Chapter 1
Introduction to Smart Cities and a Vision of Cyber-Human Cities

While there is no single accepted definition, the common contemporary understanding of a Smart City [75, 20] assumes a coherent urban development strategy developed and managed by city governments seeking to plan and align in the long term the management of the various city's infrastructural assets and municipal services with the sole objective of improving the quality of life for the citizens [59, 159]. The ICT role in the current Smart City vision is passive – related to collecting and analyzing data, predicting and optimizing infrastructure utilization, as well as facilitating communication between different city services and automated management of infrastructure.

Although extremely complex, the Smart City of today can perhaps best be described as a city planning/urban development methodology heavily relying on ICT to gather necessary input and make optimal engineering and planning decisions. This means that the city's strategies are planned well in advance, with big investment budgets through big infrastructural budgets. More importantly, the citizen is also put into a passive role. While the citizens are undeniably winners in this process as the beneficiaries of a more optimized and cheaper infrastructure they are not taking an active role in the development and daily management of the city.

We denominate the current stage in Smart City development as 'representative-smart', as opposed to 'collective-smart' – one of the terms we propose for describing the future vision of cyber-human smart cities involving a rich and active interplay of different stakeholders (primarily citizens, local businesses and authorities), effectively transforming the currently passive stakeholders into active ecosystem actors. Realizing such complex interplay requires a paradigm shift in how the physical infrastructure and people will be integrated and how they will interact.

At the heart of this paradigm shift lies the merging of two technology/research domains – Cyber-physical Systems and Socio-technical Systems – into the *value-driven* context of a Smart City. The presented Smart City vision diverges from the traditional, hierarchical relationship between the society and ICT, in which the stakeholders are seen as passive users who exclusively capitalize on the technological advancements. Rather, the architecture we propose puts value generation at the top of the pyramid and relies on "city capital" to fuel the generation of novel values and

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enhancement of traditional ones. This effectively transforms the role and broadens the involvement and opportunities of citizen-stakeholders, but also promotes the ICT from passive infrastructure to an active participant shaping the ecosystem.

1.1 Architecture of Values

The fundamental idea behind a collective-smart city is the inclusion of all its stakeholders (authorities, businesses, citizens and organizations) in the active management of the city. This includes not only the management of the city's infrastructure, but additionally the management of different societal and business aspects of everyday life. The scale and complexity of managing diverging individual stakeholder interests in the past was the principal reason for adopting a centralized city management model where elected representatives manage all aspects of the city's life and development. However, we believe that recent technological advances will enable us to share the so-far centralized decision-making and planning responsibilities directly with various stakeholders, allowing faster and better-tailored responses of the city to various stakeholder needs.

The key technological enabler for this process is the active and wide-scale use and interleaving of technologies and principles from the IoT and Social Computing domains in the urban city domain. These technologies form the basis level of the proposed architecture of values (Fig. 1.1). They allow the city to interact bidirectionally with the citizens in their everyday living, working and transport environments using various IoT edge devices and sensors, but also to actively engage citizens and other stakeholders to perform concrete tasks in the physical world, express opinions and preferences, and take decisions. The "city" does not need to be an active party in this interaction. It can serve as a trustworthy mediator providing the physical and digital infrastructure and accepted coordination mechanisms facilitating self-organization of citizens into transient, ad hoc teams with common goals. This synergy in turn enables creation of novel societal and business values.

Infrastructural values – This category includes and extends the benefits conventionally associated with the existing notion of Smart City – those related to the optimized management of shared (city-wide) infrastructure and resources. Traditionally, the management of such resources (e.g., transportation network and signalization, internet infrastructure, electricity grid) has been static and highly centralized. The new vision of a Smart City relies on the interplay of humans and the IoT-enabled infrastructure, enabling additional, dynamic, locally scoped infrastructural optimizations and interventions, e.g., optimization of physical and IT/digital infrastructure in domains such as computational resources, traffic or building management. Apart from existing static/planned optimizations (e.g., static synchronization of traffic lights), the dynamic optimizations of the infrastructure might include temporary traffic light regime changes when a car accident is detected.

