Technical Feasibility Package

Ethernet/IP Addressable Home

Study Performed by FlashPoint Development, Inc.

Table of Contents

Ethernet/IP Addressable Home

Introduction

The Ethernet/IP Addressable Home concept is an integrated home control/networking system based upon three potential communication methods: wired Ethernet, WiFi (2.4 GHz band), and Powerline. The system is assumed to be offered for both installation in new construction and home improvement retrofit via the home owner. The proposed system can allow communication and control of the following:

- **Lighting**
- **Climate control**
- **Multi-media and information management**
- **Safety**
- **General home operation and maintenance**

The scope of this report includes the following:

- **High-level Functional Requirements**
- **Proposed Component List and Feature Set**
- **Preliminary Functional Diagram**
- **Feasibility Study**
- **Revised Component List and Feature Set – post Feasibility Study**
- **Estimated Development Costs and COGS**
- **Appendix A - Potential Concept Designs**
- **Appendix B - Existing Technology, Solutions, and Links**

I. High-level Functional Requirements

Within each of the major communication and control categories, the following is a list of desired features and functions:

Lighting:

- Control over all house lighting via main control and/or subordinate control boxes/switches
- Control over all house lighting via the Web
- Control over all house lighting via cell phone dial-up
- Control is defined as:
    - Ability to turn on
    - Ability to turn off
    - Ability to dim
    - Ability to turn on all lights, for emergency purposes
    - Ability to selectively turn on lighting (room-to-room)
    - Ability for mood settings (movie time, guests, night lights)
    - Ability to program per user needs (i.e. special lighting schemes for children's rooms, etc.)
    - Future expandability for voice and motion control

Climate Control:

- Control over house climate (heating and air conditioning) via main control and/or subordinate boxes/switches
- Control over house climate via the Web

- Control over house climate via cell phone dial-up
- Control is defined as:
    - Ability to turn on (heat or air)
    - Ability to turn off (heat or air)
    - Ability to define temperature settings
    - Ability to shut down the system for emergency purposes
    - Ability to selectively turn on zone climates (where applicable)
    - Ability to program per user needs (vacation settings, etc.)
    - Future expandability for voice and motion control

Multi-media and Information Management:

- Wireless and Powerline LAN, with data speeds up to 54 Mbps (802.11g)
- Ability to transfer data to and from control panels/boxes/sockets (music, intercom services, telephone, wake-up alarms, digital TV, etc.)
- Control over home audio/video via 802.11 and IR (Universal Remote, see PMC)
- Maximized utility of control software (i.e. able to be loaded on PC's, handhelds, laptops, Web enabled cell phones)
- Open API software to allow customer driven add-on functionality
- Access and control over all telephony via control panels/boxes (via VoIP)

Safety:

- Control over home security system via main control/subordinate boxes
- Ability to provide status of alarm system and monitored areas (open windows, etc.)
- Ability to check fire alarm status
- Control over home security via Web and cell phone dial-up
- Control over video surveillance where applicable
- Control is defined as:
    - Ability to arm
    - Ability to disarm
    - Ability to view all status parameters
    - Ability to activate emergency response
    - Future expandability for voice and motion control

General home operation and maintenance:

- Control over home sprinkler operation via main control/subordinate boxes
    - Schedule/Timer
    - On/Off
    - Control via the Web
    - Control via cell phone dial-up
- Control over appliances main control/subordinate boxes
    - On/Off
    - Control via the Web
    - Control via cell phone dial-up
- Potential control over home automation products such at the iRobot Roomba

In order to obtain a general understanding of the importance of the high-level control features, a short survey was administered to a small population. Although demographically narrow (99% white male, all college educated), this sample could represent an appropriate target market. Note that the sample size was not statistically significant (19 respondents). However, some interesting findings were observed:

- Within this sample, almost 90% of respondents have high-speed Internet access (either DSL or cable). Note that total percentage of US homes with broadband access is 39 percent (http://www.public-cio.com/newsStory.php?id=2004.04.19-89998).
- 84% of respondents were either somewhat interested or very interested in wireless home Ethernet (this is a substantial increase over the 63% somewhat or very interested in wired home Ethernet)
- Regarding interest in general functions, below are graphs that outline distribution.

