Like! You saved #energy today.

Fostering Energy Efficiency in Buildings – The implementation of social media patterns as symbols in Building Management Systems' Graphical User Interfaces using Peirce's semeiosis as a communication concept

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Abstract

This paper starts with a short definition of the research field sustainable ambient computing (SAC), which unites ambient intelligence, and ubiquitous computing. SAC takes into account not only the ecological aspects of life cycle assessment and energy efficiency, but also includes HCI as main pillar. Part of SAC is building management systems, which, in their current form, struggle with lacking user integration and rebound effects. The prospect is to build, implement and test a graphical user interface in a new energy efficient building at Leuphana University, which provides a convenient surrounding and an user-friendly system at the same time. According to the pragmaticist approach of C. S. Peirce's sign theory, we propose abduction as a method of inference and semeiosis as a triadic communication process. Regarding the spread of social media usage, we suggest using elementary communication patterns taken from this field for building management systems, because known communication patterns encourage the usage of uncommon ambient computing systems. Hence, acceptance, a major challenge when trying to successfully integrate users, is facilitated. Here fore we looked on typical communication patterns of the most used social media platforms. A successful usage of these patterns in this specific context will raise the perception und knowledge of energy consumption, and can be expected also to change habits on the long run.

Sustainable ambient computing (SAC) reflects the main ICT trend in the societal and industrial development today. Computers have become part of ordinary things like walls, doors or even car seats. They build a surrounding with contactless switches (e.g. light in buildings) or actually invisible things to happen like variable heating and air conditioning in buildings or windows open and closed by smart systems and no longer by humans.

Viewed from a systems point of view, the aim of smart buildings, for example, is balancing convenience and energy efficiency. This should by no means result in using more computers hence more energy. Therefore in SAC the life cycle assessment of the systems to be taken into account is an utterly important part of the sustainability aspect concerning hardware.

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As well as for the hardware part, the software part has to be sustainable by means of anticipating and guiding users and user groups: A successful communication respectively HCI (human-computer-interaction) within BMS (building management systems) or smart buildings fosters not only energy efficiency, but may also change habitual and cultural patterns in the long run.
SAC, therefore, suggests a holistic view on any ICT supported system.

However, whilst computers became a nearly invisible surrounding for us, the usage of smart phones, smart buildings and other smart systems did not fulfil the promise for sustainable nor energy efficient infrastructures yet [1].

Planned as "closed" systems, BMS are often used to rigidly control the indoor climate. They produce a large data stock that is supposed to be used by the manager of the system to control energy efficiency and provide a comfortable ambient, however a purpose that is hardly ever reached. The lacking flexibility and interaction with users and user groups in the room often results in discomfort for the user and users bypassing the rigid BMS regime, resulting in inefficiencies on the system side. In general, "[t]he environmental effectiveness of eco-technologies strongly depends on the way users interact with them" [2].

There are several challenges – the position of the building, the weather, the subjective feel of the user. She might feel cooler in the very early hours of the day, but would love some cooler air after lunch. Also the gradual difference between the outside and inside temperature – a somehow subjective "feels like" for the person in the room. While the user can easily handle brightness in a room because of its visibility, room climate is more challenging from a user's point of view. We conclude therefore that there has to be some communication between the system and the person in the room.

Part of the interaction between user groups and the BMS is the preparation of sampled data for a user-friendly visualization that leads to clear instructions for the BMS. To create user-specific feedback, it is necessary to collect data about the handling of actors like thermostat settings and environmental parameters like humidity and outdoor temperatures.

Because of the otherwise increasing hardware requirements, energy and data, the sampling rate, the resolution and the accuracy of information should be balanced out for the needs of the user and user groups. For a sustainable system the mass of sensors and data has to be minimized to the basic necessary data that enables an interaction between the user and the BMS, e.g. the use of heating energy for the day before compared to a similarly used room. There are three main levels between the user and the system: sensor-actor-level, database and Graphical User Interface. While the development of the GUI is based on the semeiosis as communication method, the development of the level of database and sensors/actors is based on a technical efficiency perspective. Thus the holistic view is given by this interdisciplinary research approach, resuming the idea of sustainable ambient computing.