Societal values – This novel value category arises through the direct inclusion and empowerment of citizens as key stakeholders of the city. The fact that through the use

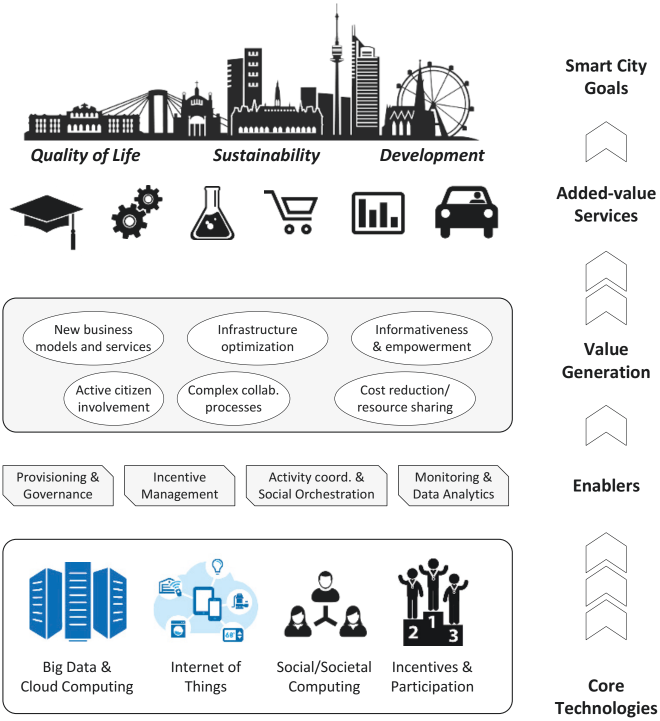

Fig. 1.1: Smart City 2.0 Architecture of values

of technology the citizens can be informed, educated, consulted and ultimately incentivized/paid to perform specific tasks in both the digital and physical environments is a powerful concept bringing along a plethora of socially significant changes.

For example, while most cities function as representative democracies, significant local changes are often decided upon through direct democracy (referendums, initiatives). While undeniably fair in principle, one of the biggest obstacles to a more frequent use of direct democracy is the underinformedness of voters [105]. It has been shown [133, 73] that informing the citizens enables them to make more judicial and responsible decisions. The pervasiveness of IoT devices enables interaction with citizens directly and opens up the possibility of informing the citizens better, or even simulating in practice the outcomes of different election choices.

Take for example the 2014 Viennese referendum where two city districts were asked to decide whether to turn one of the most frequently used shopping streets of the city into a pedestrian zone[1]. The referendum has caused much controversy, as people were skeptical that closing an important traffic artery would not cause major traffic jams. In order to give the citizens a preview of how things would work

[1] http://kurier.at/chronik/wien/mariahilfer-strasse-ja-fuer-umstrittene-fussgaengerzone/54.913.277 (in German)

after the transformation, the city invested in a temporary physical closing of the street and traffic re-organization the year before, as well as informational material. The total costs of the street transformation amounted to 25 million euros, out of which at least[2] 2 millions needed to be spent just to reach a common decision. In such cases, the citizens of the new Smart City can be included in the evaluation of the proposal and the decision process directly. The city can incentivize citizens to get informed about the pro et contra before making a decision; simple games and tests can raise awareness of specific problems. Interested parties can locate and engage same-minded neighbors and set up citizen collectives standing for their views. Finally, citizens can sign up to participate in cyber-physical simulations of the effects of different outcomes. For example: For turning a traffic street into a pedestrian zone, the IoT-enabled cars can be prevented from entering the street; For raising awareness of global warming, the citizens can be incentivized to have their apartments warmer/colder by a couple of degrees; To help people realize the low share of green energy, the citizens can be incentivized to use for a couple of days only the “green” percentage of the electricity they normally use. While simple, these simulations affect the citizens in their private environment through everyday (IoT) objects they interact with, and thus represent a strong motivational factor raising interest and informedness of an issue.

Business values – Apart from citizen empowerment and better inclusion in political processes, the existing research on decision making [110, 90], social orchestration and negotiation [147], and incentivization [158] provide a number of solutions for facilitating formation of collectives (groups, teams, task forces) of citizens, provisioning of necessary software support tools and digital infrastructure, algorithms for reaching agreement and compiling execution plans for different classes of tasks, as well as incentive models for both monetary and non-monetary compensation.

