Volume 10 Issue 01 Published, February 15, 2006 ISSN 1535-864X DOI: 10.1535/itj.1001.07

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New Uses, Proposed Standards, and Emergent Device Classes for Digital Home Communications

Mark Walker, Digital Home Group, Intel Corporation
Jim Edwards, Digital Home Group, Intel Corporation
Ylian Saint-Hilaire, Digital Home Group, Intel Corporation
Jeffrey Lee, Digital Home Group, Intel Corporation

Index words: VoIP, UPnP, DLNA, HCS, Digital Home

ABSTRACT

The exponential growth rate of Voice-Over-IP (VoIP) subscribers worldwide, increasing deployment of broadband Internet access to the home, and the steady increase in the number of installed home networks has created an opportunity to support new communication experiences in the digital home. The end result for users will be new IP-based devices, services, and capabilities that go far beyond what today's communication technologies can deliver. Enabling these new communication experiences will require a digital home communication architecture consisting of new standards and classes of communication devices.

In this paper, we summarize the results of a recent Intel Corporate Market Research (CMR) study on unmet consumer communication needs and highlight how the collected data suggests the need to develop a general, standards-based framework for digital home communications and the development of two specific new device classes. The two device classes and their uses are presented in detail. The requirements for the proposed digital communications framework are compared with the existing Digital Living Network Alliance (DLNA) framework for digital home entertainment [1]. We conclude with an overview of similar architectural components that will be needed to establish the digital home communications framework.

INTRODUCTION

Voice-over-IP (VoIP) is a term used to denote voice communications over the Internet. Current VoIP users generally fall into the early adopter category; that is, a small but rapidly growing group of consumers willing to tolerate less than stellar audio quality in exchange for features like very low-cost long-distance access to any other Internet-accessible VoIP phone in the world [2]. The evolution of VoIP from a computer hobbyist technology into a solution for mass-market communications is predicted to accelerate as major telco and cable providers enter the market, adding capacity and improving quality [2]. The recently developed 3rd Generation Partnership Project (3GPP) IP Multimedia Subsystem (IMS) recommendations for Session Initiation Protocol-Session Description Protocol (SIP-SDP)-based call control [3-4] have now established the required foundation for interoperability between IP communications providers. Finally, a number of Internet Engineering Task Force (IETF) signaling and network protocol standard recommendations that specify the operation of VoIP devices [5-8] have been undergoing a process of consolidation and profiling within the industry, greatly increasing assurances of phone-to-provider interoperability.

We first summarize the results of a recent CMR study on unmet consumer needs for communications. We describe two new digital communication device classes suggested by the CMR data: a Home Communications Server (HCS) and a Digital Communications Adaptor (DCA). The HCS is similar in function to enterprise digital private branch exchange (PBX) systems, but is tailored specifically for home use and provides services exposed on the home network via UPnP* technology [9]. The HCS fulfills unmet consumer needs by providing a single entity for managing all home IP communications in a manner that abstracts the differences between different forms of communications such as voice, email, and instant messaging. It empowers consumers with a high degree of control over family communications by enabling complete personalization of HCS behavior through UPnP standard interfaces. The DCA adapts legacy consumer electronics (CE) equipment such as the TV for use as a communications device on the home network. DCA devices capture and render voice and optionally video, pictures, audio, text, and video for richer communications. Both new device classes require a UPnP technology standards framework for digital home communications, similar to that established by the DLNA for networked entertainment in the digital home.

Finally, it must be noted that in this paper we proceed from the assumption, as does much of the current technical literature on VoIP, that IP-based communications will gradually replace Public Switched Telephone Network (PSTN) communications over time, due to lower overall costs to the consumer and the ability to support richer communications such as video, instant messaging and picture sharing. While many devices deployed during the transition from PSTN to IP will support and interoperate with both systems, these devices are not considered here.