Regarding the Human-Computer-Interaction, dyadic communication models following the action-reaction syntax are fine for closed systems only. We suggest therefore Peirce's triadic sign model and its semeiosis as methodical concept. Semeiosis uses the sign or the object, respectively representamen and interpretant relation, in analogy to action-interpretation-reaction [3] for any process that brings out another sign. This triadic model is, according to the late Peirce, not an infinite process. Peirce avoids the infinite progression giving „the ultimate logic interpretant the status of a habit or, when the occasion made it necessary, the effect of a change of habit produced by any intelligent mind – not necessarily human" [4] An introduction to Peirce's "way of thinking", his method and the derivative of a process driven communication model will show how social

media platforms as genuine communication tools form symbols that can be used to achieve the supposed objectives.

Known as the founder of pragmatism (around 1878), Peirce moved away from his own theory of pragmatism nearly thirty years later in 1905, and renamed it pragmaticism: "Pragmaticism, then, is a theory of logical analysis, or true definition; and its merits are greatest in its application to the highest metaphysical conceptions." [5] Pragmaticism in the Peircean meaning moves away from the ontological question that asks what is existent in a first category, using the term critical common-sense [6]. For Peirce, inference in the scientific inquiry cannot be made without a basic knowledge of the world called (critical) common-sense. Common-sense is indispensable for the scientist assuming a set of inferences that cannot be doubted: "[…] The test of doubt and belief is conduct. No sane man doubts that fire would burn his fingers; for if he did he would put his hand in the flame, in order to satisfy his doubt. There are some beliefs, almost all of which relate to the ordinary conduct of life, such as that ordinary fire burns the flesh, [which] while pretty vague, are beyond the reach of any man's doubt." [6] The term "critical" implies furthermore something crucial for (scientific) inquiry, namely that still any proposition can be object of doubt or can be criticized. This is Peirce postulate on science, called fallibilism. The scientist should doubt any, also later proposed inferences, views or beliefs, until they are proven.

Peirce's theory of signs, called "semeiotic" in his own term, is not meant to be a metaphysical explanation of the world, a philosophy in the traditional meaning [7] nor a solely linguistic method. Although the names and concepts are completely abstract, they are meant to be used on any category of life: "[…] all this universe is perfused with signs, if it is not composed exclusively of signs" [8]. Thus semeiotic is a method used e.g. in medicine, chemistry or jurisprudence. Peirce wanted to overcome the dyadic induction - deduction process of natural science with its strict method and terminology, as the only possible scientific method of inference. He introduced a third form of inference, called abduction. This is regarded as the only logical possibility to develop new ideas by forming an explanatory hypothesis [8]. The abductive rule will be deductively proven and inductively falsified [9] and is considered by Peirce as the only creative method of inference.

Using sign theory means therefore concentrating on processes in a sign-sphere which is called semiosphere [10]; the logic of the sign process forms patterns that allow an usage on any other sign formations, in any other sphere. We will take this approach here for the graphical user interface of a building management system, whose design metaphor follows the logic of social media platforms.

A brief introduction of the sign and a presentation of the three sign classes explain our different take on communication, expanding the dyadic model of input-output, used in communication technology, e.g. Shannon & Weaver's model [11], into the triadic form with an interpretative process. It is from utter importance to distinguish these sign classes, as they show why sign theory is an actual communication theory.

The notation of sign, as Peirce states, is that of a threefold medium with an integrated quality. A sign consists of the representamen, "something which stands to somebody for something in some respect or capacity" [9], of its object, which can be a real-life thing or an idea, and its interpretant, the sign which it creates in the third state. An interpretant does not have to be a person or a mind, but a state where the process of interpretation and sign re-creation occurs. Peirce notion of a "quasi-mind" [5] allows the interpretation and usage of this triadic concept from a calculating machine to a group of humans.

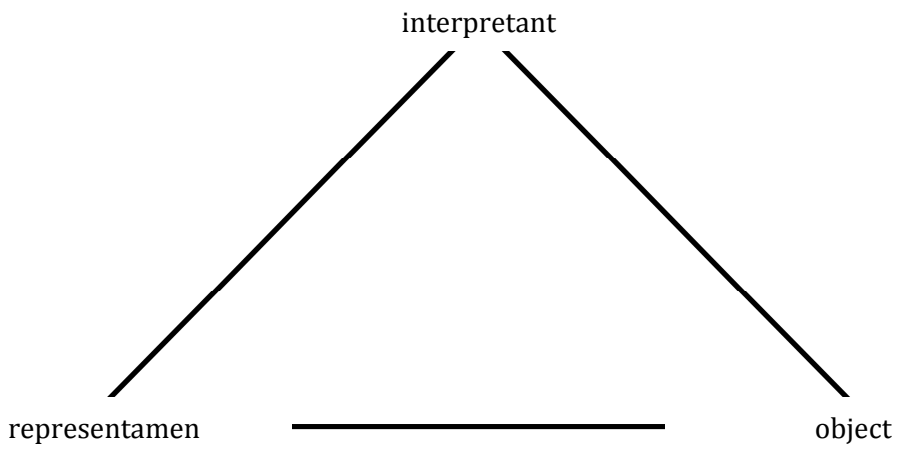

Figure 1: Sign

The existence of a sign is mediated through another sign, e.g. a word through an utterance, and it creates another sign: The same one respectively a lookalike (an iconic sign), an indicative one (an indexical sign) or a sign qua convention, a symbol.