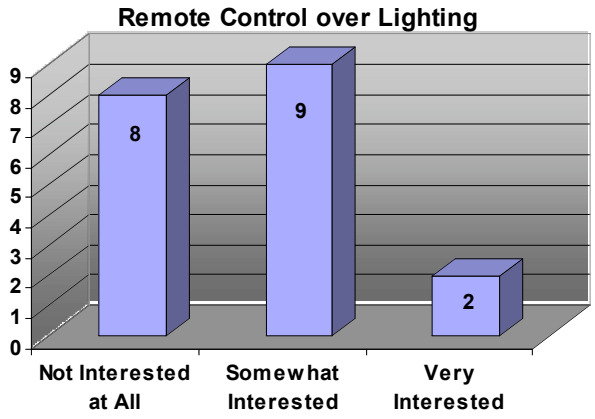
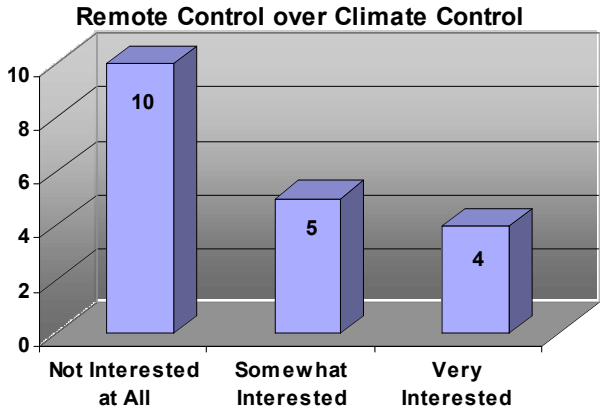


Figure 2.



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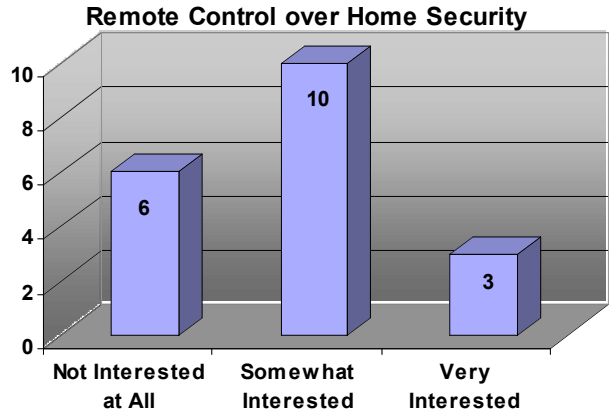

Figure 4.

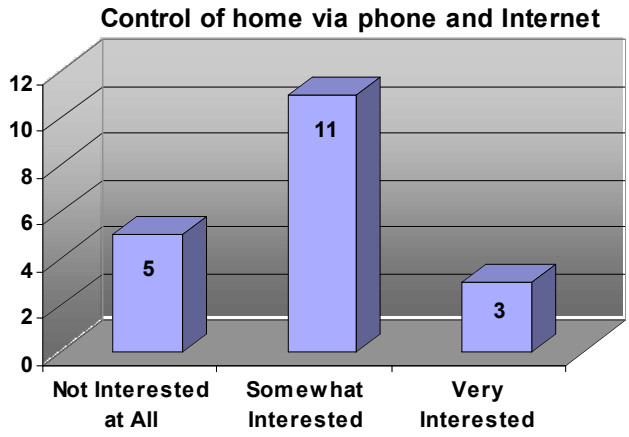

Figure 5.

II. Proposed Component List and Feature Set

Based on investigation into currently offered products (like X-10), there appears to be products that selectively match each of the desired features listed in Section I (see Appendix B for a list of current products). However, a coherent and convergent product line is currently not offered within any reasonable price point. This is particularly the case when adding in home Ethernet (either wired or WiFi). With respect to current market offerings and the limited results gained in the survey, the proposed system is first and foremost an extremely capable home network that integrates all home communications including telephony. Side benefits to the home network are home automation functions (of which there is varied interest as indicated in the distribution above) which meet the proposed Functional Requirements.

Below lists potential 'pie-in-the-sky' components of the E/IP Home that include both aftermarket and builder installed modules. Note that the list below is pre-technology vetting and feasibility.

Internet/Phone/Cable/Powerline Server - Universal Router

The Universal Router (UR), or central server, is the 'heart' of the E/IP home. All data from outside sources is fed into this unit, and made available throughout the home network. The device has the following I/O:

- Co-axial cable
- RJ45 Cat5
- RJ11 Phone
- Wall socket, Powerline
- WiFi via 802.11g
- USB

All inputs are converted to the appropriate TCP/IP, and are transmitted via WiFi and Powerline over the network. Most home switching functions are transferred over Powerline. Data includes:

- Internet Data
- VoIP
- Digital Cable

The device is assumed to be of standard size, with space for multiple inputs of each type.

Portable Master Control (PMC)

The PMC is a movable LCD touchpad-based device that has the ability to control all house functions (note that Master Control software/control can also be loaded on home PCs). Features include:

- Color LCD touch screen
- Speaker phone for VoIP and Intercom
- Temperature sensor
- Web access
- Universal Remote Capability via WiFi and IR
- WiFi 802.11g I/O
- Cat5 I/O
- USB docking station and charger

The unit can also be wall mounted if desired.

