Scalable Interactive Modular Systems (SIMS): sustainability for digital interfaces

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Abstract: Design and sustainability have long been reviewed and explored by designers, creators and policy makers. Despite the acknowledgement of the importance and need for sustainable design, little is known regarding the process that leads to one. It is important to recognise that sustainability is a system property and thus a systems perspective (including both micro and macro level changes) is necessary to fully appreciate and guide sustainable and innovative designs. SYSTEMATEKS (SIMS) is a forward thinking design concept/process that can inform sustainable and regenerative designs. The present paper demonstrates an application of SIMS (Scalable, Interactive, Modular (able) systems) for designing a digital interface that allows for visualizing key infrastructure information (i.e. information regarding municipality and key economic factors associated with it). The findings demonstrate a successful application of SIMS process to guide and inform a truly flexible and resilience digital interface that is modular and scalable.

Keywords: Sustainability, Interactive Design, Modularisation, Digital interface, Design process

1. Introduction
Design and sustainability have long been reviewed and explored by designers, creators and policy makers. Green design and consumerism, responsible design, ethical consumption, eco-design and sustainability are merely a few disciplines that have emerged in response to the growing need for sustainable and responsible designs (Bhamra and Lofthouse, 2007). It is also important to recognise that sustainability is a system property and thus a systems perspective (including both micro and macro level changes) is necessary to fully appreciate and guide sustainable and innovative designs (Gaziulusoy, 2015).

In order to respond to new waves of consumerism, for transformation of socio-technical systems and to fulfil certain social functions such as mobility, access, evolution or change many more innovative strategies need to be aligned with a sustainable transition (Gaziulusoy, 2015). Amongst other principles and design philosophies in response to this need Design for Sustainability (D4S) was initiated. D4S encourages industries to incorporate environmental and social factors throughout the life cycle of the product (Crul et al., 2006). This approach might be relevant and relatively suitable for
designing existing products but when it comes to innovative products there is a need for novel processes to ensure that sustainability is embedded in the DNA of the design. SYSTEMATEKS (SIMS) (Ferrara and Dadashi, 2016; Ferrara, 2015) is an evolutionary and forward thinking design concept/process that can facilitate such transition.

Gagnon et al., (2010) recommends that in order to move towards a sustainable practice of engineering, the design process needs to be modified. Conventional design processes often follow an iterative process of problem definition, ideation, analysis, proposition, evaluation, selection implementation and operation. However, these stages are very integrated and linearly constructed. Therefore, can lock design potential into predetermined assumptions and patterns that lead into possible solutions. When seeking innovation following such an approach becomes limiting and also tends to move towards solutions that are fixed and unchanged time resulting in less adaptability or flexibility to meet evolving needs. SIMS offers a design process that supports iteration without enforcing a specialised sequential process by necessity. All design elements inform one another and yet are distinct and are granular on their own while at the same time having the possibility of being recombinant. The key factors that permit this are context, archetype, organization and integration (Figure 1). This process model is developed based on proven cases of sustainable product designs (Ferrara, 2002) and are explained in more detail in Ferrara and Dadashi (2016).

While tested initially on product and interior design applications the practice of SIMS principles was originated from analysing software and digital media design techniques and patterns and developing a theory of how they could be migrated to environmental design. Consequently, they also lend themselves to the development of digital interfaces and more importantly to a future connected world that combines interfaces, products and environments specifically, the world of the Internet of Things (IoT). They are also especially useful in the area of user experience most specifically to service design.

The most important characteristic of IoT is its capability to provide real-time awareness and responsiveness of physical environment (i.e. it is resilient and regenerative) and to combine the physical and digital domains (i.e. it is transfigurative). This transformative reality embedded in IOT services can and will contribute to a more sustainable society, optimising use of resources and introducing collaborative service (Sangiorgi, 2011). It is important to explore new processes that guides the future of design and inform the future of interactive systems.

The present paper will explore two key research objectives: 1- to explore applicability and practicality of the SIMS process for designing digital interfaces, 2-to demonstrate knowledge transfer from sustainability within the physical design domain to digital design.

The paper demonstrates applicability and practicality of SIMS process for designing a digital interface that allows for visualizing key infrastructure information (i.e. municipal finance information and key economic factors associated with it). The SIMS process will be utilized to inform design specification and requirements and to guide ideation and prototyping. The commonalities amongst different aspects of infrastructure within their context of use will lead to the design of relevant archetypes. In addition, understanding applied models of transfiguration will provide end-users with mechanisms for regeneration and customization of the information used in the design. Finally, the design will ensure that end-users can collect relevant and sufficient pieces of information, collate them in the most optimum and meaningful way and to present them in the most sustainable and effective format.
2. Background

Design is the interface between the inner and outer, turning sentiments into the embodiments in the world around us. Design as a method of making things allows us to share the world and understand the world in a harmonious and integrated way.

