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Emperor's New Architecture: The Spatial Experience of Wireless Communication

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Abstract

Wireless communication has a growing importance in the way we connect with people and places, and its infrastructure is increasingly present in our environment. This constant transmission of wireless information is forming a new spatial layer of presence, where free Wi-Fi in public space acts like an invisible canopy. The networked experience of the city contributes to a spatial change, intensifying the way people engage with places.

In our inquiry into how space is organised by technology, we will look into aesthetic and architectural properties of wireless communication. The technology under observation is used to enable communication and exchange through a seamless flow of information. Besides the intensity of propagation and obstacles to the network infrastructure, we recognize the different intensities of use and accessibility of networks. These properties, coupled with physical prototyping tools will be explored in a structural manner.

This paper will discuss the ongoing research in building physical prototypes of spaces that interact with wireless signals in their surroundings. The prototypes (RKNFG and Quadricone) were developed within the SINLAB research lab, as part of an exploration into interactive spaces and interaction design in contemporary theatre context. We explored micro-environments that dynamically reshape according to the input from specific parts of their surrounding. Working on the line between parametric design and interactive architecture, the purpose of these experiments was to model spaces according to the presence of wireless Internet and other communication signals.

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Introduction

In this paper we will discuss the use of different spatial models as a way to experience the presence of wireless communication signals in a physical way. The models are prototypes of 'experience catalysts', physical manifestations which allow visitors to directly experience a particular phenomenon or idea. Through this experience, the spatial models, RKNFG and Quadricone foster discussion on aesthetic versus utilitarian properties of wireless communication and the invisible in our environment in general.

We will consider 'experience catalysts' in the architectural tradition. How might we give form to the presence of wireless communication signals? How can this form interact with the behaviour of wireless communication signals (signal intensity, the amount of network traffic)? Our approach to architectural form is dynamic rather than static. The 'experience catalyst' aims at accommodating change, reconfiguration, and its form itself is never the same.

Catalysing Experience

The projects described were developed within the SINLAB research project. SINLAB is an experimental laboratory that combines iterative prototype development and theoretical investigation in the context of the performing arts and stage design. Working at the intersection of performing arts, architecture, engineering and philosophy, we explored the questions of transformation of time and space perception and experience. We did so through design and construction of 'experience catalysts'; interactive systems which exploited a variety of tracking techniques and media in system's response. They engage the user to experience underlying infrastructures that are normally invisible.

The term 'experience catalysts' was coined by Jens Badura to describe an aesthetic research approach, using artistic strategies to create knowledge (Badura, 2012). The interpretation of the notion of 'experience catalyst' is a work in progress, reflected in development of interactive installations which play with different user inputs and produce output in light, sound and movement. What is important for an installation to qualify as a 'catalyst' is that it can recast a 'user' to an *experiencer*[1], from a passive observer to an individual engaging in an active and meaningful relationship with the system.

Designing the Catalyst

The development of 'experience catalyst' prototypes is an exploration of a design process. It is a process of modelling through probing the relation of the built environment to the networked digital information flow.

In his book on the so-called IT Revolution in Architecture, Antonino Saggio distinguishes two main axes of design decision processes: the deductive

[1]In his contribution to the book Mapping Intermediality in Performance,Robin Nelson describes 'experiencer' as someone with a more immersive engagement in a piece than that of a 'spectator' or 'spect-actor'; see: Bay-Cheng, S. et al. eds. 2010. Mapping intermediality in performance. Amsterdam University Press. p. 45

and the inductive (Saggio, 2010). He links the inductive to modernism, noting how decisions would be made based on ideology and a (pre)assumption about the world. On the other side we have the inductive decision making characteristic for post-modern and contemporary design, which revolves around testing hypotheses. Final design here is a result of several iterations through hypotheses and solutions. Following this line, the design of 'experience catalysts' and the Quadricone in particular aims at incorporating the dynamic component into the development of its structure and form. It offers another degree of freedom to the users who affect the current shape and condition of the structure while using it.

Experiencing Space: Architecture and Wireless Communication

What is Wireless Communication and what it is not?

