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ORIGINAL RESEARCH

Beyond 'smart-only' cities: redefining the 'smart-everything' paradigm

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Abstract

This paper presents different manifestations and problems of the 'smart-everything' paradigm, provides a critical reflection of its implications and proposes a human-centered design approach resulting in the provision of 'people-oriented, empowering smartness'. The approach is characterized by design goals like "keeping the human in the loop and in control" and the proposal that "smart spaces make people smarter". The critical reflection implies to 'redefine' the 'smart-everything' paradigm. One could also say this is a proposal in the spirit of humanized computing. While the approach has general applicability, the examples are mainly taken from the domain of employing information technology in current and future urban environments, where one can observe an increasing hype indicated by the label 'smart cities'. The paper argues that a citizen-centered design approach for future cities is needed for going beyond technology-driven ubiquitous instrumentations and installations of cities. To illustrate the situation, the paper addresses several general problem sets concerning artificial intelligence and algorithmic automation as well as privacy issues. There are two trade-offs to be considered: (a) between human control and automation, and (b) between privacy and smartness. People are not asked anymore beforehand for their permission to collect and process their personal data. People do not have the choice to decide and make the trade-off decision between smartness and privacy themselves but are confronted with serious privacy infringements. To remedy the situation, a 'privacy by design', respectively 'privacy by default' approach is proposed. The combination of redefining the 'smart-everything' paradigm in terms of empowering people, employing privacy by design and enforcing an overall citizen-centered design approach is guided by the goal of reconciling people and technology, creating and maintaining a balance of decision-making and control entities. It should convince and incite all stakeholders "to move beyond 'smart-only' cities" and transform them into Humane, Sociable and Cooperative Hybrid Cities.

Keywords Smart city · Smart-only city · Smart airport · Smart ecosystem · Hybrid city · Humane city · Cooperative city · Self-aware city · Transient city · Urban age · Urban spies · Smart-everything paradigm · Human in the loop · Human in control · Design trade-offs · Smart spaces · Empowering smartness · Ambient Intelligence · Artificial Intelligence · Ubiquitous computing · Disappearing computer · Citizen-centered design · Privacy · Privacy by design · Autonomous driving · Non-transparent algorithms · Transparent AI · Opaque AI

1 Introduction

The British architect Cedric Price (1934–2003) expressed his concerns about technology driven approaches in the remarkable provocation "Technology is the answer, but what was the question?" which he used as the title of one of his lectures (Price 1966). Buzz Aldrin (Apollo 11 moonwalker) complained: "You promised me Mars colonies. Instead, I got Facebook" (Aldrin 2012). Although at different times and in different domains, concerns and apprehensions like these can only support an already existing motivation to question the 'smart city' developments currently under way and to suggest a counter proposal for providing a route *beyond* 'smart-only' cities towards Humane, Sociable, and Cooperative Cities.

There are two points of departure for this position paper. On the one hand, the author is convinced that it is necessary to stimulate and to intensify the discussion and critical reflection of the role of automated and autonomous so called 'smart' technologies—especially with respect to the use of Artificial Intelligence (AI)—and the related issues of privacy due to its data-intensive approach, determining more

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and more private as well as public activities in our society. On the other hand, the term 'smart' has invaded our conversations in terms of requirements, expectations and promises in an importunate fashion. It is time to discuss the implications and provide new perspectives for all stakeholders. A prominent example is the ubiquitous hype about 'smart' cities, serving as major application domains of the above technologies. The concept and implementations of 'smart' cities need to be explored and contrasted with a differentiated goal orientation for the future of urban environments and the role and opportunities of citizens inhabiting them, i.e. to design and realize a humane, sociable and cooperative city. It should be made clear at this point, that the author does not intend to exclude the term 'smart' from the discussion. It is even preferred over the term 'intelligent' also used in these contexts. The criticism raised by the author is that the proposal and deployment of 'smart' technologies and its use for the creation of or transformation into 'smart' cities is guided by a mainly technology-driven perspective and less oriented towards the citizens living and working in these cities. Thus, it is argued to discuss alternative or complementary approaches to identify options *beyond* 'smart-only' cities. This results in at least two design trade-offs: "automation vs. control", on the one hand, and "smartness vs. privacy" on the other hand, to be discussed in detail in Sect. 4.

2 Redefining the 'smart-everything' paradigm

Society in its urban context and related facilities, services, infrastructures is already confronted with a dramatic dependency on the secure and continuous availability of electricity and a well-functioning 'traditional' information and communication technology (ICT) infrastructure. Soon, we are confronted with the dependency on a ubiquitous smart infrastructure, especially with the deployment of (often non-transparent, non-traceable) artificial intelligence components in so called 'smart' cities and 'smart' homes. Not limited to them, it will also be true in the rural context when we refer to so called 'smart' farming and agriculture. Therefore, it seems necessary to reflect on these dependencies, discuss the implications as well as the options to remedy the situation.

2.1 Why redefine?

The 'smart-everything' paradigm (Streitz 2017) is based on the observation of certain trends and the ubiquitous usage of the term 'smart'. Already since some time, everything must be 'smart': be it technology in general, specific devices, supporting software, services, infrastructures, environments, homes, cars, and—finally—cities. It is the result of self-reinforcing trends combining what is called the Internet of Things (IoT) and Artificial Intelligence (AI) in different application fields. The sole usage of the term 'smart' is not a problem, but the implications of how it is interpreted and applied needs a critical reflection and alternative views.

A major trend is the shift towards more or even complete automation of previously human operator controlled activities, because everything is now 'smart' and humans are rather considered to be the cause of errors and not viewed as subjects capable of intelligent operation and supervision of the environment. Smart devices and underlying algorithms are increasingly controlling processes, services and components as well as the interaction between connected devices and people. People are increasingly removed from being in charge and thus from being in control. The current developments are characterized with an obsession to automate everything and AI is considered the holy grail for executing it. The 'smart-everything' paradigm is gaining ever more ground, amplified by abundant venture capital. Only few people are aware or admit that AI will bring about many problems, some intrinsic, some due to comprehensive integration efforts based on the deployment of abundant automated and autonomous systems. A brief retrospective on the origin and development of artificial intelligence and the contrast to alternative and complementary views as, e.g., the ambient intelligence perspective, seems to be helpful for the further discussion.

2.2 Artificial intelligence in perspective

The origins of the field and term 'artificial intelligence' (AI) date back more than 60 years to a workshop in 1957 with the name "Dartmouth Summer Research Project on Artificial Intelligence" and are strongly connected to its main organizer John McCarthy. The list of (now famous) researchers involved, e.g., Claude Shannon, Marvin Minsky, Herbert Simon, Alan Newell, Oliver Selfridge, etc. is legendary and has for quite some time justified the high expectations in this field. The definition of what AI is or its scope, is changing depending on the progress in the field. The general goal of AI can be described as creating technologies (computers, machines, software) to behave in an 'intelligent' manner, often in a way that simulates not only the results of human (cognitive) processes, but also the underlying processes as they are explored in the field of cognitive science. Specific definitions of AI are often provided by examples of challenges to be met: reasoning, problem solving, planning, natural language processing (understanding, translation, production), learning, etc. A good example of its variable, time-dependent definition is optical character recognition (OCR), which is not considered to be AI anymore, but rather a routine technology. While knowledge-based expert systems (e.g., Barr and Feigenbaum 1982) were considered major contributions towards the goals of AI at that time, they became part of 'traditional' software platforms, configuration, analysis and diagnosis systems.

The fluid character of AI is—although not really satisfying—well expressed in the statement: "AI is whatever hasn't been done yet" (attributed to Larry Tesler according to Hofstadter 1980, p. 601). It seems that this characterization has still some validity today. For the point to be made in this paper, it is not necessary to propose or agree on a specific definition of AI, because it will be based on examples and on meeting predictions at a specific date.

Considering the history of AI since its origin, the current hype forgets that progress was limited and did not always meet the great expectations raised by its proponents. Take the example of comparing the predictions and results in chess. In 1957, Herb Simon predicted that a digital computer will beat the (human) world chess champion within the next 10 years, meaning 1967. In the end, it took until 1996/1997 for the IBM computer Deep Blue to finally beat the world chess champion Garry Kasparov in a tournament. This is a delay of about 30 years. And it took another 20 years after this event that Google's AlphaGo beat the South Korean Go world champion in 2016. Or take the status of speech understanding and translation systems as an example. How often were we promised in the last 60 years that the big breakthrough is just around the corner?

AI proponents should remind themselves of what has been called the 'Winter of AI or AI Winter', i.e. periods of setbacks in the 1970s and late 1980s/early 1990s resulting in reduced and partially even stopped funding and general decrease of interest and belief in AI. History shows, that AI experienced several hype cycles ('peak of inflated expectations' followed by a 'trough of disillusionment') as they are common in the field of emerging technologies. At the AAAI meeting in 1984, Roger Schank and Marvin Minsky warned the business community that their enthusiasm for AI got out of control and disappointment would follow (for an account of these developments see Crevier 1993).

It seems that we are experiencing a similar hype cycle these days. AI is (again) considered to be 'the next big thing', identified by venture capitalists for investing their money. A prominent example is currently autonomous driving/ driverless cars, to be discussed in detail in Sect. 2.3. But even people working in this industry (in this case Mobileye) are warning of a hype with too high expectations (Shalev-Shwartz et al. 2017): "We believe that the development of Autonomous Vehicles (AV) is dangerously moving along a similar path that might end in great disappointment after which further progress will come to a halt for many years to come". So, caution is advised, when proponents try to convince the world that AI is the solution, because everything will be 'smart'. AI-based methods can be helpful in building assistance systems, but AI is certainly not the panacea to all our problems.

2.3 Problems of the 'smart-everything' paradigm

There is no intention to insinuate that progress in the field of AI will always show delays and discrepancies to predictions. New approaches and methods as, e.g., machine learning (ML), especially deep neural networks—also called deep learning (DL)—have been proposed and implemented with some success. But they also have their problems and limitations, e.g., their dependency on having appropriate, unbiased and sufficient training data. A major and relevant problem of machine learning approaches is their statistical nature and the inability to generate conceptual models or provide causal mechanisms (only inferred from ML data) to gain a real understanding of the relationships, going beyond of showing only high correlations between input and output data. Some of the shortcomings might be overcome, but it is still a long way to go. It is also an open issue, when and how these methods will be superseded by other approaches.