Combined together in the context of a Smart City, this allows the establishment of novel labor models where humans can engage in one-off or repeated activities within stationary or ad hoc created collectives, motivated by a personal interest or the offered compensation. These collaborative activities can range from the simplest on-demand crowdsourcing tasks such as deciding the color of the new subway line[3] to complex activities involving experts, such as IT incident management[163] or use of humans as sensing agents for predictive maintenance of non-IoT infrastructure, allowing for the effective and cheap inspection of local infrastructure.

Apart from offering their physical and cognitive abilities, citizens can be actively involved in enriching the Smart City infrastructure with their smart devices. The augmented infrastructure, access to the huge amounts of data and active user involvement in its maintenance can be exploited in a variety of ways, e.g., to optimize existing business models, reduce operational costs and create novel business opportunities. To be able to fully benefit from this inclusion we need novel ways to incentivize the citizens to “open source” their infrastructure, but also enable them to reap the benefits of doing so. The solution we propose lies in a combination of novel incen-

[2] http://kurier.at/chronik/wien/mahue-neu-es-bleibt-bei-den-25-millionen-euro-kosten/96.901.003

[3] http://qz.com/242360/stockholm-is-crowdsourcing-the-color-of-its-new-subway-line/

tive mechanisms and micro-payment technologies, which can enable fine-grained leasing and use of equipment, services and resources, as well as novel infrastructure provisioning and governance models and frameworks, which can support city-scale infrastructure management.

1.2 Smart City Platform

Contemporary Smart City development and investment strategies focus on improving the efficiency of traditional services and utilities. The focus on the "historical verticals" [80] is limiting the innovation and business potential of the city. Opening up this siloed view of the Smart City will allow more horizontal integration and creation of added values. Figure 1.2 illustrates the high-level architecture of the future Smart City Platform. The platform is a rich ecosystem that facilitates both production and consumption of added values for all the involved participants, ranging from humans to smart devices. It enables horizontal integration across different architecture layers and among different stakeholders. The main components comprising the platform include: *i) Smart City Infrastructure*, *ii) Core Platform Facilities*, and *iii) Value-added services*. Below, we describe these components in more detail.

