

# Smart Stickers

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## ABSTRACT

In this paper, we describe a concept for creating self-contained, self-powered sensor arrays that can be spread around cities, called “smart stickers.” We also detail a system using smart stickers for locating and paying for parking, called “Smart Park.”

## Categories and Subject Descriptors

C.3 [Special-Purpose and Application-Based Systems]: Real-time and embedded systems.

## General Terms

Management, Design, Reliability, Experimentation, Human Factors.

## Keywords

Smart stickers, ad hoc, sensor, WiFi, parking, urban studies.

## 1. INTRODUCTION

Recent years have seen the development of two technologies important to intelligent environments: mobile ad hoc networks and very small, cheap sensing devices. Mobile ad hoc networks are self-configuring networks of devices that can communicate with each other and the Internet regardless of fixed access points. They allow for cheaper and more flexible wireless networks, and have a variety of applications in emergency response and low-cost communications [1]. Meanwhile, electronic sensors continue to shrink in size and cost, and can detect a greater range of environmental stimuli, such as light, motion, pollution, etc. These sensors are becoming increasingly ubiquitous in scientific research, commerce, and our living environments [2].

This paper seeks to explore how ad hoc networks can be integrated with sensors to create “smart stickers.” The advent of smart stickers could have a great impact in understanding urban living and how we approach intelligent environment design. We will define smart stickers and outline four components common to implementing them: communication, sensors, display, and energy. We will detail a scheme for using smart stickers for managing

street parking. Beyond this, we will suggest other possible implementations for smart stickers, and discuss what this implies for environmental design.

## 2. SMART STICKER CONCEPT

“Smart stickers” are small, self-contained electronic devices that can communicate with each other, sense certain environmental stimuli, and can function outdoors without requiring an external power source. They are designed to provide information about one’s surroundings and enhance urban living. A smart sticker requires the following four components to function:

Table 1. Smart sticker components

<b>Communication</b>	WiFi, RFID, other network protocols
<b>Sensors</b>	Infrared, ultrasound, pollution, motion detection, visible light, vibration, etc.
<b>Display</b>	LED’s, LCD’s, e-ink, sound feedback
<b>Energy</b>	Photovoltaic cells, batteries, conductive strips

The communication component, which requires some way of wirelessly transferring information between devices, allows the smart stickers to form ad hoc networks without being tied to existing infrastructure. The sensors provide useful information for the user. A display provides immediate feedback on the sensor’s status. Photovoltaic cells and batteries power the sticker, again eliminating the need to conform to existing infrastructure.

The result is a cheap, flexible network of devices that can adapt to different uses, configurations, and environments. One possible use will be a real-time system for locating parking spots, which we call “Smart Park.”

## 3. SMART PARK

The Smart Park system uses both smart stickers and the user’s mobile communication device (e.g. cell phone, PDA) to help users conveniently locate parking spots relative to their position in real-time. It requires help from a telecommunications company with cell phone positioning services and a server to track stickers and respond to user requests.

Outdoor, public parking spaces in an urban area are interspersed with smart stickers that can detect whether a car is parked in the space in front or behind it. These can use either an infrared beam

and detector, or an ultrasonic sensor similar to those used in cars for detecting distance to obstacles. The stickers use a microcontroller with WiFi capabilities to communicate with each other and access the Internet. They are powered by a battery that recharges from photovoltaic cells that cover most of the smart sticker surface area. LED's or e-ink (useful in bright conditions) on the device indicate the status of the parking spot, such as "available," "restricted," "paid," or "unpaid." A protective plastic shell allows the sticker to withstand outside weather conditions.

The user interacts with these devices with his cell phone or PDA. While driving around the city, he can send a request by a text message to a known SMS number. The server application triangulates the user's position by phone antenna, wireless access point, or GPS (whichever is available) and locates the two closest unoccupied parking spaces to the user. The server application then sends directions back to the user by either a map/animation using MMS (Multimedia Messaging Service) or by voice directions. Once the user is parked in a chosen spot, he can send another message to the system to pay for the spot, at which point the LED/e-ink indicate this status as a parking meter would.

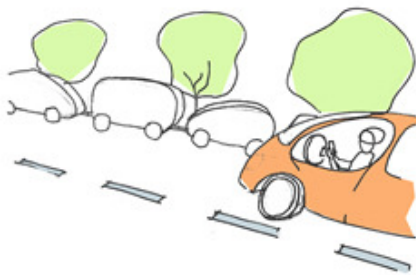
The following companies have already developed parking systems that use one or more of the elements we plan to use in Smart Park:

- MeterTek: Parking space detectors that communicate wirelessly with a server. They operate on batteries alone and do not use ad hoc networks, instead relying on fixed access points [3].
- 8D Technologies: PDA software that maps parking spots and whether they are occupied, paid for, time-expired, etc [4].
- XM Radio: Uses in-car GPS to locate position, shows nearest parking garages and space availability [5].
- Refinery: In Pennsylvania, allows online users to locate garages near a given destination and their distance, cost, and available spaces [6].
- IBM: System of calling a number to pay for a parking space remotely by phone [7].

