Pollen: Virtual Networks That Use People as Carriers

Natalie Glance, Dave Snowdon

Xerox Research Centre Europe, Grenoble Laboratory,
6 chemin de Maupertuis, 38240 Meylan, France
{glance, snowdon, meunier}@xrce.xerox.com

Abstract. In this paper, we propose a novel kind of network that uses people instead of wires (or other communication media) to carry message packets between devices and between physical places. In the course of their day, people move from device to device and from location to location. We will describe how this movement of people can be harnessed to allow the communication of electronic messages, albeit in a way that is relatively unreliable and unpredictable compared with traditional networks. This new kind of network infrastructure has a number of advantages, such as low cost and scalability.

1. Introduction

The principal idea behind the Pollen network is to network devices and physical spaces using people instead of wires. Examples of devices and objects include printers, facsimile machines, video-conferencing equipment, books and other small objects. Examples of physical locations include meeting rooms, offices, and reception desks. This large variety of devices and locations is typically very expensive to network using wires. But these nodes are already connected together – by the movement of people. The Pollen network provides an infrastructure that supports the distribution and collection of information and does so without relying on traditional network technology.

Pollen also makes it possible for information to be shared and distributed where needed simply by the everyday actions of groups of people. People need not be aware of how the distribution is taking place nor of the details of their participation in the process. Information (such as hints, tips and other comments) can be associated with physical objects in the work environment and made easily available to colleagues.

This is accomplished using, for example, PDAs to perform redundant data transfer. The metaphor we use is one of plants being pollinated by insects. When an insect visits a flower to take advantage of the free supply of nectar it inevitably collects some pollen on its body. When it moves to a different flower some of this pollen rubs off. In the same way, when a user visits a device, not only can the user leave comments on the device, but the device can also transfer pieces of pollen to the user's PDA. The pieces of pollen may be either visible or invisible to the user, depending on their relevance to the user. Relevance depends on both the person's identity and the current

context. Users are notified, for example, about pollen addressed specifically to them or pertaining to their current location. When the user next visits another device, the pieces of pollen stored in the PDA can then be selectively passed along. Through the cumulative actions of many people interacting with many devices in this way, messages are transferred node-by-node across the network. We are currently using Java iButtons [1] as the nodes with which the PDAs communicate but any small, rugged, device could be used or in the case of electronic devices they could be equipped with a suitable wireless or contact based interface.

An addition to this is a central organisational memory, which we also refer to as the hive. When the PDA is next docked with the user's workstation the cached pollen is uploaded to the central organisational memory. Information can also flow in the other direction. When comments become obsolete the organisational memory can transfer commands to a docked PDA instructing it to expire the comment(s) when the PDA next encounters the specified iButton(s). Although the hive is not strictly necessary for Pollen to function it allows the possibility of optimising the traffic flow since there is the possibility to learn which PDAs are most likely to visit a given node and thereby make "intelligent" routing decisions. The use of the organisational memory also allows people to obtain an overall view of the information in a Pollen network and to centrally update this information – for example to produce new manuals or Frequently Asked Question lists (FAQs) to be associated with particular devices, or to do distributed diagnosis.

Another advantage to this scheme in addition to the lack of a physical network infrastructure is that it is not restricted to an organisation. Multiple organisations (even homes) can use the same technology. We can use cryptography to ensure that the information can only be used in conjunction with a device with the appropriate keys.

2. Related Work

The work most similar to Pollen is Locust Swarm [3] which uses solar powered devices positioned in buildings to store annotations and provide location information to users via their wearable computers. Another application also from MIT, is Meme Tags [4] which allows small textual messages to be passed among users via badges worn by each user which communicate via infra-red.

We believe that Pollen has several advantages over existing network technology including: *less infrastructure* (little administration and no cabling is required), *lower cost* (iButtons are cheap and the PDAs which act as the information carriers are those that the users use as part of their everyday life) and *ease of configuration* (nodes in the Pollen network can be added or removed trivially, with almost zero administrative overhead).

There are a number of risks associated with the successful implementation of a Pollen network. The first is the storage and bandwidth limitations of the iButton and the PDAs. The second is the computational complexity, completeness and robustness of the Pollen algorithm, which as yet remains to be determined. The third is the

bandwidth of the Pollen network itself, which depends on the behaviour of the pollen transmitters – that is, the PDA owners themselves. Finally, there is the need to handle inconsistent information caused by multiple copies of the same information being present on the.

3. Conclusion

We now have a prototype of the Pollen network based on Palm IIIs and iButtons [1]. We are also working on simulations of Pollen in order to better understand its behaviour – our current model is based on the concept of epidemic algorithms [2] to model the spread of messages through the network.

Another research thread involves knowledge extraction from the hive's history. Can we detect patterns in the movements of people and the use of devices, which, for example, can help us improve the working environment?

Finally, in parallel with these three research threads, we are investigating possible applications of the concept not only in the work environment, but also in the home environment, in retail and in manufacturing. Since an iButton can be placed almost anywhere (including objects which are mobile), it is possible to connect just about anything to a Pollen network with almost zero overhead, thus providing a platform for numerous new kinds of application scenarios.

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