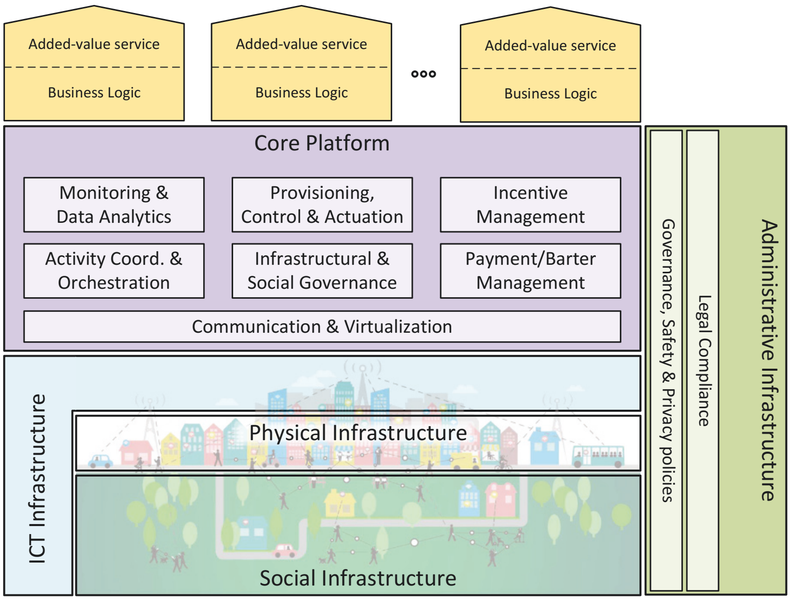

Fig. 1.2: Cyber-human Smart City platform

Starting from the *Smart City Infrastructure*, contrary to the traditionally monolithic view of a city's infrastructure, in our vision of the cyber-human Smart City, we identify different infrastructure constituents, that are inherently complementary and interdependent. *The Physical Infrastructure* consists of the union of all stakeholders' physical assets of direct interest to other stakeholders. This can include the city's transport infrastructure, electricity system, but also devices (e.g., vehicles or PV panels) owned by an individual, when they are willingly being offered to enrich the Smart City physical infrastructure and to be used by other stakeholders. *The Administrative Infrastructure* consists of the political and legal organizations governing the city's ecosystem. Collectively they act as the trusted entity determining and enforcing governance policies, guaranteeing legal and privacy protection. These organizations are not considered stakeholders of a Smart City. *The Social Infrastructure* consists of all the individual citizen and business stakeholders, i.e., of their intellectual, social and physical capabilities, as well as personal assets and resources, offered indirectly as services, individually or collectively. Examples include providing labor on a given task, or offering a ride service in a personal vehicle (as opposed to sharing the vehicle). *The ICT Infrastructure* is the cornerstone for efficient horizontal integration of different infrastructural layers and interoperability among stakeholders. It consists of all the physical and software (virtual) components for data gathering, processing, enactment of business logic, communication, and actuation of physical devices, such as sensors, IoT gateways, actuators, cloud processing and storage infrastructure and analytics software services.

Whereas the Infrastructure components resemble the vital organs of the Smart City, the *Core Platform* resembles its bloodstream, linking all the Smart City functionalities and enabling their seamless functioning. The most important functionalities of the Core Platform include: Orchestration functionalities for *Complex Coordinated Activities* (Section 1.4), *Incentive Management* (Section 1.5), *Provisioning & Governance* (Section 1.7), Monitoring & Data Analytics, as well as Control & Actuation mechanisms. Since the last two components are also present in the Smart City of today, we will not discuss them here.

The *Value-Added Services* act as the brain of the Smart City. They rely on the core platform to enable management of the Infrastructure and facilitate the value-generation process. Generally, the value-added services are largely task- and use-case-specific and we do not impose any rules or requirements on their design or functionality. They are envisioned as a playground of disruptive innovation and value generation. For example, they can be optimizations of existing business models or incubators for novel business opportunities. The value-added services are meant to follow the natural life cycle of the city's evolution and can appear and disappear in accordance with stakeholders needs.

Once in place, the value-added services can become a valuable digital asset in the ownership of the city and its citizens that can, however, extend beyond the geographical region of the city and beyond the citizens that physically reside in the city. The Republic of Estonia has recently introduced the concept of *e-residency*[4].

[4] https://e-estonia.com/e-residents/about/

It allows any person (non-Estonian citizen) residing outside of Estonia who fulfills specific criteria to become a legal subject (e-resident) of Estonia for a small fee. This status allows practically anyone in the world to remotely establish and manage a company based in Estonia enjoying all the benefits of modern e-Government services that the country offers, a reliable and transparent legal and e-banking system, as well as access to the entire EU market under the same conditions as any other EU company. This landmark concept, which allows Estonia to further profit from the services it offers and taxes it collects from the businesses established by the remote citizens, can equally be adopted by cities. The gain for a city from such residents is twofold – they pay fees/taxes for the use of services and at the same time they do not strain the physical infrastructure (e.g., roads, sewers). Many of the value-added services that do not rely on the physical presence of the service consumers can be offered in this fashion to external residents. The additional gains obtained in this way can help finance the transformation of a city into a Smart City and development of further services. At the same time, this concept fosters competitiveness among cities. Without the physical location/residence as the principal constraint, a citizen is free to choose any city as the provider of digital services. This means that cities will have to compete to offer better services to their citizens in an effort to keep them as residents or attract new, digital ones.

1.3 Stakeholders

We define the Smart City stakeholder as any physical or legal entity entitled by the city's authorities to use, manage and contribute to the Smart City's physical and social infrastructure. In practice this means that any citizen or business of the city, as well as city authorities or visitors who are given the right to access the Smart City platform are considered as stakeholders. Contributing to the infrastructure is equally important as using it. Stakeholders putting at the disposal their own devices, providing services and participating in collective coordinated activities (Sec. 1.4) bring in the human capital into the play, activate the infrastructure and generate novel values.