The electromagnetic environment is filled with waves of different frequencies conveying signals of various purpose. The infrastructure which supports this has a particular spatial presence. According to Malcolm McCullough, 'Whenever goods, people, or electronic communications flow, forms around them.' (McCullough, 2004, p.48). The particular appearance of 'space' formed by these waves can be referred to as 'hertzian', since it is composed of waves oscillating on frequencies expressed in Hz (SI unit of frequency named after Heinrich Rudolf Hertz). This term is also used to describe 'a holistic view of the electronic device and its cultural interactions' (Dunne, 2005). In their design research, Anthony Dunne and Fionna Raby consider the electromagnetic spectrum as an inhabitable landscape (Dunne and Raby, 2001).

From the first wireless information that was transmitted over a radio broadcast at the end of 19th century, the development of technology that allows transmission of information between two relatively distant points brought forth various different standards. Cordless phones, Bluetooth headphones, and satellite television are some examples. In the particular range of the electromagnetic spectrum we will find also wireless Internet that shares the frequency of 2.4 GHz with microwaves, babyphones and wireless surveillance cameras. An antenna tuned to this frequency would thus register all these signals at their different intensities.

Wi-Fi technology has the capacity to communicate multiple types of media over the same protocol: text, voice, images and video. Thus not only does it share frequency with other technologies, but the information it transmits is of a varying type. We are working towards developing a language of transformation of wireless communication into physical experience. This language should be able to describe or transcribe the complexity of network behaviour, rather than simply noting its presence. It is thus important for our research to be able to isolate and decode signal as opposed to simply catching it with an antenna.

The Space of Wireless Communication

Instead of a dark room with a screen, mouse and keyboard, we are more likely to be online in public space, scrolling down the touch screen of a smartphone. The myth had it that technology should have an alienating effect on the physical experience of the world (understandable in the light of how we used to connect to the Web in the 90s). Quite to the contrary, contemporary networked technologies are making us aware of locations, and making locations aware of us (Gordon and de Souza e Silva, 2011). Mark Weiser's vision of ubiquitous computing, which 'that takes into account the human world and allows the computers themselves to vanish into the background' (Weiser, 1991) pointed us in the right direction already in 1991.

Globalisation theorists argued throughout the 1990s that in compressed space distances play no role any more (Soja, 2003). Already with radio transmission technology based on amplitude (AM) and frequency modulation (FM) physical distance was reduced to mere seconds. Radio signal crosses big distances and connects the receivers with remote broadcasts. However, the topology of radio broadcast network is static and therefore its impact on the experience of space is not significant. What changes with the overall wirelessness[1] (Mackenzie, 2010) is the mobility of a connected device. Instead of compression of time and space, a distribution of communication devices that augment locations takes place.

Antennas and access points talking to portable devices form a distributed wireless communication infrastructure with an ever changing topography. This network supports seamless information flow The structure of the information flow around us is thus dependent on its use. The space created by wave propagation is not an objective entity but a negotiation between the infrastructure and its use.

Architecture in a Wirelessly Mediated World

Contemporary architectural practice seeks to give form to a landscape of dynamic interconnections, urban and spatial processes. We will briefly discuss here a practice that tends to actively deal with complexity of space, typical for the world of information technology. Parametricism acts on the multi-threaded, digitally augmented environment. Born from an experimentation with computer aided design using advanced scripting and digital animation techniques it aims at articulating topological information. The ability to make sense of complex input information, and even more the capacity to generate diversity of forms and relationships puts it close to the objectives behind our research.

[1]In his book by the same name, Adrian Mackenzie defines wirelessness as 'a sensibility attuned to a proliferating ethos of gadgets, services, opportunities, and enterprises that transmit and receive information via radio waves using Internet-style network protocols'. With reference to the experience of space, 'People attune themselves to signal availability and signal strength as they move around the world'.

Introducing a Design Approach: Dynamic Parametricism

Parametricism can be interpreted as a practice of modelling information, giving form to data sets. With the intention to introduce a dynamic component into the physical experience of space, certain elements of the prototypes described further in this text are dependant on a value coming from the environment. This changing value renders the form dynamic, determining the positions of dynamic elements. When designing the prototypes, we did not aim to achieve form through numbers but rather attempt to give numbers a form.

