# Telephoning Textiles: Networked Soft Architectures

## *Telephoning Textiles: Networked Soft Architectures*

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**Abstract:** *A textile receives a telephone call from a mobile telephone. This wearable textile is an innovative example of inter-layering and weaving together materials to make a composite soft material that can receive calls from mobile telephones. If a textile can be designed as a wearable shirt, as demonstrated in this paper, then many of these same fabrication techniques can be integrated into soft architecture at a scale large enough to shelter people. This project demonstrates networked soft materials; the project develops the concept of soft architecture and presents a new framework for building integrated architectural systems.*

**Palabras clave:** Computational Textile, Soft Architecture, E-Textiles, Mobile Communications, Networked Wearables.

## Introduction

Demonstrated in this paper is a textile that receives a telephone call from a mobile telephone. The wearable textile is an innovative example of inter-layering and weaving together materials to make a composite soft material that can receive calls from mobile telephones. If a textile can be designed as a wearable shirt, then many of these same fabrication techniques can be integrated into soft architecture at a scale large enough to shelter people. As a woven system textiles point back to some of the earliest forms of calculation, computation and communication, and as Gottfried Semper argued in his book the *Four Elements of Architecture*, the beginning of building. At the scale of architecture the shirt prototype offers many possibilities for the development of soft, integrative architecture that provides not only shelter, but also connection and communication.

The steps to construct this prototype integrate electrical engineering, communications design, and textile fabrication. The fabric is designed using an electronic weaving technique called Charlieplexing to communicate the call signal from a mobile telephone to a cloth map. The location of the area code of the incoming call is pin pointed on the map with a lit led. Programming is used to calculate and direct the call signal to the cloth, and computation happens physically through the weaving of the conductive cloth to provide specific conduits to direct the call signal to the correct state. In this paper the author will present the methods of construction, present a demonstration of the textile receiving a call and present some of the implications and applications for this work in soft architecture.

Space is increasingly shaped not only by material but also by the immaterial, and the intangible, that which is not seen. So many of the challenges of architecture today are to design within an augmented idea of space, which is a space that is constructed of both material and physical and the immaterial such as data, information, that also shape space through the ways people use and access both the material space and immaterial data or information. The understanding of inside and outside is complex, nuanced and time dependent in a space or place that is also built upon digital ground.

Tools and techniques that are used to work within this augmented space come from many different disciplines and in the case of this project, the techniques are borrowed from computational textiles, and computational wearables to achieve an affordable working prototype that could be changed to address the problem of structure, of shelter, of scale, however what is important here is the potential to understand through a working prototype how such a soft wall or soft built component could work. The goal of the Networked Soft Architecture wearable prototype is to serve as a test to design an intelligent soft wall that can be woven into soft building components that can then communicate with each other and to people. A goal of this project is to change the paradigm of using wiring in buildings as a separate system to bear electricity and provide other services to occupants. The Networked Soft Architecture project is a first step towards understanding what is involved in completing such a built component. [Please See Figure 1]

*Fig. 1. Textile as Wearable Shirt, Showing Map of the United States with led's*

*Fig. 2. Woven Glass Fibers around Resonators (upper left), Toyo Ito's Sendai Media Center (upper right), Kennedy Violich's Herman Miller Work Center (lower left)*

## Related Work

Optical fibers have been used commercially since 1975, and used for the first time in 1988 to transmit long distance light beams for transatlantic telephone calls. Joel Fink's laboratory at MIT has been developing silicon based fibers that are multilayered and hollow cored to control the types and kind of signals that can go through the fiber, allowing the fibers to control both sound and light. Figure 2 (upper left) shows an array of glass fibers woven around resonators to filter for a particular light wave emission. However, not much research has been done of looking at how fiber optical cable might be integrated into soft architecture components for communication and shelter. Certainly the Sendai Media Center by Toyo Ito Figure 2 (upper right) begins to suggest the potential of the transformation of wall as carrier to the wall becoming the conduit itself.

Kennedy and Violich's work with Herman Miller begins to address the concept of a communicating wall; their system allows the user to form space with the curtain fabric that attaches to a track in the building ceiling. The tracks of this curtain system deliver electricity, communications wiring, and RF/ID providing an environment that allows users to cluster digital devices; this leaves the floor area more from wires and more open to human activities. [Please See Figure 2 (lower left)]

## Project Description

The project was developed by a team of people, two in communications engineering, and two in architectural design and project development was split into two parts. The first part of the project concerned the physical construction of the textile piece and programming of the piece to receive signals from an Android cell phone. The second part of the project performed by the electrical engineers in communications was to write the program to recognize the textile and send calls to the textile.

## Electronic Weaving_Charlieplexing

The physical textile is composed of 3 layers of non woven felted fabrics that serve as insulating layers for the circuitry that is made with conductive fabric and conductive threads. On the topside of the felted fabric layers was printed a map of the United States. This was then sewn to a shirt so that the piece is wearable and mobile. The printing was done by a regular home ink jet printer onto transparent transfer paper that was ironed onto the felt. The circuit for the weave is shown in Figure 3 (left). The bottom side of the textile is seen in Figure 3 (right). The circuit was designed to receive the calls from a programmed Android cell phone, using Android 1.5. These signals are regulated by a Lilypad 328 micro-processor that sends a signal to the respective state if called from a programmed cell phone with a corresponding area code within that state. This signal is shown by lighting up the led at that particular state. [Please see Figure 6] for the circuit layout. The number of pins on the Lilypad were expanded by using Charlieplexing to expand the 12 chip ports to accommodate 50 led's. Charlieplexing is an electronic weaving technique that provides for N^2 - N led's, where N is the number of pins on the Lilypad. This meant all 50 states could be lit up.