Based on conceptual arguments and additional empirical evidence, it is worthwhile to discuss three basic problem sets of the 'Smart-Everything' paradigm as it is currently proposed and implemented:

Set A: Inability and error-prone behavior.
Set B: Rigidity.
Set C: Missing transparency, traceability and accountability.

2.3.1 Problem Set A: Inability and error-prone behavior of AI

Inability and error-prone behavior of AI and other algorithmic approaches can be observed today in many areas despite ubiquitous promises. Take the example of autonomous driving as a major application scenario in this paper, because it is closely related to smart cities and it is advertised by raising very high expectations. Although it is a specific example, it demonstrates that the implications of limited capabilities and error-prone behavior at relatively simple tasks can have quite substantial and dramatic implications.

Autonomous driving requires a wide range of smart capabilities and components (Eskandarian 2012; Hancke et al. 2013; Levinson et al. 2011; IEEE Summit 2018) as the list of employed sensors show: regular, stereo and 3D cameras; ultrasonic sensors; radar; LIDAR; GPS to name a selection. As Streitz (2018) pointed out, one must be aware that instrumentation of the car itself will not be sufficient, despite the current focus of autonomous driving efforts on the car. Instrumentation of the urban environment with its components—as part of the smart city scenario (Hancke et al. 2013)—is needed to be in the position of offering what can be considered full autonomous driving at level 4 or 5.[1] In this context, it is worthwhile to mention that a recent prediction of a selected group of international experts foresees that in 2030 only level 3 and in some specific defined areas level 4 will be available on the streets (Hyundai-Workshop 2018).

Recognizing all street signs in order to drive in accordance with regulations and laws is one relevant capability needed for autonomous cars. Take the example to recognize speed-limit signs, a relative simple subtask of computer vision, because the signs are highly standardized and not moving. The underlying rationale is to have up-to-date information and not to rely on speed limit data stored in a database connected to the map of the navigation system, because they could be out-of-date and limits for ad hoc construction sites cannot be accommodated. Of course, this is not full autonomous driving, but a relevant functionality required for making autonomous driving work. Currently, this functionality is sold as part of assistance systems corresponding to level 1–2. A long-term experiment of the author with a commercially available car of a premium manufacturer equipped with the currently available camera-based technology for speed-limit detection showed that the system is rather unreliable. The results did not change after a software update in 2017. The system is only correct in about 50% of the different traffic situations. There is no space here to cover all failure situations. One example is the following: the driver is driving at 50 km/h in the city during the day. The system informs the driver in the head-up display that he is driving 50 km/h and, in parallel, that he is (allegedly) allowed to drive only 30 km/h. Why? The system recognized a sign with 30 km/h, but failed to detect the additional information that this speed limit of 30 km/h applies only at night, from 10 p.m. to 6 a.m. It failed to detect this constraint, although it is clearly written on the sign and the system knows or should know that it is currently day time. Another example is that a 30 km/h speed limit sign for a range of streets ('30 zone' to secure playing kids, etc.) is correctly recognized and applied, but after the next street crossing 'forgotten'. Although there was no sign to cancel the 30 km/h speed limit, the speed limit shown by the car to the driver is raised to 50 km/h, although the regulation still asks for 30 km/h. The system seems to have no knowledge that it should keep the speed limit until it is changed by new information. While in the first case, driving too slowly is not dangerous, in the second case driving too fast could be very dangerous for the people. It is worth noting that the recognition of additional signs or temporary restrictions for speed limits is specifically mentioned by the car manufacturer as a special feature of this speed limit system. Although this type of pattern recognition should not be very difficult, the cars are not capable of handling these and other very simple situations. Given these limitations, where and when can one expect autonomous driving at level 4 or 5?

Since this experiment might be a singular case, it is useful to look at statistical data from the US. Carmakers testing self-driving cars in California have to be registered and must file annual 'disengagement' reports showing how many times their vehicles malfunctioned. The definition of a disengagement includes every time a human driver must quickly take control, either because of hardware or software failure or because the driver sees a problem coming. The data from the Department of Motor Vehicles show that self-driving cars failed roughly every 3 h in California during 2016. The reports cite 2578 failures among the nine firms that conducted road-testing in 2016. These numbers must be placed into perspective. They relate only to a limited number of 'autonomous miles' driven, which are not sufficient for official approval (Aubuchon 2017). In addition, one must mention that there are so far two known deadly accidents. In 2016, the 'driver' or rather 'passenger' using the Autopilot function of a Tesla car was killed in a severe accident with a truck on a Florida highway. The person believed in Tesla's marketing promise that he had an 'Autopilot' system (although it was only a level 2 assistance system) and therefore did not monitor the car. Unfortunately for him, the system made the fatal decision not to stop, because the truck turning left at the intersection with a cross road was not recognized by the Tesla system. The final report issued by the National Transportation Safety Board (NTSB 2017) was annotated with comments from board member Christopher Hart stating: "This crash is an example of what can happen when automation is introduced 'because we can' without adequate consideration of the human element". Another more recent accident happened in March 2018, when an Uber car killed a pedestrian who was trying to cross the road. The car was driving faster than the speed limit in the 35 miles zone allowed and did not even attempt to slow down and brake. The supervising driver in the car also did not take action to stop. Uber cars have also been reported to cross streets despite red traffic lights. So, there are still quite a number of open issues to be addressed.

There is another problem associated with malfunctioning of lower level assistance systems because failures have legal and privacy implications for the drivers beyond correct vs. wrong functioning. Currently, the human driver can still behave correctly despite the wrong information provided, because he does a better, more intelligent pattern recognition and interpretation so that he can drive according to the rules. Probably already now, but for sure in the

[1] Progress towards autonomous driving is categorized by levels from 0 to 5, where "0" is fully manual with no automation and "5" full automation (no human driver needed for supervision) (SAE 2014).

future, all data will be collected by the manufacturer and can in principle be transferred to the car insurance provider, the police and other authorities, rating agencies and commercial service providers. Thus, malfunctioning systems could cause serious problems for the driver (e.g., increase of insurance premium) and even have legal implications (allegations of violating traffic regulations), all based on wrong information processed and transferred to the authorities. This must be prevented in any case. Car owners and users must have full control of any data collected and must also be able to turn the data collection and transfer system off. These issues will be revisited in the sections on privacy. The implications described are consequences for human drivers using assisted driving at level 2 and 3. Imagine the implications for 'passengers' at level 5, when the fully autonomous car is also provided with wrong information and bases its decisions and driving behavior on wrong data.

Physical hacking. It has been demonstrated and reported in the media (WIRED 2015) how to 'hijack' a car remotely (e.g., via the integrated entertainment system), to disable crucial functions like airbags or to stop the car, and how to steal cars. Obviously, the possibility to hack a car's software will be even more crucial for autonomous connected cars and the danger increases when over-the-air (OTA) updates become common in the car industry. But there is also another problem, known under the term 'physical hacking'. Beyond the problem of recognizing correct traffic signs as discussed above, there is the problem that tiny changes can cause machine learning methods to fail when replacing traditional pattern recognition methods. Experiments by researchers from the University of Washington, University of Michigan, Stony Brook University and University of California Berkeley (Evtimov et al. 2017) were undertaken to show how easy it is to trick deep learning models in the context of traffic sign recognition. They found that they could confuse the road sign detection algorithms of self-driving cars by adding small stickers (so called 'scam stickers') to the signs on the road. For example, they could cause a car to 'think' that a STOP sign is a 45 mph speed limit sign. Minimal modifications of signs which are unnoticed or at least do not confuse a human driver disturb deep learning models so much, that they produce completely wrong results. Thus, small alterations to the signs by using scam stickers could result in cars skipping junctions and potentially crashing into one another. One can imagine that it might become a fun sport of teenagers or other people to modify traffic signs. This would cause substantial problems, because there is no way to safeguard all existing physical traffic signs on all roads.

In the end, it makes no difference for users, drivers or passengers of autonomous cars, whether AI malfunctions by not recognizing correct information or is physically hacked by 'scam stickers'. Both problem areas indicate serious deficiencies of the 'smart-everything' paradigm.

2.3.2 Problem Set B: Rigid behavior of AI

Rigid behavior is another problem. It can be experienced, e.g., by users and customers confronted with fully automated call centers or on-line shops without human operators involved. It needs only small deviations from the standard routine or process and the system cannot handle the requests. Currently, there is in some cases still the option to request a human operator, but it is getting less and less available. One can also experience rigid behavior of recommendation systems. Hotel reservation portals repeat irrelevant recommendations for hotels in cities where the traveler stayed for 1–2 days but departed and moved on already some time ago. He is not even in the same country anymore and his city of residence is in another country on another continent. Thus, it is not very likely that he needs a hotel room in the same small town where he stayed 6 months ago. On-line shops offer items of the same specific category which were just bought, although it should be obvious that there is no need of multiple instances of this type of object in the same category an hour or one day after the purchase. There are endless more examples of these types but no space to describe them here. Riedmann-Streitz (2018) discusses these issues in the context of customer relationship management and states "Customer Centricity needs to be redefined so that it respects the human being as it is and adapts technology as supporter, enabler, providing added value to him".

Especially with call-centers, people become desperate, if there is no human operator to turn to for resolving the situation. One is not only questioning the pretended 'intelligence' of these systems, but moreover the lack of it when thinking of their developers. These systems are depriving people of their right to get appropriate services, individual attention and treatment. In many cases, one might even suspect the system is programmed on purpose not to understand, resp. not to react to certain inquiries, especially complaints about problems with products, so that the company can avoid dealing with them. The problem is that users and customers are and will be in the future even more completely at the mercy of such systems and in loss of control due to fully automated configurations of service centers.

2.3.3 Problem Set C: Missing transparency, traceability and accountability of AI

Missing transparency, traceability and accountability is a looming issue of artificial intelligence and the most relevant problem of the 'smart-everything' paradigm. Even if—or should one say especially once—most of the problems presented above in set A and B are solved due to further progress, 'AI behavior' will increasingly become neither transparent nor comprehensible and thus not accountable.