Smart Park distinguishes itself from existing technologies by using a mobile ad hoc network, which means each smart sticker will not necessarily have to be within range of a fixed access point to be

# SMART PARK

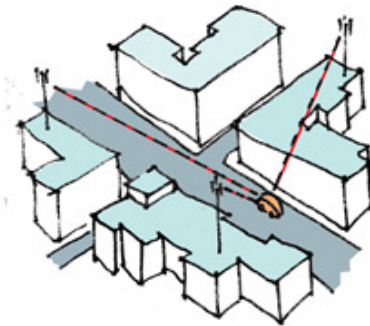
## CONCEPT:



1. Looking for a parking spot?



2. send an automated SMS saying "park me" to a memorized number. just one button to press, simplicity is key.



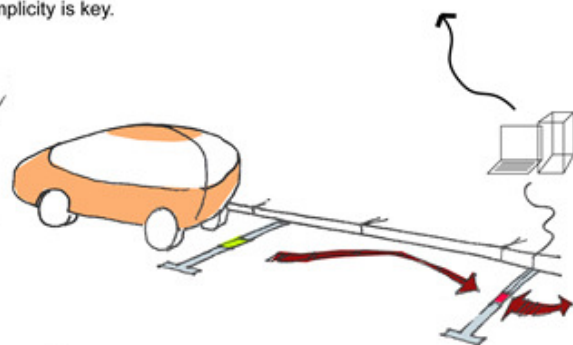
3. The system triangulates your geographic position



4. Receive an automated response by MMS or voice to guide you to the 2 nearest parking spots around you.



5. Park & send another automated SMS to start payment count



6. A viral signal is sent to the server via adjacent nodes, indicating that you have taken the spot and payed. A green LED will light up for parking staff, red if not payed.

Figure 1. Concept illustration for using Smart Park

part of the network. Each sticker needs to be within the broadcast range of another sticker, forming a flexible internal network of smart stickers. To connect this network to the Internet, only one sticker out of about a dozen would have to serve as a “backbone,” i.e. to connect to the Internet via Ethernet or WiFi. This accommodates a greater range of physical configurations.

Smart Park is also unique in that it uses photovoltaic cells as a power source, SMS and MMS as means of requesting and receiving directions, and triangulation between cell phone antennas as a means of identifying user location. Each of these allows more users to access the system through a variety of devices. Beyond this, Smart Park can be made backwards compatible with existing systems; for example, users with smart box-equipped cars can use those to determine position instead of using a cell-phone. Smart Park will also be open to further changes in the future (forward compatibility).

Implementing Smart Park raises several issues. For instance, how can we balance the number of stickers, number of backbones, and amount of information to minimize transmission errors and maximize performance? Will such devices work in places with harsh climates or little sunlight? How easily can the system be adapted to future needs and technological advances?

There is also the future possibility that the user could access the sticker network directly without routing through the Internet, allowing planners to distribute the stickers beyond the reach of existing wireless networks. This means using their own WiFi-enabled PDA or computer to access the ad hoc network directly, once they are within broadcast range of the stickers. This presents us with two models for extending access to the user; one connects the user to the information through a global network, while the other connects them on a local scale.

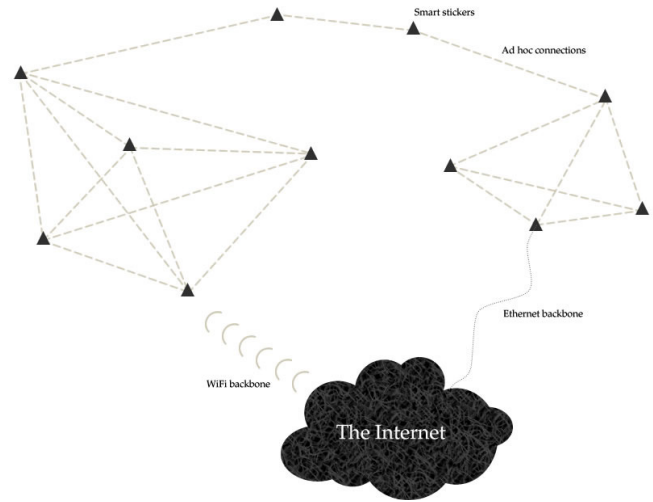


Figure 2. Ad hoc network of smart stickers

#### 4. OTHER APPLICATIONS

There are many other applications for smart stickers, especially in the field of environmental design. For example, smart stickers could be used for broadcasting location-based services to users in their range. Stickers can be distributed over a wide area and used to sense a range of weather or pollution factors, such as temperature, humidity, cloud cover, particulates, ozone, etc. Smart stickers can gauge traffic and weather in areas with a high demand for real-time statistics on road conditions [8]. They might even find a variety of uses in public art installations, as a tool for

