Issues in the Design of JetSend-Enabled Communicating Appliances

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Abstract: JetSend is an open technology that provides appliance developers with the benefits of simple, flexible and direct communications. In particular, JetSend provides a peer-to-peer communications protocol that allows appliances to connect, negotiate data types, and exchange information. This all occurs without reliance on a PC, network server or other intermediary. By incorporating JetSend, appliance developers can ensure interoperability with other communicating appliances and focus on the primary functionality of their device. In this paper, we describe how JetSend's flexibility in connectivity and information encoding provides designers with the freedom to develop novel information appliances utilising a variety of communication models.

Introduction

Information appliances are an emerging class of devices with the potential to radically change the nature and use of personal information technology. JetSend is a new peer-to-peer protocol that is intended to enable ubiquitous communication between information appliances without the need for intermediaries such as personal computers or network servers [1]. However, it is still too early to identify precisely which information appliances will become dominant, exactly how they will operate, and how they will need to connect to one another. Consequently, the JetSend architecture has been designed to enable a broad, open design space for appliance developers that guarantees inter-operability without constraining device functionality.

The key characteristic that makes JetSend suitable for a wide range of different appliance models is the flexibility it provides in two crucial areas of appliance design:

- How the appliance will connect with other devices
- How the appliance will share information with other devices

This paper explores how JetSend offers design freedom in these areas while ensuring that the resultant appliances can be guaranteed to communicate with other JetSend-enabled devices.

1. Models for connectivity in JetSend

JetSend is intended to provide an architecture and protocol for a wide range of communicating appliances with differing capabilities. One major difference between the various types of appliance that emerge over the coming years is likely to be their preferred communication channel. For example, very local-area, wireless communication might be appropriate for small handheld devices like PDAs, whereas large shared appliances such as a network printer might be better served by an internet connection.

Consequently, the JetSend protocol has been designed to be transport-independent to enable connectivity over a wide range of communication channels. As the Internet is likely to be a pervasive communications infrastructure for information appliances, Hewlett-Packard's first released implementation of JetSend uses IP as the underlying communications protocol. Jetsend over IP allows long-distance communication to devices with known addresses on the internet. For example, network scanners and printers might use JetSend to provide an internal "intranet fax" service for large corporations.

In contrast, an infra-red implementation of JetSend can be used to provide convenient and direct communication between, for example, a camera and printer. These devices can be configured within Jetsend to perform automatic discovery and connection, so avoiding the need to obtain or enter device addresses. Of course, infra-red is limited to very local, line-of-sight communication and would not be suitable in many circumstances. The point is that various information appliances will require different communication models. JetSend is intended to allow the appliance designer to choose the model most appropriate for their device.

Whichever underlying communications channel is used to connect an information appliance to other devices, there remain a number of design issues to be resolved by the appliance designers. For example, is the appliance intended to be a sending device, a receiving device, or both? Will the appliance typically engage in short connections while a specific piece of information is transmitted to another device, or in longer sessions in which some shared information is maintained and updated by both devices?

Perhaps the most common use of JetSend in the near-term might be to connect two devices simply in order to transfer some piece of information from one device to the other. For example, a scanner providing an intranet fax service as described above may only connect to a remote printer long enough to send its scanned image to be printed. JetSend supports such connections well and provides job management and status reporting mechanisms to augment its fundamental capability to transfer information. However, JetSend is not restricted to this simple case. Rather, information transfer is a specialization of JetSend's more general capability to allow devices to maintain and update a shared view of information over a period of time. Using this more general capability, JetSend could be used in distance learning, for example, to connect an electronic whiteboard and a remote projector such that marks made on the whiteboard are immediately and automatically reproduced on the projected image.

Both of the above examples illustrate one-to-one communication between a pair of devices. However, JetSend also allows both senders and receivers to handle multiple simultaneous connections. For example, we could extend the distance learning scenario to imagine a situation in which the whiteboard image is sent simultaneously to a number of remote projectors in different locations. Similarly a networked printer in the intranet fax example might have sufficient resources to accept and spool multiple simultaneous print jobs, and so accept information from multiple scanners at the same time. Again, the key requirement met by JetSend is to provide flexible connectivity so that appliance designers can choose the most appropriate connection model for their device.

2. Sharing information between JetSend-enabled appliances

As we have seen, JetSend allows information appliances to connect to one another in a variety of ways over various communication channels. Although appliances may connect simply to share status, or to perform some control function [2], we assume that the principal motivation for connectivity is to share or transfer some information. JetSend is intended to allow any two (or more) devices to connect to one another without knowing anything about the other device's capabilities, but this raises an issue: How is a JetSend-enabled appliance to ensure that the information that it sends or receives is represented appropriately? For example, a JetSend-enabled scanner may connect at different times to a monochrome printer and a full-colour display. How should it encode its scanned images so as to enable an appropriate presentation of those image at either device?

JetSend resolves this issue by allowing appliances to negotiate an appropriate encoding of information to be shared between the appliances. A sending device may offer each chunk of information (i.e. each surface) to a receiving device in a number of alternative encodings. The receiving device selects the one that is most appropriate for its needs and requests that the information is sent in that format. Note that the encodings allowed by JetSend are part of the specification of the protocol, but that they only apply to the information "on the wire", i.e. as it is shared. There is no obligation on appliance developers to use the specified encodings for internal representations of appliance information.

