RESPONSIBLE STANDARDISATION OF SMART SYSTEMS – WHOSE EXPERTISE DO WE NEED?

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Abstract: *Standards shape future technologies. The paper argues that a process is needed to enable all stakeholders to contribute to the development of these standards. This holds specifically for smart systems, which may be expected to have unprecedented societal ramifications. Such a process, which adheres to the principles of Responsible Innovation, is introduced. It follows from a discussion of the current situation in smart systems standardisation, including the representation of a variety of stakeholders and the resulting necessary multi-disciplinarity; this discussion unveils several shortcomings of the current process.*

1. Introduction and Motivation

In the past couple of years we have witnessed a development that is going to have major ramifications for society – the injection of 'smartness' into rather more 'traditional' technologies. This is achieved by the injection of Information and Communication Technologies (ICT) into well-known 'traditional' application areas like transport systems, manufacturing or power supply. Ongoing such mergers of technologies include Smart Homes, Intelligent Transport Systems (ITS), Smart Manufacturing (aka Industry 4.0), Smart Buildings and e-health. In a way, a Smart City represents a superset of these smart applications (see also e.g. [Lampe & Meng, 2023] or [Dameri et al., 2013]. In the following, a certain focus will, therefore, be on Smart Cities, but findings will be applicable to other smart systems as well. The European Commission defines a smart city as follows[1],

> *"A smart city is a place where traditional networks and services are made more efficient with the use of digital solutions for the benefit of its inhabitants and business.*
>
> *A smart city goes beyond the use of digital technologies for better resource use and less emissions. It means smarter urban transport networks, upgraded water supply and waste disposal facilities and more efficient ways to light and heat buildings. It also means a more interactive and responsive city administration, safer public spaces and meeting the needs of an ageing population".*

This will be enabled by the underlying communication infrastructure. Here, Cyber-Physical Systems (CPSs) and the Internet of Things (IoT) will allow 'smart' things to interact with each other as well as with their environment, including humans.

To make 'smartness' a reality, globally accepted standards are a sine-qua-non.

> *"Standards are the first step towards the holy grail of an interoperable, plug-and-play world where cities can mix and match solutions from different vendors without fear of lock-in or obsolescence or dead-end initiatives".*[2]

[1] https://commission.europa.eu/eu-regional-and-urban-development/topics/cities-and-urban-development/city-initiatives/smart-cities_en#smart-cities-marketplace

[2] According to Jesse Berst (the Chairman of the Smart Cities Council); see https://www.iso.org/sites/worldsmartcity/.

These standards will shape the technical development and thus, to a certain extent, the future. This *"... shaping process begins with the earliest stages of research and development"* [Williams & Edge, 1996, p. 874]. Along similar lines and more than 20 years back, the European Commission observed that

> *"Standards are not only technical questions. They determine the technology that will implement the Information Society, and consequently the way in which industry, users, consumers and administrations will benefit from it" [CEC 1996, p. 1].*

This holds all the more for smart technologies, whose likely future omnipresence makes imperative the widest possible participation of stakeholders in their development process, particularly including standardisation. Depending on your point of view, this omnipresence[3] may equal inescapability (think George Orwell and Aldous Huxley). Smart systems may indeed foster the good of humankind, but they may as well enable the emergence of a surveillance society. Accordingly, their standardisation, must not be based solely on technical and economic considerations (as ICT standardisation frequently is). Rather, societal, legal, environmental and ethical aspects also need to be taken into account. To do so in a credible way requires the active participation of stakeholders with associated interests and expertise during at least some stages of the standard sdevelopment process (see also e.g. [Werle & Iversen, 2006]).

2. Smart Systems – Standardisation

Figure 1 shows two important aspects of smart systems' standardisation. Number 1 is the 'silo' nature of smart systems. Each such silo is depicted as a simple three-level hierarchy in which a smart application deploys its underlying communication infrastructure and is subject to its governing policies and objectives.

These silos are the result of standardisation activities going on in parallel at different Standards Setting Organisations (SSOs), each one working on its own technology. So far, the vast majority of standardisation activities have focussed on the 'Infrastructure' level. Most of the ensuing standards, however, are not directly linked to smart systems, but may be applied in this environment as well. Pretty much the same holds for standards for data security and privacy.