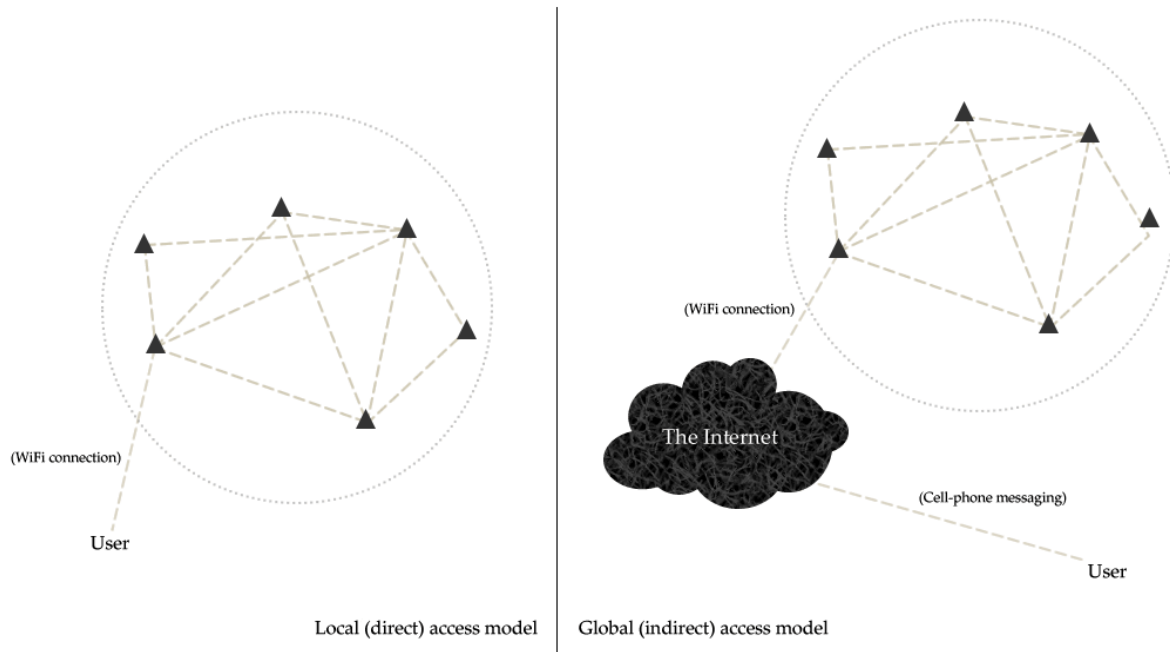


Figure 3. Local versus global access to smart sticker network

creating works that respond to the actions of users and the city.

The key is that smart stickers can be used to increase the individual user's awareness of his surroundings. With a flip of a cell phone, PDA, or laptop, the user gains access to information about parking spaces he cannot see, traffic levels he cannot measure, or weather conditions he cannot predict. The idea of smart stickers can be implemented in different ways to sense and communicate different things. Because they use ad hoc network architecture, they are not strictly bound by existing communication infrastructure. This flexible structure may also allow smart stickers to move while still retaining functionality. Mobile sensors, especially when attached to human or automobile behavior, have a multitude of possible applications as well [9].

## 5. CONCLUSION

Smart stickers have the potential to transform the way we experience cities, increasing our awareness of our environment in real-time. One implication of this is in creating efficient, sustainable cities. For instance, Smart Park could reduce the time spent driving around looking for parking spots, saving its users energy and reducing car emissions in the city. It also provides a means of quickly and efficiently allocating scarce parking resources in dense areas of cities. This could factor into the revitalization of downtowns, where improving access may revive interest in certain areas. Whether or not the tangible benefits of Smart Park outweigh the cost of implementing the system remains to be seen.

At the very least, smart stickers present one solution to the problem of wiring infrastructure in the city. Indeed, many cities are now using ad hoc networks as the basis for their own public WiFi networks in the absence of comprehensive broadband

infrastructure. Applying this concept to sensing is a cheap alternative to costly and static sensor arrays, which, while potentially useful for many applications, may be beyond the reach of most cities.

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