Incomprehensible decisions are and will stay with us as an essential problem. Being untraceable implies in some way that there are no reproducible outcomes and, therefore, also a lack of accountability and liability. We are already now confronted with the lack of transparency, as demonstrated in the financial domain with high frequency trading, not speaking of how this will develop in the future. When nobody can trace the underlying argumentation or mechanisms, we really have a serious problem. While this problem was not addressed for a long time, it is now getting more into the focus, because AI-based applications are spreading and are advertised to be the solution to almost every problem companies are facing. According to Hutson (2018), Peter Henderson (McGill University, Montreal), showed at the recent AAAI conference on AI that the performance of machine learning algorithms designed to learn by trial and error is highly sensitive not only to the exact code used, but also to the random numbers generated to kick off training and to 'hyperparameters' (settings not core to the algorithm but affecting how quickly it learns). Henderson ran several reinforcement learning algorithms under different conditions and found wildly different results. This relates to the issue of reproducibility, resp. the lack of it, because it is very difficult to reproduce many key results, especially when benchmark's source codes as well as the training data are not published.

Thus, it is not surprising that these types of AI 'black boxes' are very critically reflected. An example is the 2017 report of the AI NOW research institute of New York University (NYU) providing also recommendation for how to address these issues (AI NOW 2017). AI black boxes[2] are not only rejected by 'normal' users/ citizens, but also by companies, authorities and regulators (e.g., Financial Stability Board 2017), because they fail to meet the regulatory, compliance and risk management requirements. Especially institutions dealing with sensitive data, e.g., personal health and financial information are critical and ask for traceability of decisions. The White House report "Preparing for the Future of Artificial Intelligence" (White House 2016) addresses several of these issues. One is 'algorithmic responsibility' (Datta et al. 2016). The report asks for establishing practices and protocols to build understanding and trust in the construction and mechanisms of fundamental algorithms in software code. But it is still an open research question how valid the proposed black box testing with fictional data sets will be for real life data. It will be extremely difficult to know how the most advanced algorithms do what they do, because even many of those researchers working with highly complex models and deep learning admit, that they cannot explain why certain decisions were taken by their systems (see, e.g., the interviews in Knight 2017).

In this context, it is interesting to note that the EU General Data Protection Regulation (EU-GDPR 2016) taking effect in May 2018, includes specific articles on the right to obtain an explanation of how personal data are being processed by the algorithms of a company, how decisions are made and a right to opt-out of some algorithmic decisions. GDPR mandates that companies will need to have the ability to explain exactly how they reach certain algorithmic-based decisions about their customers. There are very high fines (up to 4% of annual global turnover or € 20 Millions) in case companies are not compliant with these regulations. Thus, it should be of advantage for every business to employ a 'transparent AI' approach assisting you to meet the GDPR regulations. A related attempt to address these issues is the IEEE Global Initiative for Ethical Considerations in Artificial Intelligence and Autonomous Systems (IEEE Initiative 2017).

The issue of transparency, traceability and associated credibility as well as accountability will stay with us and become bigger as AI addresses new domains and processes with longer chains of responsibility in public and private institutions as well as in businesses.

In summary, feasibility problems and transparency deficits must be considered as strong warning signs, especially when looking at the planned abundance of automating everything and seeking refuge and solutions in AI environments completely automated and operated by algorithms. An alternative option is presented by adopting the Ambient Intelligence approach described in Sect. 2.4 and combining it with the proposal of 'keeping the human in the loop and in control' presented in Sect. 2.6.

2.4 Ambient intelligence, disappearing computer and IoT

The term 'Ambient Intelligence' (AmI) is more recent compared with AI. It was created in the late 1990s in the context of activities initiated by Philips[3] and prominently publicized by Emile Aarts (Philips). In addition, it became known via the activities of the IST Advisory Group (ISTAG) of the European Commission (ISTAG 2001). AmI is building on the ideas of Ubiquitous Computing proposed by Mark

[2] For a complete picture of AI, it must be noted that there are also rule-based systems and approaches that are deterministic in nature. Not all AI methods involve 'black boxes' also called 'opaque AI'. Nevertheless, increasing complexity can result in situations, where even AI experts encounter problems with explaining why and how decisions were reached. People must be able to trust the outcome and the decisions, which is a lot easier with what is called 'transparent AI'.

[3] For a description of the history of AmI see Aarts and Encarnacao (2006).

Weiser around 1990 at Xerox PARC and communicated to the scientific community in his seminal article in Scientific American (Weiser 1991). Although Weiser addressed with his proposal of a 'calm technology' also the relationship of ubiquitous technologies and the perception and behavior of people, most of the follow-up research in ubiquitous computing took a rather technology-driven route. In contrast, the AmI proposal promotes an approach with a more elaborated emphasis on user-oriented design, the human perspective in general as well as on the social context addressed by social interfaces.

Complementing the ISTAG activities, a line of research with a similar spirit was funded by the Future and Emerging Technology (FET) program of the European Commission: 'The Disappearing Computer' proactive initiative (DC 2000–2005), a cluster of 37 institutions from academia and industry in 13 countries participating in 17 projects. The Disappearing Computer approach as described in Streitz (2001) was inspired by and shared several aspects of Weiser's notion of calm technology (Streitz 2008). The DC approach and the results of the DC initiative can be found in a special issue of the Communications of the ACM (Streitz and Nixon 2005) and a state-of-the-art book (Streitz et al. 2007a, b).

The mission statement of the ERCIM Working Group SESAMI (Smart Environments and Systems for Ambient Intelligence) chaired by Savidis and Streitz (SESAMI 2007) summarizes the key features of AmI in a very appropriate way:

> "Ambient Intelligence represents a vision of the (not too far) future where 'intelligent' or 'smart' environments and systems react in an attentive, adaptive, and active (sometimes even proactive) way to the presence and activities of humans and objects to provide intelligent/smart services to the inhabitants of these environments. Ambient Intelligence technologies integrate sensing capabilities, processing power, reasoning mechanisms, networking facilities, applications and services, digital content, and actuating capabilities distributed in the surrounding environment. While a wide variety of different technologies is involved, the goal of Ambient Intelligence is to either hide their presence from users, by providing implicit, unobtrusive interaction paradigms. People and their social situations, ranging from individuals to groups, be them work groups, families or friends and their corresponding environments (office buildings, homes, public spaces, etc.) are at the center of the design considerations".

This description is still valid now 10 years later without much to add, except maybe the explicit mentioning of more comprehensive application scenarios like smart cities, smart airports, or 'smart everything' being investigated in this decade and in the future. This includes also a shift from embedded or attached sensors and actuators to 'smart ecosystems' addressed in Sect. 2.5 of this paper. The human-centered design approach of AmI with its attention to social interfaces will be revisited when it is applied as citizen-centered design placed in larger social urban contexts as, e.g., smart cities.

The more technology-driven approach of the ubiquitous computing community experiences its revival as the Internet of Things (IoT) and in specific application areas as Industrial Internet or Industry 4.0. The underlying idea evolved from research on RFID and is rather straight forward: every physical object is connected to/ communicates with the Internet and thus—in principal—with every other object. This can be realized in different ways, e.g., by attaching sensors to monitor different properties of the object and communicating its state changes. It corresponds to the notion of creating a 'digital shadow'[4] of an object and relates to the concept of a 'hybrid world' denoting the combination of real and virtual worlds in a computer-augmented environment. An example of a 'hybrid world' was our proposition of a 'cooperative building' (Streitz et al. 1998), which "originates in the physical architectural space but it is complemented by components realized as objects and structures in virtual information spaces". There will be no complete one-to-one mapping, because there might be real objects with no virtual/digital counterpart and virtual objects with no real counterpart. A related realization is that every object gets an IP address and communicates with the internet and other objects/devices as an IP-enabled device. This will be possible by extending the current IP address space as planned with the most recent version IPv6 of the Internet Protocol as a key enabler of the future Internet of Things. Furthermore, these 'smart objects' have sensors to observe their surroundings and thus 'know' about their context.

An extension of IoT is called Internet of Everything (IoE), a term developed at Cisco, where people, processes, data and things are connected and become part of the overall network structure. This includes machine-to-machine communication (M2M) as well as machine-to-people (M2P) and technology-assisted people-to-people (P2P) interactions. One can, of course, extend the range of living organisms from people to animals and plants. Work on smart farming and agriculture is lending itself in this direction. Although people are listed as part of the IoE equation, this does not necessarily mean that IoE is following a human-/people-/citizen-centered design approach. It seems that people are considered as being only nodes in the IoE network. In contrast, Ambient

[4] This is not to be confused with the notion of a 'digital footprint' or 'digital traces' which refer to a set of traceable digital activities, actions, contributions (e.g., in social media networks).

Intelligence—as defined above—puts people and their social interactions at the center of its design considerations and thus in the driver seat and in control.

Many of the now intensively discussed relationships between Ubiquitous Computing, Internet of Things, Disappearing Computer, Artificial Intelligence and Ambient Intelligence were in part described and investigated in an extensive book chapter by Streitz and Privat (2009). These ideas and subsequent discussions provided a basis for several concepts and proposals formulated in this paper.

2.5 Smart ecosystems

While the current approach in IoT and the application domain 'smart city' is mainly determined by distributing, embedding and attaching individual sensors and actuators, the author predicts a shift towards a computing, communication, sensing and interaction 'substrate' that can be handled at the application or domain level. Outdoor examples would be smart street-surfaces (e.g., taking the idea of solar roadways by Brusaw and Brusaw 2016 a step further), building façades and windows; indoors you will find smart table-cloth, smart wall-paper and smart paint. It requires a seamless integration of components with a high degree of diffusion leading to an emergent smartness of the overall environment that might soon parallel other existing ecosystems. Its realization depends on results in the area of 'smart materials' (e.g., Fraunhofer ISC; Araujo and Mota Soares 2017), a difficult but promising area of research. Results exist for smart textiles (Schneegass and Amft 2017) and as steps towards smart wall-paper. Example: a 'Wallpaper-TV' (2.57 mm thin and 88 inches large) was shown by the Korean manufacturer LG at the Computer Electronics Show (CES) in 2017 and 2018. It is a flexible display seamlessly mounted to the wall with small magnets. At a smaller scale, but showing similar features is a smartphone with a foldable display which can be unfolded for providing a tablet mode. This was announced by Samsung to be available as a product in late 2018, early 2019. Note: these examples are provided to demonstrate real progress, because they are no research prototypes anymore, but consumer products.