Activities in some sectors at the 'Application' layer have also been going on for a while. At this level as well many relevant standards activities have originally been launched without smart applications in mind. Some of these standards have then ex-post been identified as being of relevance. That is, coherent activities to develop dedicated standards for smart applications have been limited at this level as well. Things look a bit different for the topmost level, 'Policies and Objectives'. Here, a number of dedicated smart city standards have been developed. These standards, however, are mostly dealing with more high-level aspects like architectures, frameworks and vocabularies.

Aspect number 2 would be the necessary multi-disciplinarity of smart systems' standardisation. Today's standards setting process typically involves one discipline for any given standard (or a limited number of closely related ones). For smart systems, things will look very different. Most notably, various disciplines of ICT will get involved. For the application 'smart manufacturing', for instance, these would include (among others), production engineering, telecommunication, computer science, robotics, AI, data science and control engineering.

[3] "*The number of IoT devices worldwide is forecast to almost triple from 8.74 billion in 2020 to more than 25.4 billion IoT devices in 2030*" https://www.statista.com/statistics/1183457/iot-connected-devices-worldwide/.

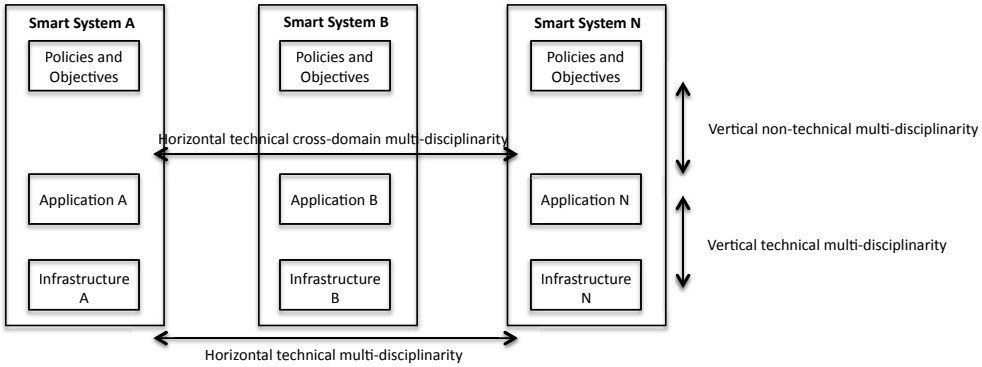

Figure 1: Multi-disciplinarity in smart systems standardisation

This multi-disciplinarity has four dimensions, with each dimension involving a different set of disciplines.

'Horizontal technical multi-disciplinarity' relates to the standardisation of a smart communication infrastructure. This used to be the domain of telecommunication engineers, but this as well is changing. For example, AI-based methods and tools will increasingly be deployed in communication systems; expertise from these sides will thus also be required for standardisation. Moreover, the likely eventual omnipresence of the IoT, especially in combination with AI-based tools, may interfere with privacy legislation and may even necessitate ethical and philosophical input (nip it in the bud!).

'Horizontal technical cross-domain multi-disciplinarity' refers to the integration of today's smart systems silos, each of which has very limited or no links to others. This is not a sustainable situation; interfaces between e.g. the smart gird and intelligent transport systems and smart buildings will be necessary, and most if not all smart applications will be building blocks of a smart city. To design these interfaces, experts from different application domains will be needed to ensure e.g. sematic interoperability.

'Vertical technical multi-disciplinarity' deals with applications' potentially hard requirements on the underlying communication infrastructure (like guaranteed levels of latency, resilience, reliability and predictability). As a consequence, application design, communication technology, operating systems and control loops will need to be extremely closely coupled – loosely coupled systems will hardly, if ever be able to meet these requirements. To achieve this, close multi-disciplinary co-operation of experts from both levels will be necessary from the outset.

'Vertical non-technical multi-disciplinarity' is probably the most relevant one for the case at hand. It represents the main link between the societal and the technical world. This link will be discussed in more detail below.

3. Societal Stakeholder Representation in Standards Setting

The previous section has shown that any meaningful standardisation of smart systems will necessitate the participation of different societal stakeholders. In the following, the current situation in this respect will be outlined, followed by a proposal for a slightly different approach.

3.1. The Situation Today

It is safe to say that (large) companies with strong economic and technical interests in the technology to be standardised, i.e. mostly manufacturers, are the dominant group of stakeholders in the ICT standardisation process. Accordingly, technical aspects (which will often be rooted in economic interests) inform the process.