SUMMARY OF RECENT RESEARCH ON UNMET CONSUMER COMMUNICATION NEEDS

An Intel CMR study was recently conducted with the goal of defining an end-user-based framework for communications usage models within the digital home. The research team was composed of cross-organizational, cross-capability individuals from various Intel divisions with responsibility for the digital home market and technology. A total of 21 in-home interviews conducted in two phases took place over a three-month period in two North-American cities. Specific goals of this study were as follows:

- To develop an understanding of what drives the need for communications.
- To generate a first-level assessment of how technology is used in the communication model.
- To identify specific unmet consumer needs that technology can address.
- To translate unmet needs into framework, device and application requirements.

The key findings of this study were as follows:

1. Communication is increasingly taking place within what the team described as a “virtual home” environment. Virtual home is a term employed to highlight the fact that Americans now spend as much time outside their primary residence communicating and coordinating as they do inside it, irrespective of family size. Typical venues where families and individuals spend time include children’s sports events and practices, churches, gyms, automobiles, etc.
2. Two key forces that drive the need for communication are “staying in touch” and “planning.” Staying in touch means using communication to achieve a feeling of togetherness. Planning is the organization of family daily routines and dealing with the logistics of those routines. Families in the study reported significant amounts of time planning the day and communicating those plans to family members.
3. Consumers are using an increasingly diverse and non-interoperable set of communication channels such as cell phones, pagers, e-mail, Instant Messages (IM), and landline phones, The diversity of these channels has created “islands” of multiple in-boxes for messages, contact lists, calendars, etc. Consumers reported spending significant amounts of time manually bridging information and content between channel applications.
4. Four general categories of unmet communication needs were identified in the collected data: Continuity, Management, Protection, and Closeness. The term *continuity* denotes activities such as successfully juggling diverse channel types and minimizing the amount of personal attention required to distinguish between *wanted* (friends, family) and *unwanted* communication (e.g., telemarketers), and making it easy to receive wanted communications. *Managing* refers to the desire to have always available appropriate contact information, especially for contacts deemed important by the consumer. Appropriate contact information includes the communication means preferred (cell phone, land-line phone, IM) by the person being contacted. *Closeness* is the need to use technology to maximize the sense of togetherness when family members and friends are apart. Finally, *protection* refers to the ability to easily block unwanted communications.

CMR Data Analysis and Requirements

Analysis of and requirements for solutions emerging from the CMR study data is enumerated in this section. The results serve to help guide the definition of technologies to address unmet communication needs. Highlights of the analysis and required solutions are as follows:

- While the traditional concept of home is being supplanted by the more recent concept of the virtual home, the data suggests that the physical home may provide a base for deploying technology solutions that combine personal communication devices in a manner that among other benefits, affords users a feeling of home while they are away from home. Home-based solutions will never replace away from home solutions like cell phones, but cell phones may leverage emerging VoIP standards to integrate with in-home solutions and deliver the virtual home user experience.

- A user-transparent, home framework for connecting diverse constellations of communication devices to each other and for sharing information may help address the problem of bridging disparate communication channels. The framework may establish at least the perception, through the connectedness of devices, of a centralized entity for managing all forms of family communications including calls, messages, alerts, calendars, etc. High connectedness permits tight integration with task management applications, such as calendar.
- Employing proven networking technologies and standards as in [1], e.g., Ethernet, 802.11, IPv4, HTTP, and UPnP, for maximum availability and/or instant access to the framework may address the desire for control and management.
- Providing access to and use of the framework from outside the home supports the notion of virtual home.
- Enabling full user personalization and control of wanted and unwanted contacts, personalized policies for call and message handling, etc. address the consumer desire for communication protection. Using the framework to abstract calls, IMs, etc. allows personalization of control to be universally applied regardless of the communication type.
- Richer communications experiences such as videoconferencing or sharing pictures of the family while talking help address the need to achieve a greater sense of closeness. Applications of this type can maximize the use of technology to achieve a greater sense of closeness by allowing users for example, to see each other while speaking.

NEW PROPOSED DIGITAL HOME COMMUNICATIONS FRAMEWORK AND DEVICE CLASSES

The conclusion that the physical home may provide a base for deploying communication technology solutions suggests a need for a home framework that facilitates the integration of in-home personal communication devices and extends personalized communication services to devices used outside the home.