An interesting approach is the above-mentioned initiative on Solar Roadways (Brusaw and Brusaw 2016). It combines several design goals and innovative features: Solar panels for generating energy, on which cars can drive and people walk. The panels contain LED lights to create lines and signage on them without using paint, which—in addition—can be employed in a flexible on-demand fashion. They contain heating elements to prevent snow and ice accumulation. Built-in microprocessors allow for a range of smart functionality by communicating with each other, with central facilities and the vehicles driving on the panels. There is no space here to describe the promises of this activity over traditional surfaces made of concrete or asphalt. The long-term, but worthwhile vision of these efforts is: if all concrete and asphalt surfaces that are exposed to the sun are covered with solar road panels, it would end our dependency on fossil fuels for generating energy. There is also some criticism of the approach, some due to conceptual issues (no slanted angle of solar panels on horizontal surfaces in comparison to traditional skewed installation designs), some criticizing problems of the implementation (details at https://interestingengineering.com/solar-roadways-engineering-failure). In any case, it seems to be a worthwhile idea to question and rethink the way how streets and other surfaces in our urban environments are currently built and to stimulate new approaches with multiple innovative implications.

In the envisioned ubiquitous smart ecosystems, the computer disappears as a 'visible' distinctive device, either physically due to being integrated in the environment or mentally from our perception (Streitz 2001, 2008), thus providing the basis for establishing a calm technology as it was envisioned by Weiser (1991). It is also the core of the 'Disappearing Computer' approach (Russell et al. 2005; Streitz and Nixon 2005; Streitz et al. 2007a, b) mentioned earlier. But it is to be noted that the 'disappearance' feature has also serious implications for privacy issues to be discussed in Sect. 5.8 on 'urban spies'.

2.6 Keeping people in the loop and in control

While the observations and comments in Sect. 2.3 and their implications sound disillusioned, the author proposes an alternative or at least complementary approach for redefining the 'smart-everything, everywhere and every time' paradigm for reconciling people and technology. It is based on earlier work on two types of smartness more than 10 years ago (Streitz et al. 2005). Since the approach is still valid and addresses an increasingly important and pressing issue in the context of smart cities, a more recent and adapted version of the approach was presented in Streitz (2017). A longer and more extensive discussion and reflection is provided now in this paper. It reflects the design approach of Ambient Intelligence, an account of which was provided in Sect. 2.4. The proposal distinguishes between 'System-Oriented, Importunate Smartness' and 'People-Oriented, Empowering Smartness'. An environment can be considered 'smart' if it enables certain self-directed (re)actions of individual artefacts or ensembles of artefacts based on continuously collected information about the artefacts, and people involved, their activities and the overall context. For example, a space can be 'smart' by storing and exploiting knowledge about which people and artefacts are currently situated within its area, who and what was there before, when and how long, and what kind of activities took place. In addition, this environment could be equipped with smart materials as described before in Sect. 2.5 on smart ecosystems to facilitate some of the features.

2.6.1 System-oriented, importunate smartness

In this approach of providing 'smartness', the space (room, house, vehicle, city, …) would be active (in many cases proactive) and in complete control of the situation by making decisions on what to do next and actually take actions and execute them without a human in the loop or in control. It exhibits automated or even autonomous system behavior based on the interpretation of collected data and in combination with given constraints and predefined rules or acquired behavior patterns, e.g., via machine learning methods.

Some of these actions and behavior could be importunate or misdirected. Take the now almost classic example of a smart refrigerator in a smart home analyzing consumption patterns of inhabitants and autonomously ordering depleted food. While we might appreciate that the fridge makes suggestions on recipes that are based on the food currently available (but we are still in control of what is finally prepared and served), we might get very upset in case it is autonomously ordering food that we will not consume for reasons beyond its knowledge, such as a sudden vacation, sickness, or a temporal change in taste or diet. The smart home locks me out, because my voice pattern does not match anymore the pattern stored in the data base due to a temporary illness or—very simple—the server of the front door access app is down or lost its connection to the network. If there is no human inside to open the door or no mechanical device to get access, the home inhabitant is in big trouble. The smart, autonomous car drives too fast at a dangerous high speed or takes us to a location we did not want to go to, but we cannot stop it. One can, of course, list many more examples of misdirected and importunate behavior of automated and autonomous systems without an option for human intervention, but with severe consequences.

2.6.2 People-oriented, empowering smartness

The above approach of providing smartness is contrasted by another perspective where people-orientation and an empowering function is in the foreground. The basic idea is a forward projection of the human-centered design approach. The design should not only consider the existing knowledge for achieving an ergonomic human-technology interaction, but it should "keep the human in the loop and in control" (Streitz et al. 2005; Streitz 2017). One could restate "being in control" by saying that "people should own the loop". The major requirement is, that people are empowered by being in control and are not at the mercy of an automated system. This approach can be extended and summarized in the headline "smart spaces make people smarter" which is described in more detail in the next Sect. 2.7.

These two types of smartness might not exist in their pure and distinct manifestations. They rather represent the end points of a dimension where weighted combinations of both are employed. This shows the need for design trade-offs between human control and being in the loop vs. automation with no human intervention which is discussed in Sect. 4.2. The goal is to have a balance between human control and automated behavior. In this context, it is interesting to note, that Shneiderman et al. (2016) changed the name of a section in the 6th edition of their book "Designing the User Interface" from previously "Balancing human and machine control" to "Ensuring human control, while increasing the level of automation". One could argue whether increasing automation should be the goal, but the combination with ensuring human control is for sure a non-disputable requirement.

2.7 Smart spaces make people smarter

Beyond owning the loop and being in control, an empowering function is proposed. It is achieved by providing information and facilitating conditions for making informed decisions and taking actions as mature and responsible people who are in control. This can be summarized as "smart spaces make people smarter". In this approach, sensors in the environment will also collect data about what is going on and aggregate them up to a certain level. Important is now, that the space does not operate automatically and autonomously, but communicates the resulting information as guidance for subsequent actions, which are still determined by a person. In this case, a smart space or system makes suggestions and recommendations based on the information collected, but humans still have the final say and make the decision. The space supports and enables smart behavior of people. This type of approach is getting popular as work on soft actuation in smart environments shows (Domaszewicz et al. 2016). The people-oriented, empowering smartness is in line with the objectives of the Ambient Intelligence approach described in Sect. 2.4.

There is, of course, a caveat concerning the "human in the loop and in control" proposal that is not to be underestimated: How much feedback and recommendations from the system do users want? How many data can users process? At which level of the data collection and aggregation process do users want or are able to be involved? In some cases, it might be useful that a system is not asking for user's feedback and confirmation for every single step in an analysis, diagnosis and action chain, because this would result in an information and processing overload. The challenge for system designers is to find the right balance. But despite the caveats, the important point is that human intervention and control is possible and therefore has to be part of system design at an early stage. The data collected belong to the people and should be exploited by them in a transparent fashion. Therefore, it is important to note that the comments made in Sect. 2.3 on transparency and traceability of algorithms in general and AI in particular are relevant here, too. In case of suggestions on complex situations provided to the users by a smart system, it should be possible, to obtain an explanation or the rationale of the suggestions provided by the underlying algorithms, and to have a right to opt-out or to make a different decision. This is also a requirement of the European regulations of the EU-GDPR (2016), mentioned before in Sect. 2.3 and revisited in Sect. 3.2. The degree of automation must be configurable by the user. The overall design rationale should be guided and informed by the objective of "keeping humans in the loop and in control" as much as possible and feasible.

The concept of "smart spaces make people smarter" can also be expressed with a different metaphor: "the smart space is a cooperative space". This implies that the space functions like a companion supporting users, inhabitants, citizens in a cooperative fashion. The space provides status information, advice, guidance and suggestions but does not make the final decisions. This view was also reflected in the very early work on 'cooperative buildings' (Streitz et al. 1998), where the term 'cooperative' was preferred over the term 'intelligent'. The concept and its terminology is also applied to the authors redefinition of a 'smart' city which is now conceptualized as a 'Cooperative City' (Streitz 2017), presented and discussed in detail in Sect. 6.

3 Privacy revisited

It is difficult to define privacy. Like trust and security, it is easier to describe, when there is a loss of it, when we do not have it anymore. Nevertheless, one can refer to Webster's International Dictionary who describes privacy as "the quality or state of being apart from the company or observation of others" and continues with "isolation, seclusion or freedom from unauthorized oversight or observation" (Webster 1981). This can be used as a guideline for the subsequent discussion.

3.1 Privacy as a legal and moral right vs. being a commodity

Privacy is considered a universal human right and is the subject of many international declarations and national constitutions, which are still valid. They were stated at a time when private life was considered as a normal state of affairs and people lived with no additional precautions.[5] Privacy was a legal and moral right, in many cases a socially negotiated feature. People had a clear understanding of borders and limits between private homes and public streets, buildings and public spaces, between a private person and public institutions. Privacy was secured, e.g., by a sealed envelope of a letter. In some interpretations, privacy is considered as "the right of people to conceal information about themselves that others might use to their disadvantage" (Posner 1981).

Now, in the digital age, this basic right seems to be in danger of being forfeited. Some people consider privacy old-fashioned. The appearance of terms like 'post-privacy' (Heller 2011) and 'post-privacy economy' (Weigend 2017) does not promise a bright future for privacy. Privacy is at the borderline of turning into a commodity one pays for or one has to 'trade' (in exchange for personal data)—with the implication that privacy is becoming a privilege. Many people are not aware that the loss of their privacy is the price they pay for seemingly free products or services, especially in the context of search engines, browsers, on-line shops, and social media like Facebook, Google, Baidu, Twitter, WhatsApp, WeChat, Amazon, Alibaba, etc., because they pay with their data. Just keep in mind: as long as you do not pay for a service or product, you are not the customer, you are the product being sold!