E/IP Home Switch Control

The E/IP Home Switch Control is an LCD touchpad-based wall mounted unit that replaces current mechanical switches. The unit provides the user with complete control over home functions. Features include:

- Color LCD touch screen
- Speaker for VoIP and Intercom
- Temperature Sensor
- WiFi 802.11 I/O
- Powerline I/O
- Provides WiFi repeater amplification

E/IP Home Socket

The E/IP Home Socket is a multifunctional electrical socket that replaces current wall mounted sockets. The unit provides the user with:

- WiFi 802.11g I/O
- Cat5 I/O
- RJ11 I/O
- (2) 110V electrical sockets
- Powerline I/O
- WiFi repeater amplification
- IP addressable sockets for control of plugged-in appliances, lamps, etc.

Aftermarket Socket Dongle

The Aftermarket Socket Dongle provides the user with the same capabilities as the Home Socket, which plugs into existing wall sockets. Features include:

- WiFi 802.11g I/O
- Cat5 I/O
- RJ11 I/O
- (1) 110V electrical sockets

- Powerline I/O
- WiFi repeater amplification
- IP addressable sockets for control of plugged-in appliances, lamps, etc.

In-wall WiFi/Powerline Wiring Dongle

The In-wall Wiring Dongle is allows the user to integrate 'hard wired' systems such as furnaces, alarms, sprinkler systems, etc. into the E/IP network. Features include:

- WiFi 802.11g I/O
- Powerline I/O
- Interface for items such as furnaces, alarm systems, sprinkler systems, water softeners, pool pumps, pool heaters, hot tubs, etc.
- IP addressable
- Designed for out-of-sight installation

III. Preliminary Functional Diagram

Below is a preliminary functional diagram based on the components listed in Section II.

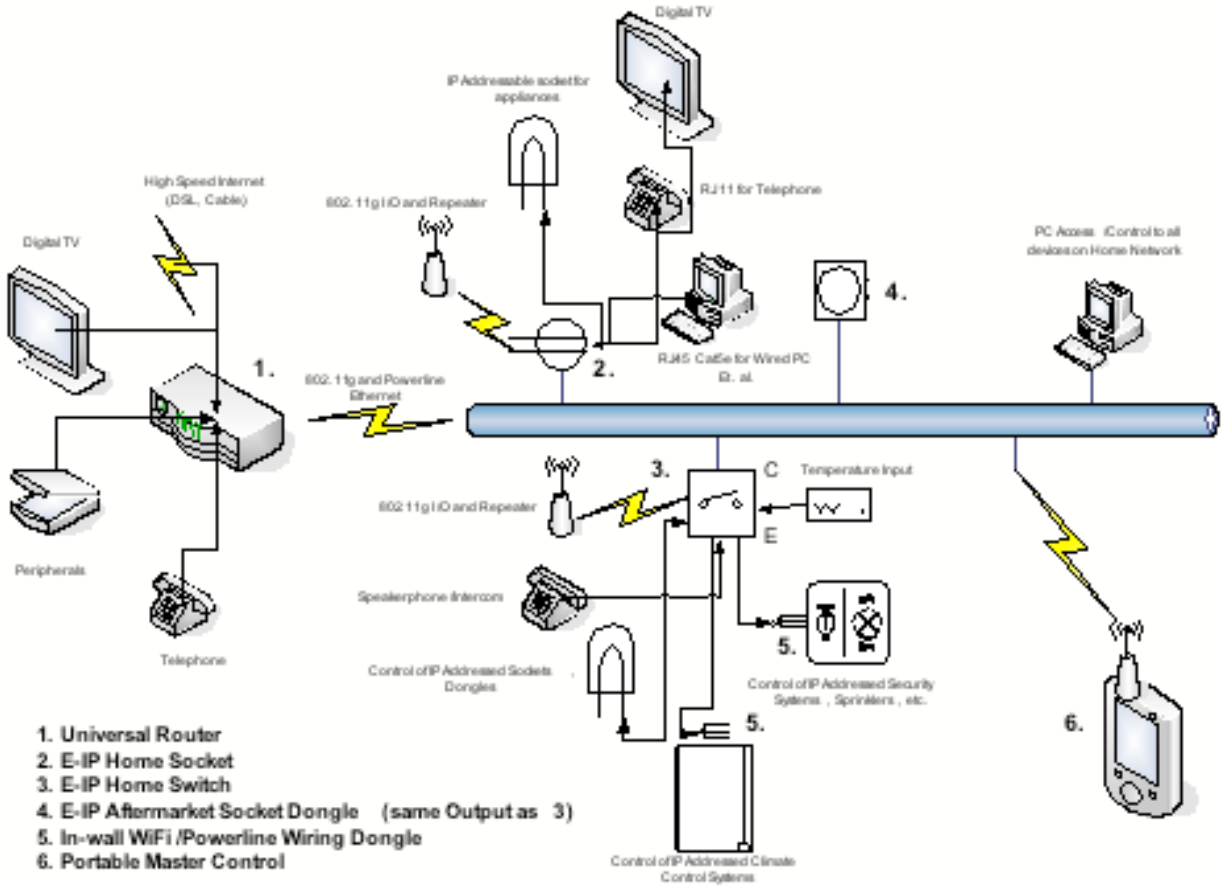

Figure 6.