The DLNA framework for network-connected entertainment devices (summarized below) is proposed as a model for developing a digital communications framework. In this section, we focus on new communication device classes that utilize the proposed home communications network to help mitigate the unmet consumer needs listed above. The first device proposed is the concept of a Home Communications Server (HCS). An HCS is similar in essential function to an enterprise PBX, but tailored specifically to home use models. The second category of devices represents client devices that depend on the presence of the HCS on the home network. Digital Communication Adaptors (DCAs) fall into this category and are detailed below. DCAs allow legacy television sets to be used for richer communications, such as videoconferencing. Other categories of client devices (not discussed here) that derive value from the HCS but are not necessarily dependent on it include cell phones and VoIP wireless handsets.

Requirements of the Home Communications Server

General requirements for HCS use are as follows:

1. HCS implementations must support the desire for high ease of use implicit in the unmet needs by allowing any newly purchased or "guest" communications device to transparently register and use the home VoIP service provider for both inbound and outbound calls. This basic HCS connection process should be as similar as possible to the current industry standards for connecting VoIP clients to a service provider. Outbound calls are placed as requests to the HCS.
2. HCS implementations must support the *Managing* need by allowing any net-connected device to browse listings of contacts. Contacts entries must be in a form to allow communications-capable clients to transparently make outbound calls using the channel preference of the person being contacted. HCS implementations must additionally support easy editing/updating of contact listings by authorized client devices and applications.
3. An HCS must also allow authorized applications and client devices to set incoming call policies for call routing, call blocking/blacklisting, call forwarding to voicemail, client ring order, client ring tone, and external call forwarding–all based on whose calling and other criteria, including time/date. HCS implementations must allow the same policies

to also be set for incoming IMs and e-mails, effectively eliminating the differences between calls and messages in the task of setting home policies.

In addition to the requirements for meeting unmet needs, two additional HCS requirements for enabling compelling new user experiences are:

1. Authorized client devices and applications must be able to actively monitor all extensions (including who they are connected to) and to set up specific groups of clients for conference calls on the fly.
2. HCS implementations must be easily integrated with other productivity and planning applications like calendar.

HCS Architecture

Figure 1 shows the HCS and other devices connected to the home network. The HCS is connected to the Internet through the router and may be bound to a specific VoIP service provider. The HCS additionally employs SIP-standard telephony and signaling [5-8] for connections to the service provider and for receiving/acknowledging incoming calls.

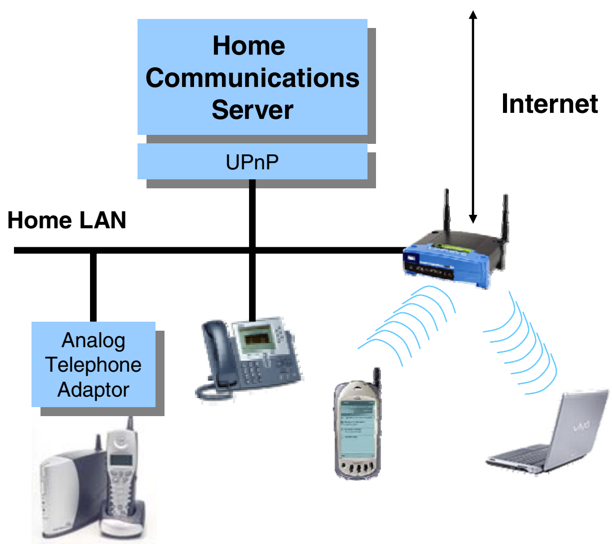

Figure 1: HCS on the Digital Home Communications Network

On the LAN side, the HCS exposes UPnP technology service interfaces to other networked devices that have UPnP control points. IP communication devices utilize their control points in the UPnP-standardized scheme to discover the HCS and obtain the IP addresses of the device and its service interfaces [9].

HCS services are grouped into four functional categories.

1. *Basic communication services*: After obtaining HCS IP addresses, IP communication client devices register with the HCS. Registered client information includes current IP address, friendly device identification, and audio capability profile. Audio capabilities are enumerated in the form of SDP parameter lists [10], that include the audio codecs supported by the device, ordered according to device preference.