Our sharing is exemplified by the nature of the market economy in which we are living. Historically the economy of representation was reflected in the market of direct trade of goods. Since the renaissance, the economy of abstraction has been shaped by the development of instruments such as money and fractional shares. The emerging economy, which we refer to as the “economy of transfiguration” relies on the world being digitally dematerialized into data and then taking that data and rematerializing it again through formatting and communication technologies that capture simulations and set up their own virtual eco systems (e.g. IoT) that then interact with physical resources in the “real” world.

The traditional representational economy relies on the direct exchange of goods that are handmade which limits and make scarce goods and services. The products are typically unique, beautiful and durable as a result. The abstract economy creates machine made multiples and distributes them through an abstract exchange mechanism which accelerates abundance but results in over consumption of resources. The new economy of transfiguration tries to overcome these challenges by creating consumables as needed and allowing for their reinterpretation when they have lived beyond their usefulness to restore the balance between consumption and production.

Elkington (1998) defined three pillars of sustainable development as: economic prosperity, environmental quality and social equality: profit, planet and people. In order to ensure effective sustainability, companies need to reconsider their profit margins, environmental audits and regulations need to be continuously considered and social and ethical aspects of designs should be recognised and followed. Design process can have a great impact on how these three pillars are perceived and adopted. As it is noted in Bhamra and Lofthouse (2007) with opportunity, comes responsibility:

“As designers we have a staggering sphere of influence—and each of the choices we make filters through to the people and places affected by this influence. (Bhamra and Lofthouse, 2007, pp37)”.

Three waves of sustainability are noted in Bhamra and Lofthouse (2007):

1. 1960s and 1970s, Green Movement and Non-Governmental Organisations (NGOs) which focused on driving change via government policy and regulation.
2. 1980s, motivated by economic crisis and environmental catastrophes led to the concepts of auditing, reporting and engagement.
3. The new millennium, followed by unrest in the Middle East led to anti-globalisation have encouraged designers to think about corporate governance and liability.

Sustainable design is responsible, synergistic, contextual, holistic, empowering, restorative, eco-efficient, creative and visionary (Birkeland, 2002). More specifically the move towards biophilic design (bio means life or living things and philia means love), invites designers to consider environmental features, natural shapes and forms, natural patterns and processes, light and space, place-based connections and evolve human relationships to nature. This biophilic approach towards design and reconnecting people to nature have positive economic outcomes (Dias, 2015).

In addition, a new philosophy of regenerative design is considered by designers to ensure and promote sustainability and ensure the repair of environmental degradation, the restoration of social equity and the redistribution of economic benefits. The aim of sustainability is to satisfy fundamental
human needs without compromising future generations’ fundamental needs. Three fundamental aspects of regenerative design are: 1-understanding of place and the unique patterns they belong to, 2- Designing for harmony with place and 3- co-evolution. These approaches and best practices may only slow the rate of environmental destruction and restoring social and economic devastation (Dias, 2015), because of this, a fundamental shift in design approach seems to be required as the appropriate next step in design thinking. A shift from a focus on objects to the design of relationships.

One approach to assure successful and effective sustainability, is to recognise various steps of the product life cycle and to allow for sustainability at each of these steps. For example, when thinking about materials, designers are required to consider biodegradable, renewable or recycled. When thinking about impact of use, designers need to consider energy source, energy efficiency, dual functionality, potential for behaviour steering and intelligent systems. When thinking about length of life, identifying optimal life span and reviewing and ensuring optimal end of life strategy (e.g. methods of disassembly) need to be considered.

In addition, in order to design a truly sustainable product, it is important to consider human needs. Max-Neef (1992) identifies nine fundamental needs: subsistence, protection, affection, understanding, participation, leisure, creation, identity, freedom. These fundamental needs are associated with four states of existence: being, having, doing and interacting.

Tosi (2012) notes the importance of Ergonomics and Design when designing for sustainability. Ergonomics can provide designers with user-oriented design process that is capable of exploring user needs, behaviours and life styles. The synthesis amongst user needs and the ability to assess multiplicity of variables (user, product, interaction) can lead into a sustainable design that is usable and timely. Examples of such project are: “Well Living: Ergonomics and Ecology in the kitchen” and “The intermodal bike, Multi-modal integration of cycling mobility through product and process innovation in bicycle design (EU Project- FP7-SST-2008-RTD-1) (Tosi, 2012).