Such an approach could be named Dynamic Parametricism as it relies on parametric principles of modelling information, while the form itself is dynamic. Dynamic Parametricism takes on the notion of Parametricism, but offers another degree of freedom: the form, attained in a programmatic manner is not fixed. It changes, it adapts, and it renders changes in the surrounding visible.

Experience Catalyst Prototypes: RKNFG and Quadricone

In the following text I will describe three of these prototypes made for different testing situations and presented to the public in different settings. RKNFG was the first structure, produced for and presented at an exhibition at Atelierhaus Salzamt in Linz, Austria in September 2012. The exhibition was the result of a summer residency programme 'Expand, Explore, Expose' curated by Doris Prlic. The second prototype was produced in SINLAB and presented at a research symposium 'Stage digital – a scenographic expedition', organised by ZHDK at Bühne A in Zurich, in November 2012. The latest iteration of the *Quadricone*, also developed at SINLAB, was part of the lab's presence at the Les Urbaines festival in Lausanne, shown at the exhibition space Espace Arlaud at the end of November 2012.

RKNFG, Atelierhaus Salzamt, Linz, AT, September 2012

The first *experienceable* structure RKNFG is built in the form of a cube, where one can enter. The dimensions are sufficient to accommodate one person which would experience the change in the cube's height. The height is the changing parameter controlled by the amount of traffic on an open wireless network that is available in the space. The top and bottom of the cube are made of wooden plates, while the sides are out of stretchable fabric. This allows the top to move up and down, increasing or decreasing the height according to the external input. Two motors are attached to the top from above and they are instructed on their position through a micro-controller. A programme which is running on a computer and scanning the network traffic is sending instruction 'up' each time there is an increase in number of data packets[1]; it is sending the

[1]Data packets are basic units of communication over a digital network; in wireless Internet traffic for example, when data has to be transmitted, it is broken down into 'packets', which are reassembled to the original data chunk once they reach their destination.

instruction 'down' when it measures too little traffic on the network. In this way, the height of the cube corresponds directly to the activity of the wireless network, giving the *experiencer* more space in the cube when there is more traffic. This in turn stimulates the person to create more traffic - browse, chat, watch videos - in order to change the cube's height.

Figure 1. *RKNFG installation at the opening of the exhibition 'Expand, Explore, Expose' in Kulturhaus Salzamt, Linz, Austria*

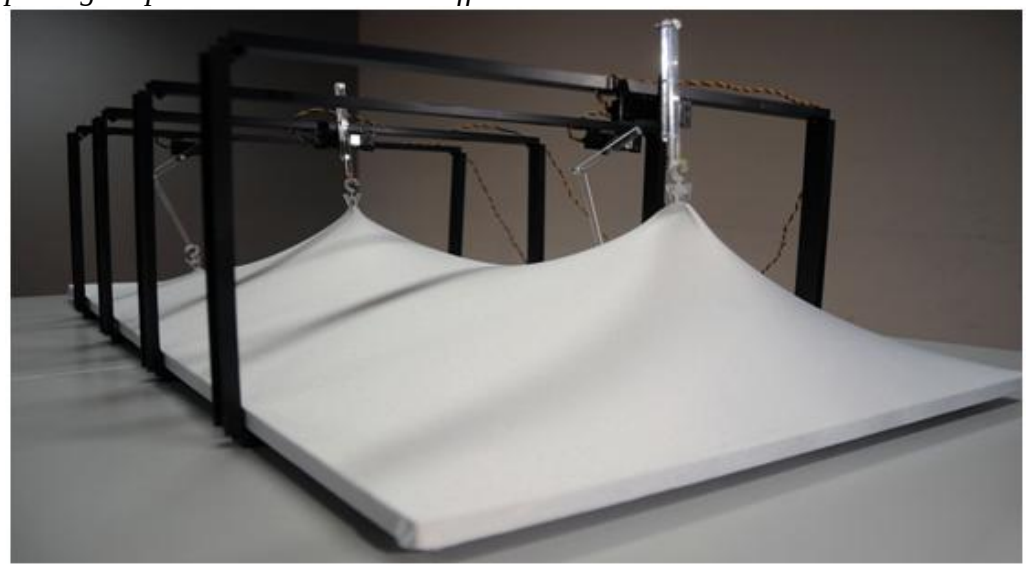
Quadricone, Bühne A, Zurich, November 2012