   Once registered, IP communication client devices utilize the SIP proxy functionality of the HCS for placing outbound calls. SIP client devices literally call the HCS, which then forwards the call to the service provider. Calls inbound to the HCS from the service provider are routed to registered client IP addresses per call routing policies.

2. *Extended communication services:* Extended communication services allow the HCS to be managed and configured by any authorized client device. Management functions include the following:

   a. *Browse/search/edit/update contact listings:* These functions allow any device to view and edit XML-standard form contact listings. Contact metadata contains detailed technical information that enables among other attributes user selection of, the right "channel" when a user initiates an outbound call. Communication clients may first browse for a specific contact and include the contact listing reference in the outbound call request. Listings can also include recently dialed/received contacts. HCS users manage contact listings using standardized XML as the exchange format. This activity may be made even more user-friendly by supporting "1-button" contact list synchronization, i.e., a communications device with a native contact list can instantly synchronize with the HCS on its personalized contact subset.
   b. *Manage message archives*: This allows consumers to manage combined views of HCS voice, text message, and e-mail listings, as well as forward, delete, and save messages.
   c. *Manage home communication policies:* This allows users to manage XML-standardized HCS policies for these actions:
      - Routing of all incoming calls/messages/mails based on caller/sender ID to specific client extensions based on device ID.
      - Calls/messages/mail blocking based on time of day and caller/sender ID.

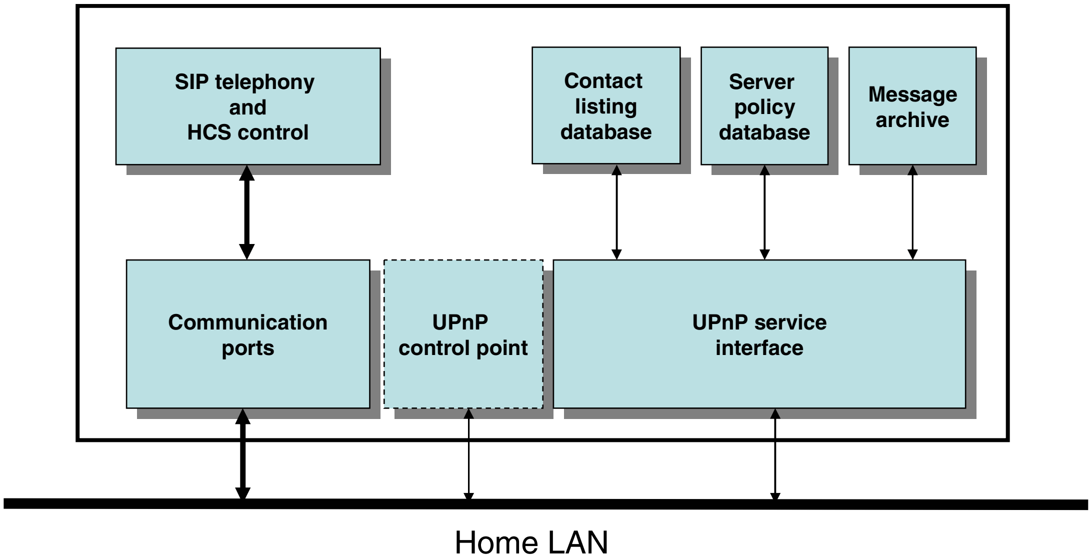

Figure 2: Functional blocks composing the HCS

- Call/message/mail priority: caller/sender ID-based priorities for incoming communications and device ID-based priorities for outbound calls.
- Caller/sender ID call/message/mail forwarding to voicemail.
- Client extension ring order.
- Caller/sender ID-based client extension ring/alert tone.
- Caller/sender ID-based external call/message/mail forwarding.

3. *Remote access*: Family members can log into the HCS when outside the home and register their current IP addresses. The HCS then forwards inbound calls, messages, and mail to externally located users based on its forwarding policies. Using current standards for Internet security [11], users are additionally able to use HCS extended communication services, including the management functions described above.

4. *Communication notices/alerts:* The HCS may optionally include functionality for discovering digital media rendering devices (DTVs, digital stereos, etc.) connected to the home network, for the purpose of forwarding notifications of incoming calls and other alerts. In the next section, we detail a new device type that takes full advantage of the potential to merge communications and rich media.