In order to respond to new waves of consumerism, for transformation of socio-technical systems and to fulfil certain social functions such as energy, mobility and food, innovative strategies should be aligned with sustainability transition (Gaziulusoy, 2015).

More specifically Gaziulusoy (2015) conducts a critical review of design approaches and frameworks and evaluates them against five criteria: strong sustainability, systems thinking, radicalism, long term orientation and mind-set change. Strong sustainability refers to irreversible, dynamic and hierarchical relationship between environment, society and economy. Systems thinking emphasise the fact that sustainability is a system property and therefore cannot be assessed in isolation. Radicalism focuses on the need for radical and shift in design approach. Long term orientation refers to temporal aspects of the design and its potential for reusability and transformation within a specific timeframe (~50 years) and mind-set change refers to the potential for fundamental change in utilisation and application of design solutions.

The ultimate goal of a sustainable design (whether a physical object, a landscape, and a piece of jewellery or a digital interactive interface) is to assure that a meaningful and continuous relationship between user and the object is maintained and in doing so, the product (physical or digital) is reusable, transformative and adaptive.

Similarly, design in the context of Sustainable Interaction Design (SID) is defined as “an act of choosing among or informing choices of future ways of being” (Blevis, 2007). Blevis (2007) has proposed five principles for SID that includes:
Despite the availability of principles and good practice guides, there are little information about the process (the how) that needs to be followed in order to arrive at a truly sustainable and transfigurative design. As Jégou and Manzini (2008) pointed out identifying a problem does not mean finding a solution and new approaches are needed to support social innovation and design for sustainable development. The SIMS process is developed through systematic review of a number of sustainable design projects and specify the steps and “the how”.

The present paper reviews the SIMS process (Fig 1) and attempts to verify its validity and applicability to design of an innovative digital interface.

![Fig. 1. SIMS process](image)

### 3. Method

The digital interface ideation and design project that was developed using the SIMS method involved visualizing large scale data sets associated with specific municipal financial information to create a series of visualization toolkits that are dynamic and modular. The main feature of this project was its multi-faceted nature where multiple stakeholders, varied types of data and a wide range of temporal (i.e. data modified in time) and spatial indicators (i.e. data modified depending on the geographical region) were to be integrated so that users could understand the finance of cities. In order to avoid creating multiple data visualisation platforms, it became evident that modularisation and scalability should be at the core of this project and that SIMS could be an appropriate mechanism to guide this design.
The goals of this project were to enhance the accessibility and understanding of financial data and its policy implications for the general public as well as policymakers. The SIMS process was followed through a series of data collection and knowledge elicitation techniques including using collaborative design practice techniques such as charrettes. Following the SIMS process designers and other stakeholders explored the context and then identified an archetype/group of archetypes that could potentially generate an ecology of solutions. This led to the creation of an organisational framework that guided the generative ecology. Finally, the plan was to integrate it into the context of municipal and provincial staff and policy makers and develop relations with the world both in terms of the users of the system, the context they worked within and impact on the presentation of information.

3.1 SIMS Step 1: Context

This step refers to understanding the work domain, high level user requirements, system purpose and design missions as well as design challenges and constraints. In order to explore the context associated with the digital interface design workshops and charrettes were undertaken. Charrettes are intensive design workshops that bring together interdisciplinary teams to solve complex problems. These are extremely valuable as they bring together diverse groups and stakeholders with differing needs and interests and developing consensus through creative problem solving. A one-day charrette was held with stakeholders to engage staff, thought leaders from public and private stakeholders’ organisations. The following questions were explored during the one-day charrette:

- What areas and trends would benefit from being visualized?
- What messages and information are critical?
- What needs to become visible?
- What types of visuals and ways of presenting information could be helpful?
- What information would be useful to see on a dashboard?

These questions were selected since they provided a high level and reductionist understanding of the essential pieces of information required for the project and developed which visualization were relevant and sufficient.

The information collected, collated and reviewed thematically to provide a detailed understanding of the context. This provided sufficient knowledge of the work domain and contextual needs of the organizations included to ensure that the proposed design solution was modular and resilient for the majority of user populations.

3.2 SIMS Step 2: Archetype

This step refers to searching for a fundamental building block and to considering various options for shape, format, material, modes and forms of interaction. Following the thematic analysis of the context and from the data collected during the charrette designers proceed with ideating and strategizing the visualisations. The findings from the charrette led to realisation that the goal is not to create singular visualizations, but rather a system that allows for the creation of a multiplicity of visualizations. Examples of these visualization modules are shown in Figure 2 below.
The important aspect of this visualisation system involved understanding the modifiers, this was due to the fact that there were too many sources of information available and the need for modifiers and modularization to assist with data and meaning management. Moreover, following this process it was evident that the visualisation modules should be adaptable to different data sets and be transformable based on various parameters and types of data. This provided the opportunity to utilise various forms (2D & 3D) in order to facilitate the third step of SIMS process: Organisation.