When discussing privacy, one should distinguish between two aspects: Outgoing data (being collected via logging, monitoring, tracking, and surveillance) vs. incoming data (resulting from intrusion, unsolicited communication). The focus of the current discussion is primarily on privacy infringement via data collection, tracking, etc., especially in the virtual/digital world. But unsolicited advertisement and intrusions are also a curtailment of our privacy. A good account of the problems of intrusions and how to handle them is provided, e.g., by Espinoza et al. (2007). Both developments have severe consequences, and, in many cases, they are combined. First tracking and then intrusion by unsolicited advertisement.

3.2 Privacy by design and privacy by default

To counteract these challenges, privacy enhancing technologies (PETs) are called for and therefore subject of research and development. PETs originated in the work of a joint team of the Information and Privacy Commissioner of Ontario, Canada, and the Dutch Data Protection Authority in 1995 with their first report on Privacy Enhancing Technologies. Closely related is the approach of 'privacy by design' (see e.g., van Rest et al. 2012). The approach demands to make 'privacy' a first-order objective of system design and engineering and to embed it throughout the entire life cycle of technology development. It is an important approach

[5] Here, we do not address activities of secret services or criminal investigations.

which needs much more attention and impact as part of the overall design considerations. But it is a difficult business, because it implies requirements as, e.g., "specific rules to impose 'privacy by default' settings" and "to introduce the principle of 'accountability' for organizations to demonstrate compliance" (Hustinex 2010). How to engineer privacy by design is described by Gurses et al. (2015). There was also a cross-projects effort on PETs in the Disappearing Computer Initiative (Streitz et al. 2007a, b), because the disappearing computer approach creates a difficult situation. How can people recognize and identify that sensors for collecting data are present when they are embedded and hidden in the environment? This relates to the discussion on how to design 'affordances' (Streitz et al. 2007b) for the interaction in a smart environment, where the computer disappears, because it is integrated in the environment and thus not visible. This aspect will become especially important in the smart city context (see Sect. 5.7, 5.8). A good overview of the current work on PETs is provided in the proceedings of the annual symposia on PETs (see PoPETs website).

Privacy by design and PETs are relevant measures to facilitate privacy for users and citizens. But they must be supported by regulations and legislation. In Germany, legislation exists already for some time (since 1983). It states that personal data belong to the citizens and cannot be collected and used without their consent ("Recht auf informationelle Selbstbestimmung"). In Europe, there is the Data Protection Directive effective since 1996. Soon, it will be superseded by the General Data Protection Regulation (EU-GDPR 2016), adopted in April 2016, to be enforced starting in May 2018. This will be soon complemented by the ePrivacy directive of the EU currently under discussion.

While users are welcoming increasing privacy efforts, entrepreneurs and business people in Germany and Europe often complain that they have a disadvantage because of restrictive regulations on privacy, data collection and security compared with their competition in the US or in Asia. In contrast, the author takes an unequivocal stand on protecting and ensuring data security, personality rights and privacy. In addition, the author proposes that what is currently felt as a disadvantage, might soon turn out to be a competitive advantage, because it will allow to offer new business models where privacy and security is a USP (unique selling proposition).

A good example of such a change of perspective was provided by the country of Iceland many years ago. After the financial crisis, Iceland had to think about new business models. They did that by putting together a package of the following measures: offering safe and secure physical facilities for servers (provided in abandoned NATO bunkers), providing cheap and clean energy for the server clusters by exploiting their geothermal resources, routing a new separate secure sea link cable between Iceland and Denmark (to avoid the supervised main internet hub in Great Britain) to provide secure access for users in continental Europe, and, finally, passing laws on a compliant legislation supporting privacy and security. The whole package constitutes a USP for Iceland. The model works very well, and Iceland acquired interesting clients ranging from known car manufacturing to software development companies.

This example shows that the claim for privacy is more than a liberal rights movement as some might denigrate it. The author is convinced that 'privacy by design' can be a competitive advantage, a USP in the global market, where Europe can take a lead by reflecting on its basic democratic and ethical values. In addition, this will be enhanced and facilitated by the new General Data Protection Regulation (EU-GDPR) taking effect in May 2018. There is an important and by non-European companies often neglected aspect, i.e. the EU-GDPR apply to all companies doing business in Europe and not only to European companies.

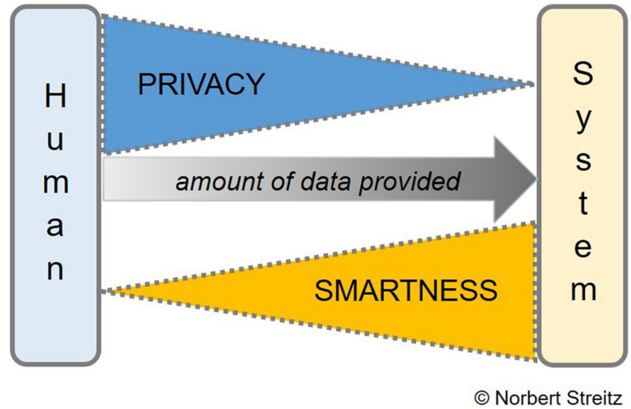

Fig. 1 Design trade-off between privacy by control over personal data vs. degree of smartness provided by a smart system or service

4 Decision and design trade-offs

4.1 Privacy vs. smartness

There is a tricky trade-off between creating smartness and providing or maintaining privacy. Obviously, a smart system can usually be 'smarter' with respect to a service offered, if it has more knowledge about the person compared to a system with no or insufficient data. Thus, there is a trade-off between collecting and processing data for tailoring functionality to make the system 'smart' and the right of people to be in control over which data are being collected, by whom and how they are used, i.e. the issue of privacy. The challenge is now to find the right balance. Determining the balance—under the control of the respective person—requires transparency about the options, which are not always provided by the different companies. The discussion of the 'smartness vs. privacy' trade-off (see Fig. 1) requires to address the conflict between unobtrusive data collection and human control over the data to be considered at an early stage of the overall system design and not to make it an add-on after the design and implementation process has been finalized.

The point to be stressed here is that this trade-off should be transparent and made by the people who own the data in the first place. People often provide data for certain benefits (e.g., loyalty/payback cards, lotteries, sweepstakes) and it seems to be a conscious decision. But one can argue if it is always also an informed decision because many people are not aware of the real equivalent value of the data they provide. In this context, one must mention that there are also unnecessary trade-offs proposed. For example, why does a flash light app on a smart phone require to have access to the list of phone calls and the address book with all contacts? These data are not necessary for providing the flash light function.

Unfortunately, trade-off procedures are in most cases neglected and people are not offered a choice. This is the reason why 'privacy by design' and 'privacy by default' must be adopted as guiding design principles (see Sect. 3.2).

For a complete picture of the story, one cannot ignore the fact that data are voluntarily provided and uploaded by people, be it as unsolicited 'selfies' and videos in social media networks, augmented glasses recordings of activities or sensitive health data being part of a fitness or 'quantified self' health app. These data are often stored on the server of a provider in a foreign country with very weak or no legislation to protect privacy and security. This shows that much more information and education is needed to demonstrate the implications and consequences (sometimes with delayed effects) of this behavior. People should be free to do whatever they want. Therefore, systems must be designed in such a way that people have the freedom to make a conscious choice to decide on the trade-off parameters.

4.2 Human in the loop and in control vs. automation

Once people have decided that they are willing to provide personal data for obtaining a smart service in return, there is still the open issue of how much control they have over the actual realization of the smart service. Are they still in the loop to determine how the smart service is provided? Can they still intervene, take control and regulate or even stop the smart service or are they confronted with an automatic system behavior with no option of human intervention?

In the previous Sect. 2.6, a "system-oriented, importunate smartness" approach was contrasted with a

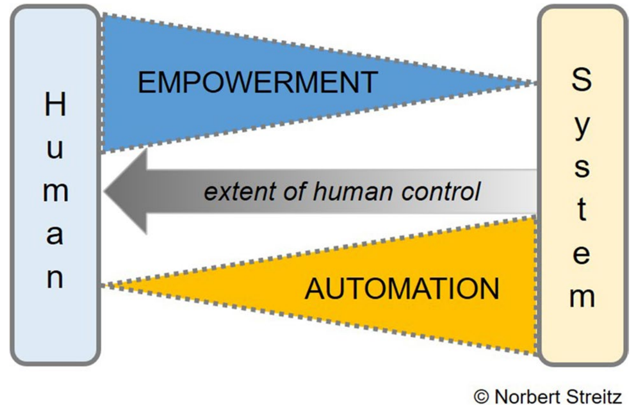

Fig. 2 Design trade-off between human empowerment and system automation depending on the extent of human control maintained

"people-empowering smartness" approach. As pointed out, the two types of smartness might not exist in their pure and distinct manifestations. They rather represent the end points of a dimension where weighted combinations of both can be positioned. The goal is to have a balance between keeping the human in the loop and in control and automated system behavior, in many cases even autonomous behavior. Thus, one can also look at it as a design trade-off to be made between "human control vs. system automation" (see Fig. 2). The important aspect is that the design trade-off should not be a fixed decision made by a system designer, who determines where on this dimension a system is to be positioned. System design should allow for flexibility and rather make possible variations accessible under the control of the user (Fig. 2). What kind of combination and balance will finally be implemented and chosen depends very much on the application domain, the profiles of users and citizens and the degree of automation possible without risking too much, because technology might not be mature enough (see, e.g., the discussion on autonomous cars in Sect. 2.3.1).