Figure 2 shows a generalization of the functional blocks that compose the HCS. The contact listing database, server policy database and message archive are exposed directly through the UPnP service interface. The UPnP service interface also exposes communication ports available for outbound calls. The SIP telephony and HCS control module receives inbound calls, messages etc., and routes them according to policy to registered client devices. The optional control point can be used to discover and utilize other UPnP devices, including display devices.

Continuity, Management, and Protection

The HCS fulfills unmet consumer needs summarized above by providing a single entity for managing all home IP communications in a manner that abstracts the differences between different forms of communications such as voice, e-mail, and IM. It empowers consumers with a high degree of control over family communications by enabling complete customization of HCS behavior through standard UPnP interfaces.

Additional HCS Benefits to the Consumer

In addition to addressing the unmet consumer communication needs above, two additional benefits for home IP communication users are realized with an installed HCS:

1. *Call-quality assurances***.** Using the HCS as the proxy mechanism for initiating outbound calls allows the HCS to accept/reject call requests based on detected available bandwidth–on both the LAN and the LAN/WAN boundary. A user receiving an acknowledgement from the HCS for the requested call is generally assured of the bandwidth necessary to maintain a good communications experience. This will become an especially critical capability as network-connected digital entertainment devices are

deployed and begin consuming bandwidth on home networks.

2. *Voice interaction*. Advanced HCS implementations may include capabilities such as voice recognition and Text-To-Speech (TTS). Voice recognition can be utilized to establish voice user interface for command and control functions such as voice dialing and voice browsing/searching of contacts. TTS capabilities can be employed for talking IMs and e-mails.

PCs as HCS Devices

The PC possesses both advantages and challenges for implementing HCS functionality. The major advantages include computational power for rendering rich UIs used for communications management, storage capacity for storing messaging and contact info, and the ability to provide voice recognition and TTS applications. Challenges include a perceived gap in the level of robustness that consumers associate with CE appliances. While PC architecture is improving and the PC industry is working to address availability and reliability, an HCS implementation may be perceived as a single point of failure in case of power outage, denial-of-service (DOS) attacks, software, or hardware failure. Consumers accustomed to the reliability of traditional PSTN telephones might have concerns. For these reasons it seems reasonable to consider a deployment model in which the HCS functionality is split across two platforms connected to the home network. Basic communication functions would be deployed on a CE appliance device, possibly possessing an uninterrupted power supply or battery backup. The remaining extended capabilities like HCS management, etc. would be supported by the PC. In this manner the PC would function to greatly enhance the convenience, manageability, and personalization of home IP communications, and would also be the focus of bridging to IP-connected entertainment devices without being in the critical path.

Digital Communications in the Family Room

The presence of both communication and digital entertainment devices connected to the home network provides an opportunity for supporting communication experiences that leverage the rich media features of entertainment devices. High-definition televisions have the potential to deliver full family (rather than personal), videoconferencing, picture and music-sharing communication experiences in the family room in a manner more compelling than previous generations of video telephony devices.

Use cases for videoconferencing include the notion of "virtual presence." For example, family members unable to be together for the holidays establish a high-definition videoconferencing session between household members in the family room. Such sessions are enhanced by spontaneously sharing photos and music. Another type of virtual presence use case is the concept of persistent communication channels that enable, for example, the monitoring of elderly or infirmed individuals. Having direct support for control of persistent videoconferencing from the digital television (DTV) remote can effectively provide closeness with friends and family members in the form of "channels," controlled and selected in the same way that cable entertainment is controlled and selected.