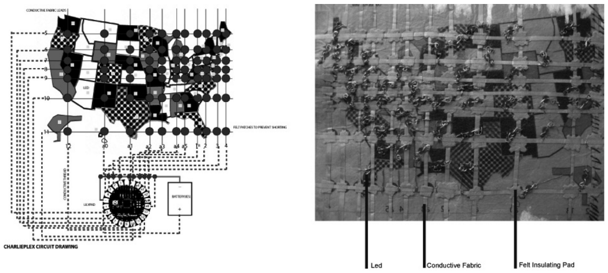


*Fig. 3. Circuit Weave (right), Back of Textile (left)*

Traces were sewn with 2 ply silver plated conductive thread at 82 ohms per foot to a grid of conductive fabric [Please see Figure 4 (left)]. The conductive fabric was ironed to a sheet of iron on fabric glue, and then laser-cut, glue side up. This made for much less fraying along cut edges. These strips were laid horizontally and then vertically to make a grid, which separated the horizontal from the vertical strips at their intersection with a small piece of insulating felt. All of these pieces were then ironed onto the base piece of felt. Additionally, the edges of the conductive fabric were treated with clear acrylic nail polish to ensure that there were no small frays that could short the project. Next, the positive legs of the led's were sewn to the horizontal bars of the conductive fabric grid, and the ground legs were sewn to the vertical strips of conductive fabric. Power could then be sent by Arduino program to each led, and turn all the others off by making them the opposite charge of the led we wanted to light up. The horizontal pins were set to HIGH and the vertical pins set to LOW. Each state on the map had an associated led, to turn on a particular pin its horizontal bar was called at HIGH and its vertical bar was called at LOW, all the other pins were programmed the opposite so that they could not be turned on. This combination of digital programming and physically woven grid structure to accommodate different state charges is called Charlieplexing. [Please see Figure 4 (right) for the diagram detail].

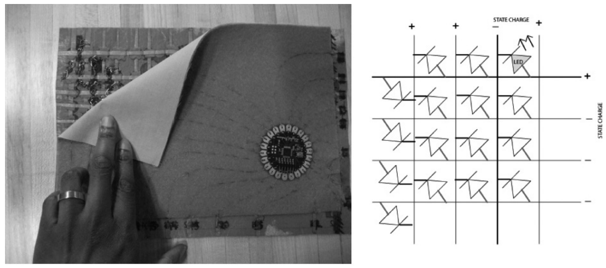


*Fig. 4. Conductive Thread Traces on Textile Connecting to Charlieplex Weave (left), Charlieplex Diagram (right)*

## Scale and Mnemotechnic Applications

While again it must be stated that the project was designed as a shirt, the potential of the project to be developed in architectural applications is high. If one can look at the issue of electronic weaving as a metaphorical constructional method used since the 1950's by the engineering discipline to provisionally connect the multitude of informational devices that provide knowledge to the human mind, such as RFID tags and GPS, then the shirt can be seen as one instance connected to a larger network of knowledge devices. If the shirt connects to a phone, then it can connect to many other devices through the phone. Thus scale is not just a literal reading of material size of the object; rather scale could also be registered by a capacity to connect to other things. Today in our homes, places of work and leisure there are millions of devices that keep track of what we buy, how much we spend, how much electricity we use, how much trash we make etc. because of this, the space that we inhabit is mediated by this invisible "mind" or storage place that can be accessed when we need that information. This shapes activity, cycles and patterns of living inside of architectural form. What is demonstrated in this project is that the information received and illuminated by the shirt is indexed or categorized by code and allotted to specific fibers making the indexing of the entire weaving by code and material engineering enterprise visible and explicit. The indexing here gives a location on a fabric map to an incoming coded signal. As a receiver and potential keeper of information, the textile has a gridded and modular physical character that can be used as a way for humans to visually access spatial tele-information in an architectural application. It is also possible to imagine that same textile sending a signal back to the caller indicating the receiving caller's location within interior space, mapping the national scale against the intimate or personal.

If one can imagine an architecture that has walls of rather densely knitted, nano designed fibers, some conductive some not, that can distribute and receive many different kinds of information and capacities such as heat, cooling, images, lighting, etc. across a knitted or woven surface, then one can begin to imagine a soft architecture.

## Contributions of the Project

The project demonstrates techniques used to network with soft materials, by integrating conductive fibers into the material itself. The project proposes a new framework for considering soft architectural components using a communication interface, which can be both mobile and stationary, and changes the meaning of public and private space.

The telephoning textile project changes the relationship between what is seen and what is unseen in an architectural application; by using conductive textiles to channel signals that ordinarily would have been a hidden behind a sheetrock wall and created as a separate wiring system.

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