Other stakeholders, including users and SMEs (small and medium-sized enterprises) have long been under-represented (see e.g. [Jakobs 2005]). This holds even more so for societal stakeholders, despite the recognised need to include these as well:

> *"European standardisation organisations shall encourage and facilitate an appropriate representation and effective participation of all relevant stakeholders, including SMEs, consumer organisations and environmental and social stakeholders*[4] *in their standardisation activities" [EU 2012, Article 5].*

The work of these organisations is definitely valuable. But there are some issues to be considered. For one, they are not overly active in ICT, let alone in the area of smart systems[5]. Moreover, [Jakobs 2015], for example, argues that umbrella organisations should not automatically be the representatives of choice for their whole constituency. This is because the diversity within a group of stakeholders implies that in very many cases a common ground to be represented by such an umbrella organisation will not exist. This holds particularly for SMEs, for the other groups, this still needs to be established.

In addition, the general need for wide stakeholder participation (as required by e.g. the European Commission) may be contested. [Egyedi 2003], for example, argues that 'democratic' standardisation is not necessarily a value per se and that it depends on the type of standard at hand. For compatibility standards, for example, she states that

> *"… non-consensus consortium standards would seem preferable if seen from the 'democratic' viewpoint" [Egyedi 2003, p. 33].*

Along similar lines, [Jakobs 2005] argues that for purely technical standards trying to bring in everyone would be counter-productive. For standards with potential societal ramifications, however, adequate stakeholder representation needs to be guaranteed.

'Adequate' is a tricky term, though. Numerically adequate representation would be one thing, adequate influence may be something entirely different. There is ample evidence that representatives' diplomatic, negotiation, rhetoric and similar, non-technical skills are important. Eventually, this may enable even a very small organisation to punch well above its weight in the process. As [Umapathy et al. 2007, p. 296] put it:

> *"The human dimension of standards setting is an important component of the consensus-based process …".*

On the other hand, there might be an acceptance problem,

> *"Committee members have also named technical sophistication on the side of the user representatives as a major prerequisite for meaningful participation" [Jakobs et al., 2001, p. 106].*

The reveals a major misconception. For technologies like smart systems, technical expertise ('expert' knowledge) will need to be complemented by both 'lay' knowledge and 'domain' knowledge. This will be addressed below.

3.2. A Way Forward

The discussion above suggests that simply bringing additional stakeholders into the standardisation process – to be represented by umbrella organisations, as proposed by the European Commission – may not be the most promising approach. So, let us consider a different idea.

[4] The respective representing organisations include Small Business Standards (SBS), representing SMEs, the European consumer voice in standardisation (ANEC), the European Environmental Citizens' Organisation for Standardisation (ECOS) and the European Trade Union Institute (ETUI).

[5] See https://www.cencenelec.eu/societal/Pages/default.aspx for a list of committees and working groups where the three organisations are represented; there is a remarkable activity of ETUI in the field of ITS, though.

Close relations may be identified between standardisation and R&I (Research and Innovation; see e.g. [Botterman, Cave, and Doria 2020]). Notably, standards may bridge the gap between the two. And in ICT, specifically in telecommunication, standardisation often functions as an early stage of innovation. I would thus argue that principles of Responsible Innovation (RI) should also be applied to standardisation, yielding 'Responsible Standardisation' (RS). RI's main principles [Stilgoe et al., 2013] nicely reflect the requirements of smart systems standardisation:

– Anticipation – consider societal and ethical impacts during the standardisation process.
– Inclusion – bring in additional stakeholders to identify socially more desirable outcomes of a standardisation activity.
– Responsiveness – react to new knowledge and to emerging views, norms and circumstances.
– Reflexivity – place research into its wider (societal and ethical) context by reflecting on the values and beliefs during research and development.

Graz & Hauert [2019] observe that it is very complicated, yet crucial, to actually mobilise lay knowledge for the daily work of SSOs' committees or working groups. Very much in line with their point of view, I would argue that in the case of smart systems standardisation the distinction between lay knowledge and expert knowledge is artificial at best. What may be seen as lay knowledge for e.g. technical deliberations may become expert knowledge when it comes to the consideration of societal and/or ethical impacts of the technology to be standardised (and vice versa). That is, only expert knowledge, from both societal and technical domains, needs to be available. And it should be of equal value. To reflect this equality and to also address the problem of mobilising societal knowledge, I would propose a modification to the current standards setting process (at least for smart systems).