The Digital Communications Adaptor

DCAs are used for personal videoconferencing and are architecturally similar to Digital Media Adaptors (DMAs) in that they rely on a connection to a home media server and function principally to render digital streams onto legacy televisions. DCAs differ in that they add 2-way audio and optionally, 2-way video capture and media sharing capabilities to the basic DMA profile. The DCA depends on the HCS to respond and connect it to incoming calls. All external telephony, links to service provider, contact listings, etc. are the responsibility of the HCS. DCAs are the lowest cost implementation for personal videoconferencing. DCAs achieve low cost by off-loading functionality to the server (HCS) such as contact archives, SIP telephony, and certificates needed for authentication to a service provider that would otherwise be required to be implemented by the device locally. Low manufacturing costs potentially allow consumers to deploy videoconferencing on every television in the home. Finally, since DCAs are connected to TVs through an auxiliary or similar type of connector, the DCA and the videoconferencing experience is selected from the TV remote like any other channel.

Figure 3 shows a simplified representation of the functional blocks that compose the DCA. Thick black lines indicate the flow of audio and video media. Thin black lines indicate the flow of control information.

The A/V stream control module simultaneously manages the flow of received packets of audio and video, as well as transmitted packets. An external microphone and video camera captures audio and video. If the sensors are analog, analog to digital conversion (A/D) modules are be required to generate digitized samples. Digital to analog conversion (D/A) is additionally required to support analog output devices.