The second prototype introduced more complexity, but on a smaller scale. This model 1m long and 50cm wide has stretchable fabric laid over a wooden board, and picked up by motors at four points. The motors are attached to vertical frames, set at equal distances along the longer side of the model. The distribution of the pick-up points is arbitrary, as it isn't mapping the properties of networks by intensity nor geographically. However, each point is assigned to one wireless network available in the space. The points are pulled up or down, creating bigger or smaller 'cones' in the surface of the stretchable fabric.

When it was presented at Stage digital research symposium, three to four wireless networks were available for use in the space. One was an ad-hoc network used by another piece to communicate between devices. Others were open or set up for the symposium. In this way, direct interaction with the structure was not only possible but also quite intuitive. There was a clear feedback between the use of a network and the intensity with which the motor would pull a 'cone' peak up. One could clearly see when they were connected

to a particular network and created a lot of traffic on it. More people could take part in this, adding to the complexity of the shape. Raising one or another cone higher and higher would change the look of the whole surface and when another peak would take over the deformation became more complex. The fabric thus acted as a kind of interactive skin. Finally, the model offered more of a *bird's eye view* on the phenomenon as it's scale limited immersion to imagination capacities of the observers.

Figure 2. *Quadricone: the scaled model presented at Stage digital research symposium, Bühne A, Zurich, Switzerland; stretchable fabric fixed to a wooden board, 100x50cm; four motors are mounted on metal frames at equal distances along the longer side of the model; plexiglass arms are attached to the fabric, pulling it up when there is more traffic*



Quadricone, Les Urbaines, Lausanne, November 2012

The third prototype engaged a larger piece of space and interacted with users of four wireless networks. The surface of the fabric was stretched over an area of 7 by 2.5m at approximately 1.8m height above the floor. This meant visitors could stand directly underneath the reconfiguring surface. Four motors were connected to the fabric by strings that would pull it down at a sign of dense traffic. The distribution of the pull-down points was again not in a relationship with the geographical location or any other property of the analysed wireless networks. It was rather established with the intention to facilitate passage under the surface, and at the same time allow for interesting shapes to appear at the ends.

While the scale of the prototype was sufficient to allow physical interaction with the 'skin', the situation with wireless networks was quite the opposite. The scanning system could capture only very little or no traffic and the networks available in the space were all protected with passwords. We had no access to any of them, which made direct interaction practically impossible. Because of this, the system was scanning for beacon frames instead of data

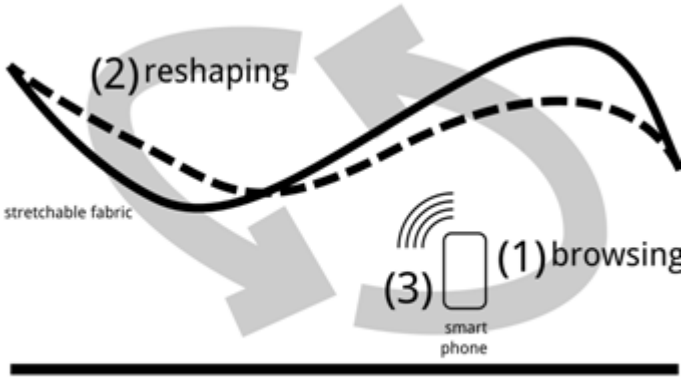
packets, in order to keep a dynamic component of the installation. Beacon frames are sent in regular time intervals to communicate basic information regarding the communications process with a wireless network access point (Geier, 2013). The time interval depends mainly on the setting of an access point but is also affected by distance. This was displayed in the installation, so that access points that were closer to the installation had a more active behaviour than the further ones. In practice this meant that all four points on the fabric were lowering down or freezing in place at different rhythms, depending on the basic activity of four WiFi access points.