Obviously, there is a close relationship to the general discussion on redefining the 'smart-everything' paradigm. It is worthwhile to repeat at this point the comments on autonomous driving made by the NTSB board member Christopher Hart on the final report about the deadly Tesla accident (see Sect. 2.3.1, problem set A) issued by the National Transportation Safety Board (NTSB 2017): "This crash is an example of what can happen when automation is introduced 'because we can' without adequate consideration of the human element". Hart compares the present autonomous driving situation with the introduction of automation in the aviation industry and comments that the auto industry has not learned from aviation's mistakes. With reference to the aviation industry, Hart stated: "That resulted in an evolution toward human-centric automation,

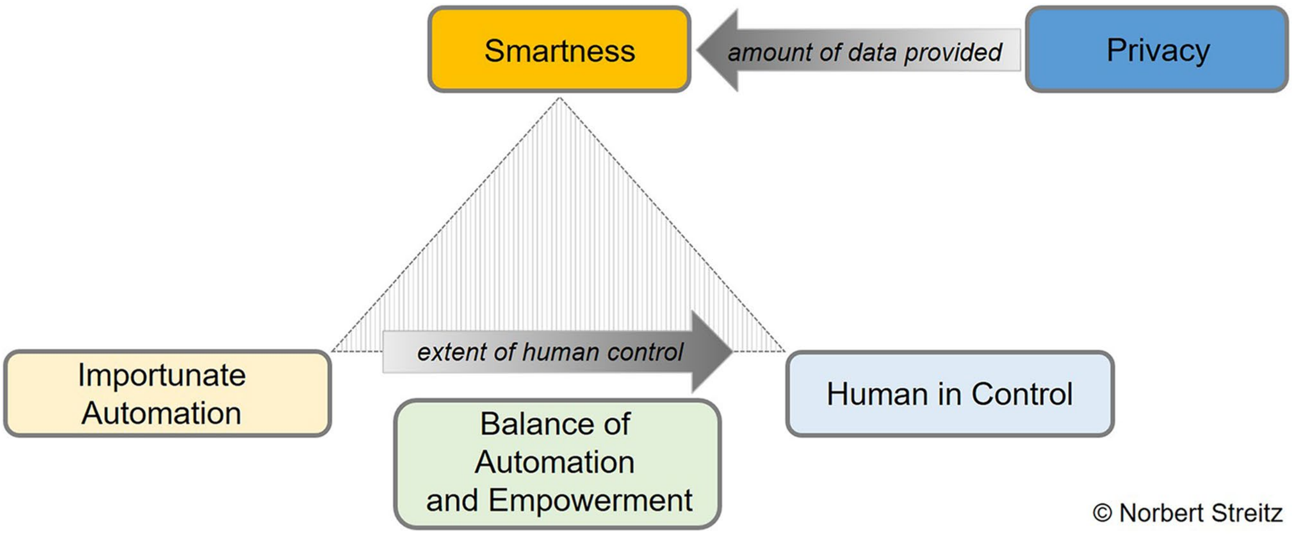

Fig. 3 Combined view of the two design trade-offs indicating the desired provision of smartness provided by a balance of partially automated system support and human control and empowerment at the same time. Design should allow for different mixtures with more or less human control possible

in which the objective was improving the overall performance of the human-automation system". This view is reflected in our objective to strive for people-oriented empowering smartness (Sect. 2.6.) and implies that people are in the loop and in control. Finally, in everyday life encounters with smart systems, people should also be able to decide what kind of smartness they want. Thus, the design trade-off is also a decision trade-off by the users as described in the next Sect. 4.3.

4.3 Combination of design trade-offs

It is now an obvious follow-up activity to discuss the combination of the two trade-offs described before. While the trade-off between privacy and smartness depends on the amount of data provided to the system for further processing, the trade-off between being in the loop and in control vs. automated system behavior is determined by the degree of control maintained by the human. Data provided by the human to the system are combined with additional data collected by the system. The combination is processed and aggregated to a certain level, interpreted by the system in a semi-automated fashion and then communicated to the human providing the basis for a decision by the human. Therefore, we talk about 'empowering' smartness which allows for a mature and informed decision of the human and subsequent actions and behavior. In Fig. 3, we present a combined view of the two trade-offs. It shows that we have dependencies between the two. Especially, one can observe the potential for a range of different manifestations or degrees of smartness. This means, that the trade-off options are initially prepared by the designers, but then they are appropriated by the users when making conscious decisions about which and how many data they provide and which level of control they want to maintain. Our elaborations provide a framework which then has to be populated with specific parameters for different application domains.

5 Beyond 'smart-only' cities

While the previous analyses and elaborations are meant to shed light on the general issues of the 'smart-everything' paradigm and the general design trade-offs to be encountered, this section applies the general ideas to the application domain of urban environments. Urban environments are experiencing dramatic changes on many dimensions. Only a few can be named here. There is the increase in population caused by the migration from rural areas to cities with all its complex implications. There is the challenge to cope with the increase in transportation needs which results in too much traffic and its ecological implications for the environment and the health of people. And then there is the increasingly propagated proposal that cities must be transformed into 'smart' cities. Some proponents argue that this might solve many or all the problems cities are facing today. It remains to be seen whether the promises of such a technology-driven ubiquitous instrumentation of our urban environment can be delivered and what are the consequences for individuals, communities, social coherence and society in general, especially if there is no citizen-centered design approach employed.

This chapter presents examples which serve as the basis for why and how re-thinking and re-defining of the 'smart-everything' paradigm can be applied with the implication of moving beyond 'smart-only' cities and propagating Humane, Sociable, and Cooperative Cities as described in the final Sect. 6.

5.1 The context of urban age

An important context is provided by numbers from the United Nations. World population will rise from 7.3 billion in 2015 to 8.5 billion in 2030 and 9.7 billion in 2050. Population in cities will rise to about 6.5 billion in 2050. Then, 2/3 of the world population will live in cities with the growth taking place especially in Asia and Africa, where we can observe how migration and urban construction result in so called 'mega-cities'. Due to the fact that more than 50% of the population are living already since several years in urban areas, cities have been and will increasingly become the central hubs of determining life in the 21st century, resulting in what has been called the 'Urban Age'. While this context is always to be kept in mind, the focus of this article is on the role of information and communication technology (ICT) for designing future cities. Beyond this, a wide range of issues exist, including socio-economic, ecological, sustainability aspects. They are very important, but beyond the scope of this article here. Furthermore, it should be made clear that the smart city proposal could be only one way of addressing some of the problems in the urban age. And it will only be convincing, in case that cities are designed according to the goals elaborated later, i.e. towards Humane, Sociable, and Cooperative Hybrid Cities. In any case, it is only one perspective and not at all a comprehensive solution for all the problems cities and society are facing today and even more in the future.

5.2 Urban environments as hubs and transient spaces

Quality of life and economic prosperity will largely depend on the ability of cities to exploit their full potential and to manage the necessary transformations. Therefore, it is important to explore the type and range of different activities in urban environments. Contemporary life styles become less focused and increasingly multidimensional. People's lives are taking place betwixt and between multiple offers and options. People's roles change within short time frames due to polyphasic activities in co-located and distributed situations.

Urban environments are characterized by a multitude of features and built instantiations. While the majority is determined by living quarters, a larger variety of challenges can be found in public administration and enterprise office buildings, industrial facilities, markets, shopping and entertainment facilities, restaurants, hotels, sport facilities, parks, places, streets, bridges, towers—just to name a selection. Buildings and spaces have their infrastructures and are populated by people, animals, plants, vehicles and other mobile as well as stationary objects. This list is not intended to be complete. It only serves the purpose of providing context for the following reflections. In this article, the discussion is mainly limited to applications in public urban spaces. Nevertheless, these considerations and requirements can also be applied to smart office buildings and smart homes as shown in previous EU-funded projects (see websites of Ambient Agoras, Amigo).

Public spaces stand out from the rest, because they are accessible to all citizens, often serving in a 'hub function' connecting many of the urban objects listed before. The public parts of most urban environments (e.g., streets, parking lots, places, markets, parks, bridges, foyers, shopping malls, passenger areas in train/bus stations and airports) can be characterized as 'transient spaces', a term used primarily in architecture, but it has multiple connotations, e. g., also referring to the temporary existence of spaces. Within the limitations of this paper it is not possible to explore the concept of transient spaces in full detail here. We understand 'transient spaces' in the urban and public context as spaces that are designed to accommodate a degree of mobility of people passing-through (e.g., getting from the entrance of the airport to the check-in area or the boarding gate) or by staying in such a space, e.g., in a waiting area, for a limited period of time, although it can sometimes turn out to be unexpected long when the plane is delayed or the train/subway/bus is even canceled. The focus is here on public transient spaces that require special design considerations.

5.3 Airports viewed as transient cities

Airports are good examples of transient spaces, because passengers, crew members and other temporary personnel stay only for a limited period. On the other hand, the range and type of activities are very similar to activities of people in public spaces of cities; just think of the types of services and opportunities offered (shopping, restaurants, bars, gaming and entertainment). Thus, one can consider airports as 'transient cities' (Streitz 2015a) and model airports with respect to several dimensions as scaled down cities with a prominent existence and distribution of transient spaces, especially when taking the passenger perspective.

While there is currently a strong emphasis on designing future cities, the application domain of 'future airports', is discussed only in limited communities. This is surprising, because airports are already now very important hubs of transportation and logistics activities and their relevance increasingly affects millions of people. One can compare the role of airports in this century with highways in the twentieth century, railroads in the nineteenth century and seaports in the eighteenth century. Furthermore, it is a very interesting domain for research and studies due to its well-defined locality and usage scenarios. Thus, many of the remarks made about design issues of smart cities can be applied to smart airports.

5.4 Different notations for smart cities

The idea of transforming cities into 'smart' cities has been around for quite some time using different terms. It is not the intention of this paragraph to provide a historical account or a comprehensive overview on smart city projects, but to shed some light on different interpretations and connotations.

In the 1980s, the term 'wired' cities was used, inspired by the book of James Martin "The Wired Society" (Martin 1978). In those days, the focus was on how cable, telephones and other wired media were changing the infrastructure and thus our access to information and services.

Another term was 'Digital City' or 'Virtual City'. These were early notions with no concrete relations to 'real' cities. Examples are 'De Digitale Stad' developed in Amsterdam, which was operational during 1994–2001. Rooted in this tradition, Amsterdam has now a wide range of 'smart city' projects (see website Smart Amsterdam).

'Second Life' with using avatars was started in 2003 by Linden Lab in the US. It was a big hype where every company wanted to be represented and a lot of money was invested. It still exists, but the interest was lost, and younger people do not even know it anymore.

More recently, Digital City is being used again in parallel to Smart City, e.g., Digital City Wien.