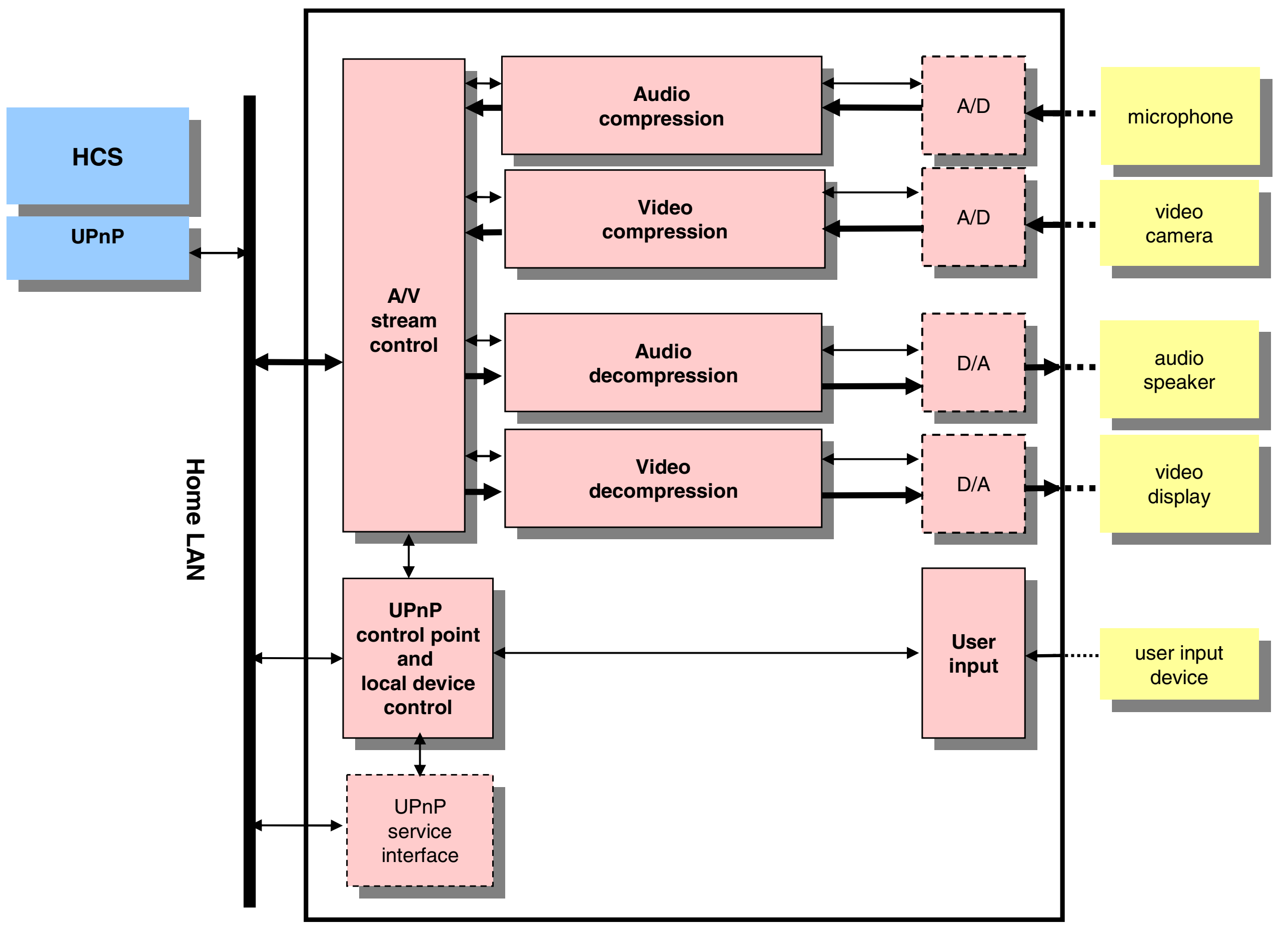

Figure 3: Functional blocks composing the DCA

The UPnP control point and local device control module allows the DCA to discover and utilize the HCS and manage commands received from the DCA user input device. Figure 4 shows a DCA connected to the home network. When an HCS is located, the DCA utilizes the browse contacts capability to identify contacts with videoconferencing capability. Contact metadata include sufficient information to establish media format and transport protocol compatibility between caller and callee in a manner transparent to the user.

A DCA implementation may optionally host its own UPnP service interface (dotted line module at lower left in Figure 3), enabling the DCA to be utilized by other UPnP devices connected to the LAN. The DCA UPnP services may allow the DCA to be notified of and receive inbound calls from other communication devices inside the home.

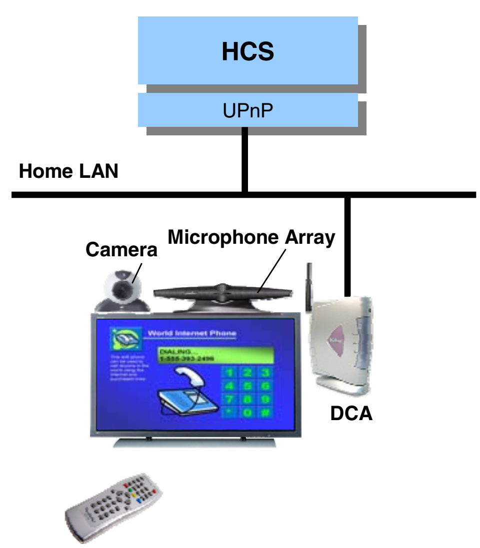

Figure 4: DCA connected to the home communications network

Meeting the Need for a Greater Sense of Closeness

High-definition videoconferencing and the option to persist video sessions over extended periods of time effectively maximizes the use of technology to achieve a greater sense of family closeness.

THE DLNA FRAMEWORK–ROLE MODEL FOR A DIGITAL HOME COMMUNICATIONS FRAMEWORK

Consumers are acquiring, viewing, and managing an increasing amount of digital media on devices in the CE, Mobile Device, and PC domains. Consumers want to conveniently enjoy that content across different devices and locations in their homes. Delivering this vision mandated the creation of a common set of industry design guidelines to ensure interoperability and additionally to allow companies to participate in a growing marketplace.

As a result, the DLNA Home Networked Device Interoperability Guidelines 1.0 were created. The Interoperability guidelines are based on an architecture that defines interoperable components for devices and software infrastructure. The DLNA architectural components are as follows:

- physical media
- network transports
- device discovery and control
- media management and control
- media formats
- media transport protocols

The essential technology ingredients that underlie the architectural framework for digital home entertainment in the Interoperability guidelines are generally the same technology ingredients required to establish a common architectural framework for digital communication devices: Ethernet, 802.11, IPv4, HTTP, and UPnP technology. A successful interoperable framework for communications would therefore follow the example of the DLNA by institutionalizing an industry-wide consensus on the following:

1. Essential technologies (in addition to the ones enumerated above) for home communications.
2. Common architectural components in communication applications, both present and future.
3. Common transport protocols.
4. Common audio and video formats.