### 3.3 SIMS Step 3: Organization

This step explored the archetypes within the context of their use and provided an opportunity for relative comparison to understand the optimum archetype that would align with considerations developed from the understanding of context. The selected archetypes were tested in various user scenarios to assess their effectiveness. Testing through design allowed the project team to create and ideate different forms and structures. One beneficial aspect of modularisation was the ease for comparison, participants were asked to compare and evaluate bounded and clarified modules reducing the complexity associated with comparing specific design solution to various design briefs. The capacity of a particular module towards multivalence (the capacity to generate multiple meanings and solve multiple problems) accelerated its choice as a dominant archetype within the overall system.

Various forms of structuring and organising archetypes (or a system of archetypes as it is the case with the present project) were studied and iterated. This step is not only related to structuring the information and forms of visualisation, but it is also used for evaluating and assessing the extent of resilience and transfigurability of the archetypes.

Filtering, rotating, re-arranging, interpreting data sets provided a basis for comparing various forms and opportunities for transfiguration. Furthermore, the data were re-organised and decomposed further to explore modes of visualisations and formats of presentation as well as opportunities for conversion and comparison. This step led to creating a system of archetypes and their optimum configuration setting.

### 3.4 SIMS Step 4: Integration

The fourth step was to integrate the systems of archetypes within select use scenarios in order to explore various forms of visualisations. For example, by selecting any of the features (spatial archetype) within the base representation maps, a user may be provided with further breakdown of information. It must be noted that this step is still on-going and continuous interaction with
stakeholders has led to creating a number of relevant use cases and the process is evolving to address various needs and opportunities.

The integration allowed for the final design, a dashboard, to showcase desired pieces of information (i.e., right information to the right user at the right time). Essentially every storyboard will lead to a customised dashboard that empowers users to select pieces of information and visualisations and analytics that are relevant to their own specific needs.

4. Discussion
This paper demonstrates the applicability and practicality of SIMS process for designing a modular and scalable digital interactive design solution. Following the SIMS process led to a design that is generative, where it can generate complex objects, capturing transfigurative sentiments, transformable across multi-dimensions and manipulateable by a co-creator. More importantly SIMS allowed for exploring alternative designs and assessing multiple forms that would have been ignored otherwise. Enabling and flourishing innovation is one of the underlying features of following SIMS process. Designers are not only able to arrive at a regenerative solution, but they are also encouraged to think about alternative ways of presentation and transformation and this leads to novel design solutions.

More importantly following the SIMS, process of design (although significantly inspired from a top-down approach) explores the bottom-top components of knowing, sharing and believing and thus forms a balanced creation (i.e. a system of systems). SIMS is inspired by systems thinking where design should be scalable, interactive, modular (or “modulable”) and optimal. Because SIMS are generative, granular and recombinant. They evolve and yet persist they are relational and scalable and contemporaneously physical and non-physical.

The design process proposed in this paper is iterative and holistic, where there is no one sequence to follow but rather elements that inform one another. The steps explored in this paper provide one story and a recommendation of how a designer can approach a project. However, they are also able to pick and choose these steps depending on their preferences or natural inclination and the availability and access to information that allows them to complete their work.

The design solutions that are developed following this approach is sustainable because of their flexibility and resilience. This flexibility is achieved by following through the various stages of a SIMS project and practicing the continuous iterations that are encouraged throughout the process. Within the design of digital interfaces, SIMS principles/process can be of an important benefit to enable customization while allowing for the optimum use of resources.

The existing design practices have thus far dominated digital design need to change to a new way of thinking if we are to address the dynamic and evolutionary nature of the digital world and our physical world as well. The sequential method where a designer envisions and materializes solutions for the user can be replaced by a method that engages the user considering their sociological and participatory impact on a design and allows them to contribute to the design over time. In addition, a regenerative design paradigm can ensure and promote a more sustainable approach over time whose highest aim is to satisfy fundamental human needs without compromising future generations’ fundamental needs.
5 Conclusion and next steps
The present paper successfully showcases the applicability and practicality of SIMS process to design a sustainable and regenerative digital interactive interface. This is the first step to demonstrate this process within both digital and physical domains. More examples and case studies should be explored in order to fully understand the activities and features associated with each of the four steps of SIMS. Currently the project team are working on using SIMS process to inform a Jewellery design project as well as to explore the extent of SIMS in guiding and designing IoT products within smart homes.

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