dispatch messages to laptops on board police cars attending to and around incident locations. Video analytic systems can autonomously identify behavioral patterns and profile suspects in ways that facilitate detection and tracking in crowded urban environments. The result is wireless metro-wide, mega bandwidth connectivity, with incrementally and economically deployable service system that potentially revolutionize decision-making process related to security and infrastructure operations.

However, despite the theoretical and managerial implications debated above, the current study can be considered as a first step to lay the theoretical foundation for the development of an integrated model for smart surveillance in cities management according to a system perspective. Therefore, the conceptualizations introduced can be applied through a qualitative exploratory approach that-based on observations and semi-structured interviews-can extend and redefine the enabling dimensions and drivers of social changes discussed in this context. The identification of the key drivers for the redefinition of human-computer interactions and for users' technology acceptance can help future research defining the drivers, enablers, and consequences of citizens behavior and to detect the most proper management strategies. Then, by highlighting the social and behavioral implications of smart surveillance in cities, forthcoming studies can shed light on how innovation and well-being can be managed through social participation and engagement and through a proper combination of smarty service system's elements (people-organizations, technology, shared information/resource integration).

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