Figure 3. *Quadricone at Espace Arlaud: Stretchable Fabric Fixed Above the Visitors, who Could Interact with its Form Using Wireless Network Traffic*

Results and Discussion

As it is demonstrated here, all Quadricone prototypes are tuned towards a particular kind of interaction between the people and the structure. It involves both aware and non-aware human input, machine input and output and mechanical output. While the system is 'listening' to the traffic on one or more wireless networks, anyone who is using those networks would participate in the interaction. This includes both visitors to the space where prototypes were exhibited and others not physically present or aware of their impact on the installation. Once this behaviour is recognised by the people present, they would take intentional steps in order to cause a reaction from the system (raising or lowering the top; pulling or releasing the 'cone' peaks). They would start downloading more content, playing more videos or, to the contrary, stop all browsing activity or switch their Wi-Fi off. The reaction chain that connects the elements and participants of the setup is illustrated below.

Figure 4. *The General Scheme of Interactivity: The Loop Chain Reaction between the Shape and Browsing Activity of a User*



Four points on the Quadricone (or the top of the cube in the case of RKNFG) react to the activity of wireless access points in the surrounding. This activity can be generated by the visitors present in the space or remote users of these networks. Accommodated by high stretchability of the fabric, the space of the installation modifies, making it more claustrophobic. Visitors react by modifying their browsing activity (usually trying to generate more network traffic) to the desired effect they want to have on the 'skin' (making the space more comfortable or claustrophobic). The two following schemes illustrate the reaction chains specific to the RKNFG and Quadricone installations, respectively.

Figure 5. *RKNFG: Interaction Diagram*

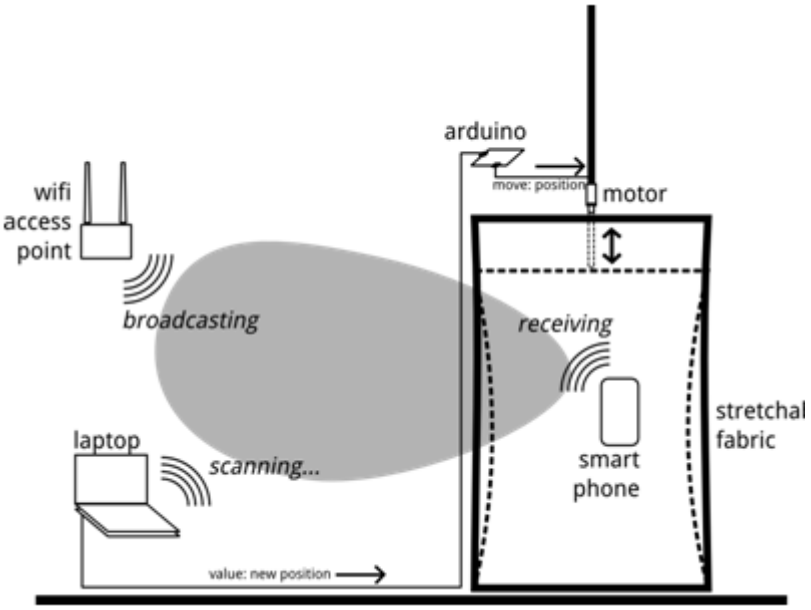
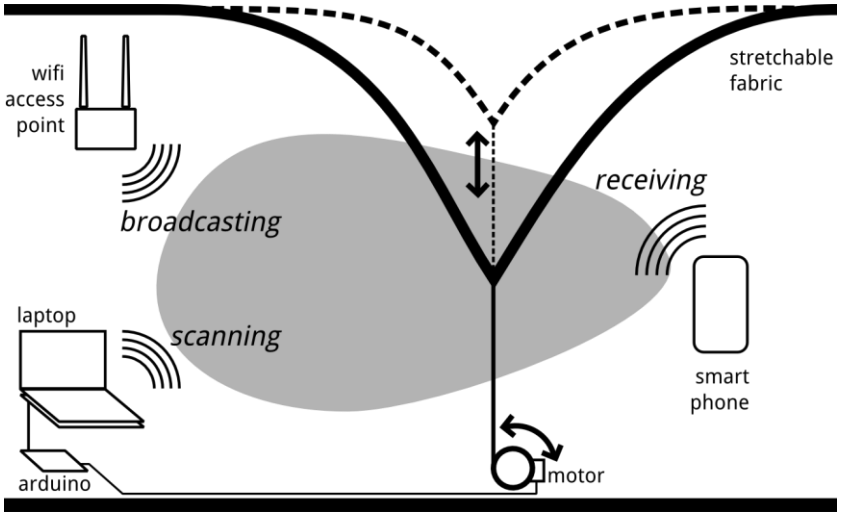