1.4 Complex Coordinated Activities

One of the principal defining characteristics of the envisioned Smart City is the existence of and support for a rich set of interactions embodied in the concept of complex, collaborative *coordinated activities*. These activities are fundamental to the generation of societal and business values described in the previous section. Whether initialized by the municipality, local businesses or the citizens themselves, a Smart City platform acts as the legal, trust and coordination enabler of such activities. On the 'physical layer', the activities comprise the following interaction types:

1. M2M – interactions between IoT devices and software services (e.g., sensing, actuation, data analytics, service compositions, micro-transactions).
2. H2H – interactions between humans/citizens (negotiation, joint planning, collaborative task execution, learning, direct democracy).
3. M2H – interactions between humans and (their) devices (notifications, personalized use, context sensing, augmented reality).

Since the machines (devices, services) are used on behalf of humans, on the more abstract level the activities represent the interactions among the various city stakeholders. In fact, the main objective of such coordinated activities is to actively facilitate the various stakeholders to (self-)organize and reach a common goal, both on a personal (micro), as well as on a city (macro) scale. The facilitation is performed through various coordination and communication mechanisms delivered by the Smart City platform. These mechanisms serve both as direct and indirect controllability methods – either enforcing specific constraints and policies (e.g., negotiation protocols, SLAs), or indirectly influencing behavioral responses of humans through incentives and peer influence. Examples of complex coordinated activities can range from collectively organized transportation [3], private infrastructure sharing[5], collective learning [60] and game-based learning[6] to gainful activities, such as collaborative software development [116]. While the size of the heterogeneous collectives participating in these activities need not be large, the potential and reach are global, allowing most citizens to participate, thus actively shaping the society, city and business environment they share.

1.5 Incentives as a Soft Controllability Principle

Managing humans in various socio-technical systems has often been criticized as neglectful of true human nature [81]. Humans are often used as role enactors in human workflows [15, 112, 6] or executors of instructions [57]. While such approaches allow the difficulties related to human-understandable context interpretation to be overcome, the human intelligence is harnessed in a passive way, since the execution is machine-driven and deterministic. This means that the collaborative and social capital of humans is not fully exploited, despite the prospective of delivering a profound positive impact on the society we live in [176]. Crowdsourcing [44] and various other platforms for collaborative consumption have partially tapped into this potential, allowing for human-driven, albeit tightly structured, collaborations.

A distinguishing characteristic of human participation in socio-technical processes is the need for motivation. Unlike software services or devices whose usage can be requested for compensation and whose outputs are deterministic, human participation is driven by personal motives, which vary individually in time and also depend on

[5] https://switcher.ie/broadband/news/upc-ireland-rolls-out-horizon-wi-free-service/
[6] http://www.nobelprize.org/educational/medicine/ecg/

the (social) environment. Furthermore, diverging individual motives and interests make team assembly and coordination of collective activities inherently complex.

Incentives are a means for inducing motivation and aligning disjoint individual interests in a group [155]. They include not only monetary/material rewards, but more often rely on intrinsic motivational factors, such as altruism, curiosity, competitiveness, social status. Compared to the listed role-based workflow systems where humans are issued concrete actions to perform, incentives serve as a powerful mechanism for "soft controllability" inducing wanted behavioral responses, setting psychological engagement constraints but leaving the liberty of action to the humans.

A cyber-human Smart City wishing to engage citizens into collaborative actions should offer incentive management services, such as [158], through its platform (Fig. 1.2), giving to different stakeholders the tools to motivate and engage other stakeholders into collaborative activities. The incentive management service allows the provider of the incentives to compose and tweak incentive schemes optimally for a particular purpose and a given target population. It also allows the monitoring of the incentive application and effectiveness, and subsequent adaptations. The city can incentivize the citizens to engage in decision making or to get better informed, or to change their habits (share infrastructure, promote a healthier lifestyle). Businesses aligned with such goals can provide for the costs of incentivization. Finally, where mutual resources and devices can be shared, individual citizens can set up incentive schemes to encourage bartering and partially substitute the use of money with alternative/local currencies (see Ithaca HOURS[7]) in micro-transactions having positive effects on local businesses [168] (Sec. 1.7). The incentives can be delivered through different channels, using personalized messages, to different hand-held or IoT devices. Serious games are also an attractive environment for engaging people and delivering incentives, especially for learning purposes [99]. Their captivating power is best evidenced by the recent global success of the augmented-reality game Pokemon Go[8]. As the timing and the perception of the incentive, as well as trust in the incentive provider, are the key factors of its effectiveness, we argue that the described Smart City context is a well-suited environment for the implementation of such incentive management systems. The Smart City platform provides the trusted third party technically managing the application of the incentives, while not taking an active provider role. Thanks to their pervasive distribution IoT/Edge devices are used to deliver incentive messages and provide raw data for automated monitoring of incentivized activities.