One can be interested in a sign in three different ways, namely on the thing itself, on something the sign is indicating or on an association with the sign, a representation (of something) which calls up an association or an "idea" [12]. The first sign class, icon, is a sign that looks like the represented object, like a diagram in geometry or a portrait [13]. It is a sign that one can directly perceive. The second sign class contains signs that indicate something: an index would be smoke that indicates fire. Symptoms like raised temperature and shivering are indexes for a severe illness. For the third class, the symbolic sign, the relation between its object and representamen is due to a convention. A symbol enables us to "create abstractions" [14, 15];, it exists because it is interpreted in a certain way. The symbol for heart does not look like a heart itself nor does it denote a certain heart, but any heart. Any sign is already a symbol, because we use the concept of language to denote it. Mathematics is a science that is based on symbols.

A symbol contains all sign classes in it, what can be shown on a pictogram of an emergency sign.

Figure 2: Emergency sign

As an icon, it denotes a simplified picture of a human being that runs in the direction of the pointing arrow. The pictogram itself indicates a certain situation, an escape. The emergency sign itself can be only interpreted as a symbol, for which the person that looks at it only knows the interpretation. Without having seen a sign like this before, or without knowing that green as a colour has a positive connotation in our culture, a correct interpretation would not be possible [16].

Supposing communication is a triadic concept mediated through signs in a semiosphere, communication proceeds as following: The iconic sign is also the object, the indicating sign is a

representamen and the symbolic sign is the interpretant. Thus communication implies continuous processes that are developed through symbolic signs. Defining communication as an action using and by itself building symbols means we can already take functioning symbols and their patterns and apply them to different semiospheres.

This paper will not examine social media as a communication medium in the sociologic way. The discussion about reasons of usage or impact on people, society or technology shall here be left disregarded, although this is an important part of the discussion. With blogs starting to get common around 1999 [16], the usage of social media platforms like Facebook and Twitter has pervaded everyday life since the spreading of smartphones with mobile Internet access [17]. The most important social media platforms are blogs, Facebook and Twitter. A blog is run by one or more authors who generate content that can be commented by the reader. Blogs became popular for many reasons, like the blog software Wordpress and webhosts like Google's Blogger, which are non-expert systems that do not need programming skills. They also became popular because they enabled people to speedily publish and receive a feedback from their readers [16]. Facebook is a platform that allows the user to connect with friends respectively other users, share activities and e.g. pictures. Facebook's "like" button grew up to the symbol of social media. It gives an instant positive feedback to the posted content. Twitter unites the key functions of blogs and Facebook-like content generation (in 140 signs), feedback in the function "reply to", connection and sharing with other users via the timeline and the positive feedback, the "favourite" button.

Figure 3: Screenshot of an initial tweet, a reply and a favourite tweet

An overlapping logic or structure, respectively, determines the special semiosphere of social media: the possibility of feedback, interaction with several people and immediate, positive acknowledgement of the utterance (Like and Favourite buttons). Further the usage of the platforms creates symbols, thus signs qua convention, for communication mediated exclusively through computing devices - just like Facebook's thumb and the claim "Like!". These symbols are encoded twice because of their usage in online as well as communication processes solely. It can therefore be supposed that these symbols will be used correctly in a manner that is common for the user, as in any computer mediated communication process, e.g. in a building management GUI (Graphical User Interface).

Introducing the term of sustainable ambient computing SAC, ambient intelligence plus ubiquitous computing, means to bridge the gap from computing as an engineering approach with ubiquitous systems that solve real-world problems [18] to a conception of information and communication systems that are ecological from the perspective of life cycle assessment, user-friendly and have a supportive effect on decision making as well on cultural habitual change. In this research field

building management systems can be considered as environmental technology at the intercept between industry and everyday life. Tools and systems in this field are made for different user groups, i.e. experts, engineers and non-experts or everyday users of the building. The latter group shall be enabled to partly take control of the system themselves, so the human-computer interaction becomes a stronger focus in BMS research and development.