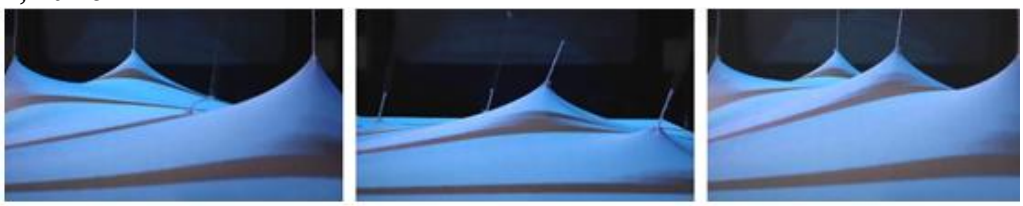
Figure 6. *Quadricone: Interaction Diagram*



The surface of the stretchable fabric becomes an interface between the information flow through wireless network infrastructures and people using this infrastructure. It renders their activity tangible, spatially *experienceable* and it gives it shape. If articulation of spatial experience is at the core of architectural tasks, the 'skin' formed out of stretchable fabric has apparent architectural qualities. Space is 'created' by an event taking place within it (Tschumi, 1994), it exists only through its practice.

The dynamic 'skin' articulates the flow of wireless communication, translating one of its' parameters - the amount of data packets into a physical parameter of the form of the 'skin'. Following de Certeau's observation that articulation of thoughts by talking corresponds to articulation of space by walking noted in his seminal Practice of Everyday Life, (de Certeau, 1984), data packets demarcate space with wireless communication. The usage of the network is expressed as a mechanical movement, emphasizing the physicality of the phenomenon.

Figure 7. *The changing form of the stretchable fabric, depending on the network traffic; Quadricone model at Stage digital research symposium, Bühne A, Zurich*



With the described prototypes, I explored dynamic, spatial representation of our wireless communication. At the same time, it is an exploration of an interaction system, where physical space interacts with data and people. The loop-chain involved an input from the environment generated by the person

interacting; translated into a physical response of the system which would in turn have a spatial impact on the person.

Besides being unable to test the interaction and immersion on a larger scale (described above when discussing Quadricone installation at Les Urbaines), the current focus of the setup on analysing WiFi traffic proved to be insufficient for the research. As majority of the people today walk around with smartphones with data plans and have access to the Internet through the 3G service, they do not automatically participate in the analysed traffic. Getting them to switch to WiFi in order to experience the installation is counter intuitive.

As an answer to the problem of spontaneity of participation (the fact that the system requires a visitor to switch to Wi-Fi from the usual 3G service) future plans include extending the range of 'sensitivity' of the system. We will explore the possibilities to analyse the intensity of traffic over the GSM network from mobile phones. Being able to interact with GSM signals would not only broaden the range of application, but also give a more relevant and realistic image of the wireless communication landscape.

Next to this, the project raised many questions. Amongst them, to which extent does it matter who generates the signals and what are the consequences for interaction? What is the clarity of interaction in such a system, when the input is translated to a linear mechanical movement of the 'peaks'? What is the aesthetic value of the dynamic shape, the different forms manifested in the stretchable fabric?

In the light of interaction design, is it important what input is used for dynamic shape-making? If the installation was attuned to another type of input – like the CO2 level in the room or humidity, the overall aesthetic of the piece would not change significantly. Thus there was not a strong connection between the final form and the aesthetic potential of the phenomenon under observation. However, the experiments with the Quadricone demonstrate a way to 'represent' wireless communication infrastructure, as opposed to simply 'using' it.

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