In Figure 2, the box 'Technical Standardisation' represents the 'traditional' process of technical ICT standardisation (see e.g. [Jakobs, 2020] for a description of this process). This is now preceded by a 'Desirability Analysis', during which e.g. societal, environmental, legal and ethical aspects of a technical proposal are considered. This addresses the principles of 'Inclusion' and also those of 'Anticipation' and 'Reflexivity'. Based on the outcome of this analysis a go / don't go decision is made. In case of a 'go', a list of requirements to be met and of boundary conditions not to be violated are provided. To also address the 'Responsiveness' principle this analysis should also continuously complement the technical work, e.g. through regular input in case of new developments.

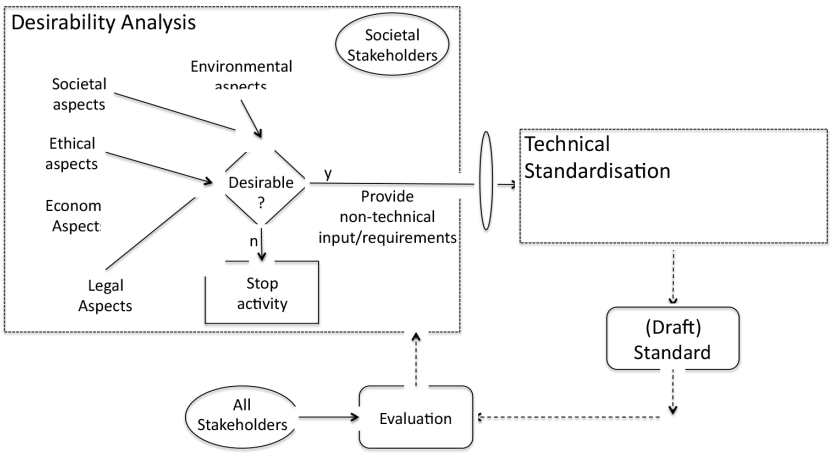

Figure 2: A modified standardisation process (adapted from [Jakobs, 2020])

One benefit of such a process would be that the technical part will remain largely unchanged. Another one would be that the communication between the technical and the societal world would largely take place at one well-defined interface (the contribution and explanation of societal requirements). Benefit number three is that such a split would significantly reduce the necessary level and duration of societal stakeholders' involvement (and thus the associated costs), which should encourage a broader variety of them to become active in the process (and thus at least reduce the 'mobilisation problem'). A subsequent joint evaluation of the (draft) standard by all stakeholders, potentially initiating a new round of technical standardisation, would be highly desirable and should also be performed.

Smart systems standardisation is still at a comparably early stage, so it should not be too late to implement a process that adequately caters for the standardisation of a technology which has the potential to dramatically change society – for better or worse.

4. Some Concluding Remarks

Given the likely future ubiquity of smart systems, along with their data collection and processing power, it does not seem to be a good idea to base their design and development solely on technical and economic considerations. These systems must not just be technically sound and economically interesting but also ethically, societally and environmentally desirable and legally above board (especially with respect to data security and privacy). To this end, the international standards setting process may be deployed. In its current form, however, this process is very much tailored to purely technical and mostly mono-disciplinary work. These characteristics render it largely unsuitable for smart systems standardisation. To overcome this problem some things will need to happen. For one, a much broader diversity of stakeholders will need to contribute to the process; this includes specifically societal stakeholders. Moreover, the process will need to provide a level playing field. That is, the distinction between (technical) 'expert knowledge' and (societal) 'lay knowledge' has to be overcome. Rather, the process needs to deploy and, most importantly, integrate 'domain knowledge', i.e. e.g. societal, legal, application specific, AI, environmental, communication technology specific and ethical knowledge. The process proposed in this paper aims to achieve this, while also taking into account practical constraints and boundary conditions like inter-domain communication problems and lack of funding.

In reiterate: The one overriding issue that has to be addressed in some way is to overcome the distinction between so-called lay knowledge and the coveted expert knowledge. Both are equally important for the design of sustainable smart systems that are beneficial to all.

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