'Ubiquitous City (u-City)' is another term, reflecting a concept with a strong focus on technology and infrastructure. It applies a ubiquitous computing infrastructure for the functionality of urban systems providing ubiquitous services. The term was very popular in South Korea. A well-known elaborated example is Songdo in the vicinity of Incheon, the airport of Seoul, and part of the Incheon Free Economic Zone (IFEZ).

'Green/Sustainable City' or 'Resilient City' are used when the term smartness is interpreted with respect to ecological and environmental aspects.

'Smart City' is the currently most common and most inclusive term (Caragliu et al. 2011, 2013). In general, it refers to the deployment of information and communication technology (ICT) infrastructures for realizing future cities providing smart services (Angelidou 2017). Now, all major cities in the world have smart city efforts, too many to name them here. Singapore, being certainly at the forefront, uses even the term 'smart nation', due to the identity of city and nation. The term smart city is overused and has no sharp definition anymore. The concept and realizations were questioned by several authors, e.g., Greenfield (2013), Townsend (2013). Smart City became a buzzword and is especially popular with the large IT and construction companies, but also picked up by public institutions like city administrators and the European Commission. For an overview see the Market Place for Partnerships of Smart Cities and Communities (EU-Smart Cities website).

Other related terms are 'Interactive City', 'Responsive City' (Goldsmith and Crawford 2014; Schmitt 2016) or 'Adaptive City' (Buš et al. 2017). They are often used to indicate a more differentiated approach and to distinguish themselves from the general 'smart city' euphoria. In principle, every 'smart' city should be interactive, adaptive and responsive.

'Hybrid City' is the term used and preferred by the author (e.g., Streitz 2011, 2015b) and an extension of the notion of 'Cooperative Buildings' (Streitz et al. 1998). It refers to the combination of the real urban environment and the digital/virtual world, constituted by digital representations of real objects (=> 'digital shadows') and by additional digital/ virtual elements which have no direct corresponding equivalent in the real world. So, there is no complete one-to-one mapping. Important is the connection, balance and interaction of real and virtual worlds. A more detailed description of hybrid cities is provided in Sect. 5.6.

5.5 Smart cities as 'self-aware' cities

As shown above, there is a wide range of 'smart' city related concepts and terms. Beyond these generally used and accepted notions, the author likes to introduce a different interpretation and term.

This conceptualization is based on the proposal that the 'smartness of a city' can also be characterized by how much the city knows about itself and how this is communicated to the city administration and its citizens. This is the concept of the 'self-aware' city (Streitz 2017). There are two perspectives and advantages. First, city authorities in charge of administering and managing the city obtain additional knowledge about the different urban parameters and can take more informed decisions. This is in line with the "smart spaces make people smarter" proposal in Sect. 2.7. Second, citizens are enabled to have a more comprehensive, augmented view of their city. At the same time, it empowers them to engage and participate in addressing open city-related issues. In several cases, citizens will even play an active role in the data collection process. Examples are projects on open data and civic apps (Lee et al. 2016). A very active open data community can be found in Amsterdam.

Providing awareness and experiences, is one way to convey the status of the city. Examples are feedback on air and sound pollution levels in the city, congested traffic, numbers of bicycles used today and, in the past, (e.g., the 'Velo-Barometer'[6] in the city of Luzern, Switzerland, provides this information about bicycles in real-time in a public space), delayed trains, broken roads, non-functioning devices, etc. Providing direct location-specific awareness, e.g., on pollution, by using an ambient display in a transient public space, is one way to convey the status of the city to its citizens. Other ways of communication are also useful: posting real time data on websites, providing personalized/ individualized awareness, using visual information via overlay displays (e.g., augmented reality type glasses), using local sound (in earphones) or tactile hints employing vibrations conveyed by your clothes. There is no general solution which means must be used to convey the awareness information. The design decision depends on which human senses are appropriate and compatible for a given situation.

Konomi et al. (2013) developed a very good example of enabling and communicating self-awareness by measuring urban congestion in trains of the Tokyo subway. It applies a clever approach of using indirect measures (the CO_2 level in the train compartments) for determining the congestion level (the more CO_2, the more passengers). This method is an example that collecting necessary data involves active and consenting participation of citizens. Konomi et al. (2013) calls it the 'civic computing' approach. Another example to explore the status of a city is to use ambient Wi-Fi signals for identifying occupied and vacant houses in local neighborhoods (Konomi et al. 2018).

5.6 Hybrid smart cities

Taking the notion of an internet of things (IoT) seriously, one ends up with large ensembles of augmented physical objects. Physical objects in the real world will have a digital representation (also called 'digital shadow') in the virtual world. The most recent version (IPv6) of the internet protocol was also developed to avoid running out of address space for providing every device and object with a unique IP address for identification and location definition. Thus, IPv6 will be a key enabler of the future Internet of Things.

The term 'Hybrid World' denotes now the combination of real worlds and digital/virtual worlds. Depending on the purpose and level of detail of modeling the real world, there are different digital representations. Using augmented reality (AR) methods and devices, one can generate overlays and multiple representations, thus providing views into the combined hybrid world and enabling a certain degree of transparency. As remarked before, one must be aware that there is no one-to-one mapping between all real and all virtual objects. Only a subset will have direct correspondence relationships.

Applying this distinction to urban contexts, the term 'Hybrid City' (e.g., Streitz 2011, 2015b) is a direct consequence. This conceptualization is preferred by the author and was used already for a long time (since 2008). It reflects the understanding that designers should address the connection, balance and interaction of real worlds and virtual worlds, if they want to get the full picture of what is relevant for the design of our future cities.

Pervasive computing and ambient intelligence infrastructures are transforming urban environments into interactive information and action spaces that are meant to be adaptive, responsive and smart. It results in what is called a 'smart' city and in our view a 'smart hybrid city'. It is obvious that there are many opportunities and applications of such a platform. Having established a ubiquitous and pervasive infrastructure, the next step is to exploit it by collecting, aggregating, evaluating, and processing data from sensors distributed in the urban environment and, more advanced, integrated smart materials constituting the environment (see Sect. 2.5 on smart ecosystems). The resulting data will enable creating knowledge about people as well as states and changes of associated mobile and stationary objects (ranging from smartphones to vehicles, from street lights to buildings, etc.). We will observe a transformation towards smart environments, where all activities will be monitored, and smart services are provided as offers to people based on personal profiles by matching them with options available at these places (e.g., personalized location-based services). There is no doubt, that this will have severe implications for privacy issues which were already presented at a general level in Sect. 3 and will now be discussed for the case of smart hybrid cities in the next Sect. 5.7.

Building a smart hybrid city should not be a goal in itself. It should rather be considered as a vehicle for realizing the overarching goal of a humane, sociable and cooperative city as will be explained in Sect. 6.

5.7 Privacy in hybrid smart cities

It is agreed that the smart city approach provides multiple opportunities. At the same time, there also exist the threats articulated before. One is the increase of the already existing

[6] Velo is the Swiss-German word for bicycle.

dependencies on reliable and working ICT infrastructures, including the resource of electricity. Another one is providing security by being prepared for and fighting criminal manipulations and cyber-attacks. In this paper, the focus is on the third major risk for citizens in a smart city, i.e. the loss of privacy in terms of losing the control over personal data. While the current discussions on privacy focus mainly on the virtual world, e.g., misuse in social media networks, e-commerce and on-line shops (see also the general discussion in Sect. 3), the more prevalent and pressing issues will surface in the smart hybrid city context concerning personal data of citizens in the real, resp. hybrid world. The discussion of privacy issues here is based on earlier work (Streitz 2016, 2017).

While privacy is already now an issue, it will become even more important in the smart hybrid cities to come. While in the virtual world, one can—to a certain degree—still use fake identities and anonymization services it will be more difficult to achieve this kind of disguise in the real world. The data that exist about a person in the virtual world are now complemented by and combined with real world data and vice versa. Public and private CCTV cameras are taking pictures of people entering a shop or a restaurant with known locations, while face recognition identifies personal identities. Real objects that people are wearing, carrying, using, buying will be recognized by sensors in the environment because these objects are tagged, maybe not 100% of all objects, but increasingly many products.[7] The car or bicycle is a tagged object broadcasting its location and properties resulting in driving trajectories. The instrumentation of vehicles will increase in the context of autonomous driving efforts. Personal walking behavior is transparent when carrying a smart phone (based on radio signal multilateration or GPS). Thus, it will become more and more difficult to avoid object and person tracking, because soon most objects and their parts will be tagged, respectively have integrated IDs (=> smart artefacts made from smart materials). Location-based services in a smart hybrid city exploit not only location and preferences but can also be used to build up a complete profile via monitoring activities (e.g., buying goods, looking at public advertisements, contacting people), when and where, including also other people involved in the situation. For example: when and where were you in a restaurant, what did you wear and what did you eat when meeting a friend. Installed smart speakers with microphones would even allow to record your conversations. Profiles are then matched against commercial offers of shops and restaurants in the vicinity. The results are unsolicited offers and advertising on mobile phones and on public displays (see 'Digital out of Home—DooH' in the next Sect. 5.8). Pedestrians in public spaces are looking at or passing by these displays with personal offers which in turn might result in compromising their personal preferences also in public to people around them. This future envisioned for 2054 in the movie 'Minority Report' (created in 2002) seems to be very close now as it is the subject of the commercialization promises for the smart hybrid city.

Who can really predict what will happen to all the data generated in the real environment (either unobtrusively collected or voluntarily provided) and then stored up in the 'clouds' of numerous service providers and manufacturers, especially when these servers are based in countries that have no or very limited privacy and data security legislation? It should also be pointed out that Weiser—already at the time of his work on ubiquitous computing (Weiser 1991)—regarded privacy as a key issue for this kind of environments and its acceptance by users, respectively citizens.

5.8 Urban spies

Considering public and transient urban spaces, there are obvious design issues and implications for privacy. Beyond the almost ubiquitous and for people usually visible CCTV surveillance cameras, there are many sensors that are hidden in the environment. Current and near future examples of privacy infringements are a result of augmenting urban objects with different types of sensors and actuators. The following examples are not a comprehensive account of these constellations. It is rather the attempt to draw attention to installations which are not so obvious at first sight due to the 'disappearing computer' aspect, described before in Sect. 2.4.