How does the appliance designer decide on a range of encodings to offer or accept? Consider the example of a scanner wishing to send single scanned images to connected devices. In JetSend, images are encoded according to the following dimensions:

- Size - in inches
- Resolution - the density of pixels used to represent the image
- Colour depth - the number of bits used to describe the appearance of one pixel
- Colour space - the scheme for interpreting the values of pixels
- Compression - used to reduce overall data size

The scanner might be capable of producing, say, 24-bit colour images at 600dpi, and its designer will naturally prefer to transfer images of this quality to other devices. In other words, the first choice of encoding might be one that shows the appliance in its best light. Next, the designer might be aware that scanners are often connected to monochrome printers. In these circumstances, either the scanner or the printer will have to grayscale the colour image before it is printed. The scanner designer could leave this to the printer, but may prefer to retain control of the conversion algorithm and explicitly offer a second, grayscale image encoding suitable for immediate use by monochrome printers. Finally, the designer needs to ensure that the scanner will also transmit the image successfully to unknown devices with perhaps very limited capabilities, and so adds the JetSend mandatory image encoding (300dpi, Grey, 1 bit/pixel, RLE compressed) to the scanner's offerings.

The designer of a receiving appliance goes though a similar process to determine the encodings that the appliance will accept. For example, the designer of a colour printer might choose to accept JPEG encoded colour images to facilitate printing from digital cameras, and GIF encoded images for pictures originating on the world-wide web. Again, the printer designer would add the mandatory image encoding to ensure that it can receive images from other devices incapable of generating the printer's preferred encodings.

So far, we have described how appliances can be designed to share a range of different image encodings during communication that balance the need to optimise anticipated connections while guaranteeing acceptable information transfer to unknown devices. The same approach can be used for other basic data types such as text and audio. In addition, Jetsend provides a second means to encode information by adding structure through two related constructs: planes and associations.

Planes provide a means of specifying spatial relationships between basic data types and backgrounds, and may be thought of as corresponding loosely to document pages. Figure 1 shows an example of a plane containing two images.

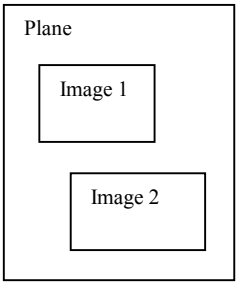

Figure 1 Example of two images laid out on a plane.

Planes allow a sending device to specify how it would *prefer* the e-material to be presented at a receiving device. The receiver may not be able to follow the preference precisely. For example, an A5 printer would not be able to print out an A4 sized plane and may choose to crop or scale the image before printing, However, a well-behaved receiving device should respect the sender's preferences where possible.

Associations provide a means to group chunks of information into collections as shown in Figure 2, which may be thought of as (loosely) as separate pages within a document.

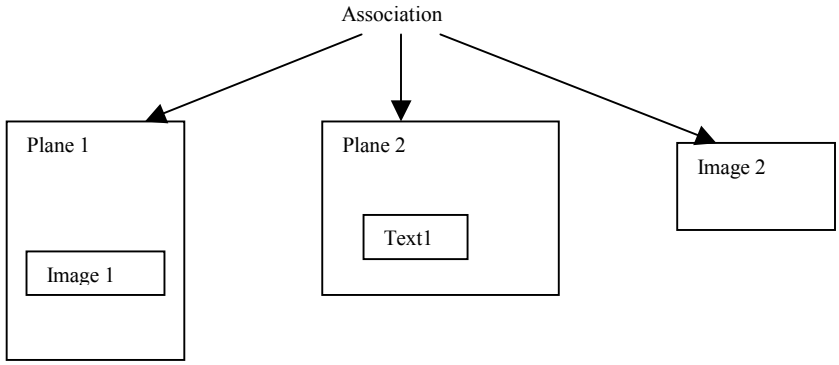

Figure 2 An example of an association containing two planes and an image

The purpose of both planes and associations is to increase the design freedom of the appliance developer by providing a way to more accurately reflect inherent information structure in the appliance. For example, the developer of a multi-page scanner may choose to use an association of images to communicate to spooling printers that a set of images belong together and should be printed contiguously rather than interleaved with other material.

JetSend allows complex information to be offered in a variety of structured encodings just as an image may be offered in different image encodings. Again, the choice of encoding will depend on the natural structure that the developer of an appliance wishes to express and the need to communicate with limited devices. For example, a sending device may offer a "page" of information both as a plane containing graphical images and text blocks, and as a single page-size image. A receiving device with a browser-like human interface might select the more structured encoding during negotiation to maximize its ability to rearrange the lay-out of the page for presentation, whereas a simple printer may select the non-structured encoding (i.e. the single image of the page) because it is easier to render to the print engine.

3. Conclusions

JetSend is a flexible, peer-to-peer protocol that enables appliance developers to adopt a wide range of communication models while guaranteeing inter-operability with other JetSend-enabled devices. As we cannot yet tell which information appliances will pass into widespread use, it is important that any new technology does not constrain its usage to current models and data encodings. The JetSend architecture is intended to allow developers of novel information appliances as much design freedom as possible to explore new models while retaining a guaranteed level of communication between conformant devices. The key characteristics that provide this design freedom are the flexibility JetSend allows in connecting devices together in different ways over a variety of communication channels, and the flexibility with which alternative representations of shared information can be negotiated between devices.

References:

[1] *JetSend: A Flexible Appliance Communications Protocol*
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[2] *Ubiquitous Remote Control of Network Appliances using the JetSend Communications Protocol*
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