A main goal of generating a successful interaction between the BMS and the user is saving a maximum of energy by avoiding rebound effects. Rebound effects are lowered energy savings (due to technical efficiency) by increased usage, often because of less costs or a “greener” feeling [19]. A high degree of automation in the BMS can lead to inefficiencies due to rebound effects in two ways. First, the “efficiency improvements ([...] energy) made possible through technological improvements are counteracted by increasing demand […]” [20]. Second, if users can`t influence the energy demand, e.g. the heating, in a way that fits their requirements, they will find other ways to achieve a better surrounding. This lack of participation could cause a difference up to 70% between the planned and the real energy usage of a building [21]. A difference like this can, for example, be a result of simultaneous opened windows and activated heater. Thus the impact of uncontrolled usage underlines the importance of manipulation possibilities and a resulting satisfying communication between the users and the BMS from both perspectives.

Regarding SAC as a semiosphere allows usage of the triadic conception of signs and their classes on different levels. There are sign processes concerning hardware and machine language, which are related to the engineering part. Another sign process is the communication between the system and the user group, allowing decision making and eventually changing behaviour. Deconstructing the semeiosis (sign processes), these can be regarded the following way: The hardware as a concrete object and technical medium, the software and sampled data as an instrument thus representamen, and the usage or interaction with a user or user-group as interpretant. In the special contextual situation of BMS we gain a sustainable usage in matters of energy consumption qua the hardware and engineering part. Further a successful usage of the interface between system and user is essential, which should result in creating new “symbols”. That is the status of the interpretant, which is not only a habit, but also the effect of a habitual change. This means a successful interaction with the user would minimize the system’s infrastructure, generating a sensibility for energy efficiency, and resulting in more energy efficient behaviour. Supposing BMS data is already processed and filtered thus simplified for the user, the GUI will be convenient to handle if we are using a certain set of symbols that are derived from the usage of social media platforms. Therefore we essentially suggest using common signs already known for communication purposes in a communication context, as we explained before.

The conceptual metaphor for the GUI [22] includes double coded symbols we know from social media usage. We can find them similarly in all proposed three main platforms. First comes the possibility to generate content. This is proposed without any quality nor interpretation. Because the building management system generates the first content, we must regard this in the sense of common-sense as a set of inference or data that already exists. The user should have the possibility to generate “own” content, so not only participating to but initiating (sic!) the communication process with the system. She could choose the components of the information like temperature and humidity to correlate to the felt temperature. Second, different forms of feedback have to be possible. Comments and spreading information could be regarded as indexical signs in the process. The single user might be regarded as peer to a group where, however, information is shared or commented. The possible feedback to the system should further include the possibility to manipulate it to a certain extent, even up to the submission of a first data set initiating the communication process. The communication process continues while setting the object, such as the

data, into a context. Here we postulate the interpretant in a way that the symbol that comes out qua convention is able to put its object (the subjective “feel like” in the building) in a solely positive context. This happens in social media activity with the “like” button or the “favourite” star. What differentiates the mentioned symbols from a symbol even more widely known, e.g. a traffic light? For the latter, the convention respectively the interpretant arises not from the user itself, but it is imposed by an invisible authority. The user knows that traffic lights command and forbid certain actions on crossroads based on a societal convention, and also an everyday situation that can be connected to negative notions like prohibits or being late. The positive connotation that involves social media activity becomes apparent in the virtue of the “like” button or thumb symbol, because these terms are used in colloquial language.

We used the method of semeiosis to analyse the social media as a sphere of signs, a semiosphere, and determined three utter important communication patterns. We propose using these symbols, understood as habit changing possibilities, in a case of building management systems. The logic of the elaborated, practical communication process should be able to develop a successful communication between users and the BMS.

The prospect of this analysis follows Peirce’ understanding of science. After having deduced what the requirements for the graphical user interface of the BMS are, a first GUI will be designed as part of an interdisciplinary project. It will be implemented and tested in a new energy efficient building at Leuphana University by an interdisciplinary project team.

We will keep the interdisciplinary perspective and theoretical foundation based on Peirce’s theory and, at the same time, take into account the technical requirements (i.e. the resolution of the sensor system, the monitoring concept and the design of the BMS) and knowledge to create a set of requirements for the design of the GUI. Finally all parts together build the holistic SAC system, however a centralised database will still be needed, as well as data mining, filtering and comparing algorithms to generate content for the user – the informatics part of the concept.

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