5.8.1 Smart cars

Smart cars being augmented to gain autonomous driving capabilities have a wide range of sensors (cameras, ultrasonic sensors, radar, laser-based LIDAR, GPS). Will they go off to sleep when the cars park on the curbside of the street? The fact that the engine is turned off, does not mean that the car is not active and sensing anymore. Nobody knows if and what the cameras and microphones are recording. Pedestrians walking by can be monitored. Peeking into the windows of the adjacent houses and apartments is no problem either. Who has control over the sensors and access to these data? Should the car company be allowed to utilize these data? Certainly not.

5.8.2 Smart street lights

Similar considerations apply to street lights being equipped with cameras and radar for the official main purpose of

[7] See the developments for so called 'product memories', were tagging allows to monitor the complete production and retail process of a product from the producer (fair trade yes or no) to the consumer, who might also check, e.g., if the cooling chain of the fish was maintained throughout the process until delivery in the shop. These are positive aspects of tagging.

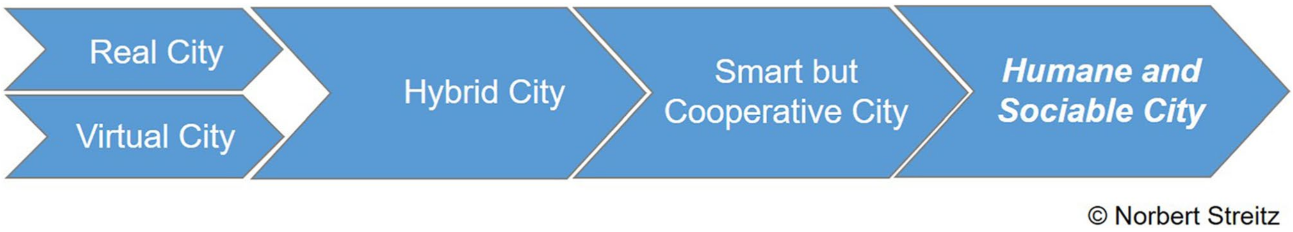

Fig. 4 Relationships and goal orientation of city characteristics

monitoring the street looking for free parking spaces, because smart parking is a prominent issue in the smart city scenario. Who knows what kinds of data are collected about the complete urban area within the view?

5.8.3 DooH—digital out of home

Another example are smart large public displays used for advertisement (DooH = Digital out of Home). They are monitoring where passers-by are looking and analyze their emotional reaction to the content displayed. Additional application domains for the DooH set-up are airports when turned into smart airports and equipped with large smart indoors displays, but there are also some similar pilot installations in retail shops. The sensing/monitoring options include to determine gender, age and soon the identity of people based on face recognition and then display individualized personalized content to them. Beacons and face-tracking are employed in these scenarios. Did anybody ask for permission in these public spaces? No. Who owns the data? The people should have control over them.

The principal problem is: How can people know what is going on, when they are not aware of being tracked and monitored, when they cannot perceive the different sensors, the manifold smart devices distributed in the urban environment due to the before mentioned disappearing computer approach? The issue of providing corresponding 'affordances' (Streitz et al. 2007b) about interaction and sensing options in the augmented environment is more prevalent than ever. There is a big need for providing transparency on the sensors hidden in devices and the built environment.

6 Humane, sociable and cooperative hybrid cities

The previous chapters analyzed the problems and diagnosed deficiencies of the 'smart-everything' paradigm in detail. Together with the implications for privacy infringements there is a need *to move beyond 'smart-only' cities* by putting a different set of requirements and design goals in the first place. One could use a rephrasing of smart: "smart, but only if cooperative and humane". In accordance with the design trade-offs presented in detail in Sect. 4, the overall goal of designing and realizing future or refurbishing existing cities should be: To build *Humane, Sociable and Cooperative Hybrid Cities reconciling people and technology by providing a balance between human control and automation as well as privacy and smartness*. This implies to foster and enable the following seven actions and requirements:

1. Establishing a calm technology providing ambient intelligence that supports and respects individual and social life by "keeping the human in the loop and in control".
2. Respecting the rights of citizens, especially in terms of privacy and security. Therefore, personal data should—as much as possible—only be collected based on consent by providing choices and control of the process, including models of temporary provision and access and/or obligations to delete data later. EU-GDPR regulations provide a good basis.
3. Viewing the city and its citizens as mutual cooperation partners, where a city is 'smart' in the sense of being 'self-aware' and 'cooperative' towards its citizens by supporting them in their activities. This requires mutual trust and respect for the motives and vested interests of all stakeholders involved.
4. Acknowledging the capabilities of citizens to participate in the design of the urban environment (=> participatory design), especially with respect to their local expertise, and stimulating their active participation.
5. Motivating citizens to get involved, to understand themselves as part of the urban community, to be actively engaged by contributing to the public good and welfare (=> collective intelligence, mapping useful aspects found in the approach of the Greek 'agora' as a marketplace of ideas).
6. Enabling citizens to exploit their individual, creative, social and economic potential and to live a self-determined life, and thus

7. Meeting some of the challenges of the urban age by enabling people to experience and enjoy a satisfying life and work.

Figure 4 provides the global picture. It indicates the merging of real and virtual representations of the city into what is called a 'hybrid city' and its augmentation and provision with the characteristic features being the core of moving beyond the 'smart-only' city. The combined representations provide the basis for modeling the city and to define how the different parts can be augmented with smart properties in order to create an urban environment with ambient intelligence. One must determine how this augmentation can be used for the overall benefit of the city and added value for each individual citizen. This is the idea of moving beyond a 'smart-only' city and transforming the city into a "smart, but cooperative and humane city".

While the motivation for designing a 'humane city' (Streitz and Wichert 2009; Streitz 2011, 2015a) and a 'sociable city' (Streitz 2017) appears to be rather straight forward, the notion of a *Cooperative City* might need some explanation. It is also based on our earlier work on Cooperative Buildings and Roomware (Streitz et al. 1998, 1999; Tandler et al. 2002). In this tradition, it is proposed here to apply human-centered design principles that have proven useful, e.g., in human–computer interaction (HCI) and computer-supported cooperative work (CSCW), now in this context as *Citizen-Centered Design*. The 'cooperation' perspective is considered as an overarching goal for the design process. It allows integrating functionalities and policies from the very beginning, viewing citizens as prospective 'users' or 'customers' of city services. This perspective results in what can be called '*city as a service*', where the urban environment is the interface between the city and the citizens. A transparent urban ambient intelligence environment enables city authorities as well as citizens to make more and better-informed decisions, because *both* (and this is essential) parties can access and exploit the wealth of all the data collected. Still, one always should keep in mind, that 'smartness' is not a goal or value in itself, but it has to be evaluated against the needs of the citizens and the resulting design guidelines stated before. Therefore, a discussion in a cooperative and respectful manner is needed in order to contribute to the objectives of the *Cooperative Humane and Sociable City*.

Having painted this somehow ideal and optimistic picture, one has, of course, to be realistic and be aware that the 'smart' city, especially the 'smart-only' city, poses new challenges. There are a number of potential pitfalls. One is the increasing commercialization of many aspects of urban life. It is no secret that the 'smart city' scenario is considered by many companies as the 'next big thing', where large profits are expected. If this trend continuous and is dominated by a technology-driven perspective, it will result in fewer options for citizen participation in the decision-making process and more privacy infringements, because the commercial objectives will—in many cases—be different to those outlined above.

Another issue is the danger of comprehensive and smart automation with its resulting dependencies and loss of control. Like the already existing dependency of our urban systems on a stable, secure and continuous availability of electricity, we will be confronted with the dependency on smart systems, especially with the deployment of often non-transparent artificial intelligence components, e.g., in autonomous driving, voice-controlled smart homes, etc.

7 Conclusions and outlook

While the cooperative smart hybrid city proposal contains many opportunities, one should also be aware that there are severe risks which require the discussion of pros and cons. It is the explicit view of the author, that the smart hybrid city promises will only survive and be successful if our future cities are designed as Humane, Sociable and Cooperative Hybrid Cities. Urban environments should be designed to enable people to exploit their creative, social and economic potential and lead a self-determined life. Ambient Intelligence approaches can play a major role in achieving this goal by reconciling people and technology and—based on the design trade-offs discussed in detail in Sect. 4—establishing a balance between human control and automation as well as privacy and smartness. The paper is concluded with the following seven claims for future developments and a brief outlook.

1. The more the computer disappears and becomes invisible, the more it determines our lives.
2. It's all there in the smart hybrid urban environment. The world around us, the cooperative hybrid city is the interface and provides a rich bouquet of offerings and services—some that we need and want, some that are offered unsolicited without our approval.
3. Privacy will become a commodity and thus a privilege, unless we do something against this trend. Assuring privacy by an appropriate development approach ('privacy by design') and supportive European regulations (GDPR) and legislation, could result in a USP for European industry and a benefit for all citizens.
4. People-oriented design is needed for "keeping people in the loop and in control", being transformed into citizen-centered design when applied to cities.
5. There is an eminent need to redefine the 'smart-everything' paradigm to avoid that people are losing control and are at the mercy of non-transparent, error-prone and rigid algorithms.

6. Consequently, efforts are needed to prioritize "people-empowering smartness" and control over autonomous automation so that "smart spaces make people smarter".
7. This is especially true for the development of future cities, which must move *beyond 'smart-only' cities* towards humane, sociable, and cooperative hybrid cities based on citizen-centered design.

As an outlook for accomplishing such a 'cooperative city' environment, the author proposes and is engaged in future work on establishing a *Citizen ⇔ Cooperative City Contract (CCCC or C^4)*. It will contain agreements between the involved stakeholders based on defined conditions and constraints. The agreements enable to negotiate the trade-offs on automation vs. control/empowerment and smartness vs. privacy. This requires open system and software architectures and new approaches for the validation of negotiations, agreements and contracts. Here, one could consider the proposal of so called 'smart contracts' based on block chain technology as an option for realization. Appropriate interfaces for citizens as well as service providers are needed for the integration of their components overseeing the negotiations of the trade-offs. Participating stakeholders specify their requirements and parameters for an equitable negotiation and trade-off process for the benefit of all parties involved.

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