CONCLUSION

The results of a recent CMR study of unmet consumer communication needs were summarized. Unmet communication needs discovered in the study were grouped into the categories of Continuity, Management, Protection, and Closeness. Analysis of the needs data suggests that the physical home is a good base for deploying technology solutions that combine personal communication devices in a manner that affords users a feeling of home while they are away from home. A user-transparent, home framework for connecting different communication devices to each other, both inside and outside the home addresses the problem of bridging disparate communication channels. Enabling full user personalization and control of wanted and unwanted contacts, personalized policies for call and message handling, etc. addresses the consumer desire for communication protection. Richer communications experiences such as videoconferencing or sharing pictures of the family while talking help address the need to achieve a greater sense of closeness.

A new framework for digital home IP communications possessing architectural components similar to those of the established DLNA framework is proposed. Two new device classes that exploit the framework are additionally proposed. A Home Communications Server is proposed to satisfy user needs for communications continuity, management, protection, and a greater sense of closeness.

The HCS will enable a new class of devices that depend on its standardized network APIs. Digital Communications Adaptors are devices in this category and address the unmet need for a greater sense of closeness by performing personal videoconferencing and media sharing during a call. The DCA depends on the HCS to respond and connect it to incoming calls. DCAs achieve low implementation cost by off-loading functionality to the HCS such as contact archives, SIP telephony, and certificates needed for authentication to a service provider. DCAs are connected to TVs through an auxiliary or similar type of connector, allowing the DCA and the videoconferencing experience to be selected like a TV channel.

ACKNOWLEDGMENTS

We acknowledge Antony Barton and the members of the Corporate Market Research team for providing the CMR data and for granting permission for its use in this paper.

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AUTHORS' BIOGRAPHIES

Mark Walker is a senior architect in the Intel® Viiv™ Technology Platform group. Mark joined Intel in 1993 and his past duties have included research and development in the areas of video/audio/speech compression, text-to-speech, videoconferencing, and digital packaging. More recent activities include contributing architect and chair positions in ITU, ISO, UPnP, and CEA standards efforts focused on developing an interoperable framework for digital home entertainment. Mark is the author of eight patents in the areas of video, audio, and speech compression, IP-based communications, advanced Internet application networking, and home Ethernet. Mark holds B.S., M.S. and PhD degrees in Electrical Engineering, all from Arizona State University. His e-mail is mark.r.walker at intel.com.

Jim Edwards is a principal engineer and manager in Platform Architecture and Advanced Development in Hillsboro, Oregon, working on the architecture, standards, and tools/stacks for consumer PC platforms in the digital home. He oversees a team of developers and architects responsible for leading the development of key digital home standard specifications. Jim was previously the chief architect for Intel's Extended Wireless PC initiative. Prior efforts that Jim participated in at Intel Labs led to the development of protocol independent telephony and network APIs for the PC. He holds five patents in communications and networking. Jim holds B.S. and M.S. degrees in Electrical Engineering from Cornell University. His e-mail is jim.edwards at intel.com.

Ylian Saint-Hilaire is a senior software engineer and architect at Intel Research Labs in Hillsboro, Oregon. Ylian began his Intel career in network security, focusing on enterprise-wide deployment of IPsec and VPN. Ylian then became an architect in the Intel Digital Home Labs leading the development of Intel UPnP technologies which became the leading UPnP compliant stack. Ylian also worked with the UPnP forum on the definition of remote displays, and he worked with the Intel team on the development of digital media adaptors. He holds B.S. and M.S. degrees in Computer Science from the University of Quebec in Montreal (UQAM), and he holds four patents in communications and networking. His e-mail is ylian.saint-hilaire at intel.com.

Jeffery Lee is a strategic planning manager in the Digital Home Group, where is he responsible for long-range plans, market/business analysis, technology definition, strategies, and roadmaps for consumer platforms. Jeff has been with Intel since 1990 and is located in Folsom, California, where he has held a variety of roles in strategy, planning, product marketing, and technical marketing working on flash memory, cellular/handheld devices, graphics, and chipsets. Before coming to Intel, Jeff was with Oracle Corporation and Xerox. Jeff holds a B.S. degree in Computer Science from the University of California, Berkeley, and a Masters in Business from California State University, Sacramento. His e-mail is jeffery.lee at intel.com.

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