1.6 Citizen Informedness

When talking about societal values a community can most benefit from, the importance of informing, educating and actively including citizens in different life aspects

[7] http://ithacahours.com/

[8] http://www.bbc.com/news/technology-36763504

of the community cannot be overstated. Conventional education teaches ground truths and well-established rules, and as such will remain the fundamental growth generator for any local economy. While these ground values retain their full importance in a Cyber-Human Smart City, the new environment, being much more dynamic both in time and space, requires additional continuous learning and adaptation by the citizens living within it. Often the new knowledge is short lived and useful for a limited period or geographical space. This can prove to be especially challenging to vulnerable social groups (seniors, low-income families), which are disadvantaged when it comes to learning about the new technologies and adopting them. While this problem is already present today it is to be expected that it further escalates in a Smart City environment, where people are de-facto forced to interact increasingly with different and unknown devices built into surrounding everyday objects and varying in user interfaces and functionalities. In such cases it is important for the Smart City platform and the particular devices to offer technological support for running test trials and practical demonstrations whenever possible. Novel approaches to tackling this problem in a similar way have already started to appear (e.g., Living Labs [159]) but the research in this area has yet to get into full swing.

Apart from the need to constantly learn to adapt to an ever-changing IoT environment, citizens of our Smart City are also confronted with a sea of information which needs to be filtered to each citizen's needs and visualized in a simple format at a proper time. Some of the current technologies such as Google Now already try to implement the basic principles, by delivering highly personalized information via smart phones. In the future Cyber-Human Smart City, the spectrum of processed information will need to drastically expand to cover the usage of different IoT devices as well as past and potential interactions with other citizens and/or their devices. This also means that the information services will have to move from the purely passive aggregation and filtering functionality to interactive services which are able to dynamically gather additional information (e.g., from different users) in order to deliver only meaningful and useful information. Let us consider for example a ridesharing scenario (cf. Chapter 7). The scenario starts with a number of users submitting ride requests with offered/wanted origin-destination pairs that are then matched by the ride-sharing platform. Unless a large number of ride requests are constantly being submitted, the chances of producing enough matches are slim. This means that the matching will work satisfactorily most likely only in large and densely populated areas, and only if the ride-sharing platform is a popular application used by large numbers of users. On the other hand, if the software takes over the responsibility of monitoring various ride-sharing platforms for suitable matches and informs the user on time, the chances of producing a match rise, even outside large cities. If the initial step of submitting the ride request is instead performed autonomously by a software assistant on a user's behalf based on learned travel patterns or booking confirmations, the chances of producing a match rise further. The user, naturally, ultimately decides whether the match is useful to him, and whether to proceed with negotiations and ultimately accept the ride. In order to do this, the information service needs a runtime feedback response from the user. In the described case, the autonomous agent gathers and processes information relevant to the user at a speed that would be impossible for a human. Therefore, the informedness of the user in this case is indirect, but the actual empowerment obtained by transmitting only the relevant information is practical and concrete.

1.7 Provisioning and Governing Infrastructure as a Utility

At its core the Smart City assumes an interplay between cities and technology. At the moment this relationship is most obvious at the infrastructure level. In this regard, we mainly focus on ICT infrastructure, but due to its nature, realizing Smart City infrastructure requires a multidisciplinary effort, ranging from electrical and civil engineering and urban planing to ICT. From the ICT point of view, Smart Cities are ever stronger developing and evolving Cyber-Physical/IoT Cloud Systems that blend in Internet of Things (IoT), network elements, Cloud services and humans. This results in complex IoT Cloud infrastructures that need to be provisioned dynamically on demand and governed throughout their entire lifecycle.

The majority of traditional city infrastructure resources such as electricity or water are delivered and consumed as a public utility. Such utilities are traditionally subject to forms of public control and regulation ranging from local community-based groups to statewide government monopolies. Moreover, Smart City stakeholders engage in utility generation and consumption, as well as its distribution (e.g., sale), generally in a regulated market.

However, to date Smart City ICT infrastructure is hardly delivered and consumed as a utility. To enable this paradigm in the Smart City of the future, we identify a set of design principles that serve as a road map towards realizing the utility-based delivery and consumption of Smart City ICT infrastructure. These include: *Everything as code* – all the concerns, i.e., application business logic, but also Smart City infrastructure resources provisioning and runtime governance, should be expressed programmatically in a unified manner, as a part of the application's logic (code). *API Encapsulation* – Smart City infrastructure resources and capabilities are encapsulated in well-defined APIs, to provide a uniform view on accessing functionality and configurations of IoT cloud infrastructure. *Central point of operation* – conceptually centralized (API) interaction with Edge devices allows for a unified view of the infrastructure's provisioning and governance capabilities, without worrying about low-level infrastructure details. *Automation* – main provisioning and governance processes need to be automated in order to enable dynamic, on demand configuration and operation of the Smart City infrastructure without manual interaction with Edge devices.

Realizing the utility-based consumption of Smart City ICT infrastructure, among other things, requires rethinking traditional approaches to provisioning and governing both applications and the infrastructure. In our previous work, we have addressed some of the aforementioned challenges by introducing models and frameworks that implement and enforce some of these principles in order to facilitate utility-based provisioning and cfity-scale governance. In [120, 122], we have introduced a unified provisioning model and a framework for logically centralized provisioning large-scale, geo-distributed Smart City ICT infrastructure. This work was mainly intended to address a stringent need: To enable the Smart City ICT infrastructure to be refactored into finer-grained resource components whose behavior can be defined in software; To provide conceptually unified representation of both Edge and Cloud resources; As well as to enable automated and scalable management of IoT Cloud resources, application components and their configuration models in a logically centralized fashion. Furthermore, in [119, 125] we introduced a novel governance methodology and runtime framework for governing the Smart City infrastructure and services. The main aims here were: To bridge the current wide gap between stakeholders involved in governing Smart City systems; To enable governance strategies to be enforced in a large-scale, geographically distributed setup; and to enable dynamic, on-demand deployment and invocation of governance capabilities via cloud-based APIs.

However, although this work lays a cornerstone for realizing our vision of the Smart City, additional work needs to be done in order develop a full-fledged tool suite that is capable of facilitating the value generation chain (cf. Section 1.1). One of the key enablers is to provide novel support for realizing the delivery-consumption-compensation model for the previously introduced Smart City capital. Traditional public utilities exclusively rely on existing markets, business models and monetary institutions to realize this model. However, to realize broader participation in the previously presented architecture of values Smart Cities largely lack suitable business models for exchanging resources and services among stakeholders. Moreover, infrastructure owners and infrastructure brokers require an ecosystem to support trading Smart City services and assets.

1.8 Summary & Organization of the Book

In this chapter we have introduced a novel vision of the Cyber-Human Smart City that is based on the architecture of values. This value-driven architecture is characterized by complex coordinated activities involving the City's services, stakeholders and their smart devices. It puts the citizens in first place and promotes them to active stakeholders as opposed to passive users. We presented a set of key enablers to realize the vision of the cyber-human Smart City, which include: i) Complex Coordinated Activities, ii) Incentives as soft controllability mechanisms, iii) Citizen Informedness, and iv) Utility-based provisioning and governance of Smart City infrastructure. Finally, we presented a concrete set of design principles and requirements that serve as a manifesto of Cyber-Human Cities of the future and lay down a road map toward realizing a comprehensive Smart City platform.

This chapter both serves as a general introduction to the book and also presents a coherent vision that ties together all the components that are required to realize our vision for Smart Cities of the future. In the remainder of the book we discuss these components in depth. Part II of the book discusses our previous work related to the provisioning and governance of Smart City systems and infrastructure. In Part III, we introduce our previous work on the core technologies and technological enablers for managing the social component of the Smart City platform. Both parts (see Chapter 2 and Chapter 6), also present the state-of-the-art research and industrial efforts in the respective fields. Finally, Part III provides a road map towards Cyber-Human Smart Cities and concludes the book. We discuss the requirements and concrete technological advancements needed to move beyond contemporary Smart Cities, towards the Smart Cities of the future.

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