IV. Feasibility Study

The notion of using Ethernet-based protocols for home control is not entirely unique. In short, such a system is practical, and the technological basis has come of age. Even so, some clever design will be necessary to make it a practical alternative to today's simple systems, such as the previously mentioned X-10. The proper decisions need to be made on what components and features are included, as development and COGS are keys to the success of the system (along with elegance and simplicity).

Basic Architectural Decisions

A few basic decisions influence the design of any home network system. Some fundamentals:

- **Client/UR or peer-to-peer command architecture.** While, especially for multimedia systems, data will ultimately be set up for peer-to-peer flow, the commands necessary to set things up may be peer-to-peer, client/UR, or multiple-master/slave configurations. This is going to define the minimal system. A central UR allows devices to be very simple, as they only need to communicate to/from the UR. The UR is necessary, as pure peer-to-peer is difficult with small devices, as they tend to lack the ability to learn about "next years" new equipment. Multiple master/slave essentially distributes the UR work among multiple hardware units, and may tend to require smarter slaves, depending on how small a master can get.

- **Homogenous or heterogeneous networking.** Another issue is the overall layout of the networking. While certainly everything runs via the TCP/IP stack, it's not necessarily cost effective to put everything on the same networks. For example, basic X-10 style home control is well served by any connection that can happen in "human time" i.e. Bluetooth, Zigbee, HomeLAN, something proprietary, etc. Multimedia, however, can bring an 802.11a or 802.11g network to its knees, if you add enough nodes, or deal in more modern protocols (for example, 802.11g has enough bandwidth, typically, for no more than two standard ATSC 1080i bit streams under perfect conditions). It's not difficult to deal with a mixed network system, but where everything "hangs" is something that needs to be defined up front.

- **Quality of Service.** Using a common network, such as a home wireless LAN, is conceptually elegant, but there are pitfalls. The primary concerns are essentially quality of service based. For example, network video that glitches, ever, is unacceptable. Audio, phone calls, etc. must also work at least as well as their analog point-to-point counterparts, or the system will be rejected. On the other hand, user input (remote control buttons, voice, etc) has to be as responsive as traditional direct-wired IR controllers, or the system will be rejected. There's some pertinent work being done here in the 802.11e draft, but that may not cover it all.

The Big Issues

As in most technology plans, the big issue isn't "can we do this." The networking technologies, the computers and microcontrollers, the various interfaces, all of these are mature technologies. The real cost issues are using some moderately expensive technology to replace ultra-low-cost consumer products, and at that, you risk audio/video quality, or on the home controls side of thing, established basic simplicity. There are "cool" things such a system can do, but it's not the simple functions that win, it's ultimately going to be the perception that it's doing many, many things, all integrated, all in one. So the general issues to consider:

- **Room control replacement**. The IR control units that come with your TV or VCR or DVD player are free. DVD players start at $19.00, TiVo-PVR units as low as $150, etc. What is

compelling enough about this system to drive the certainly higher price? Will this be something average people, even tech-friendly but not technically skilled, will love, or will they fear it?

- **Telephone/Intercom.** Whole house 2.4/5.6GHz, multi-handset, expandable phone systems start at around $150. What can really be compelling about adding the telephone as a network function?

- **Home control.** A system like X-10, as flawed as it is, is certainly well established. This means that multiple vendors make the hardware. So you have established residential wiring companies like Leviton making X-10 wall receptacles that sell for approximately $22.00. No one makes an 802.11b network card that alone retails for $22.00. Costs and selection have to be adequate. Such a network can do very cool things with light, power, and heating control, but it can be assumed few customers are going to embrace necessary complexity to manage the regular, day-to-day operation of the network. The two factors that must be considered along with features are cost and simplicity, at least when you want it.

- **Wireless Internet.** Currently over 1 million US households now have wireless networks (source: http://www.pcmag.com/article2/0,1759,1574323,00.asp). Wireless 802.11g routers start at approximately $35.00 and up. Key question: what additional functionality does the E/IP system offer to users to justify potentially higher cost? Certainly the system needs to be a top notch network – and in addition, the added functions need to create a high perceived value.

Review of High-level Functional Requirements

Lighting

"Lighting" is actually more of the lighting, switching, and power functions that are the basic things controlled in an X-10 style network. These are actually distinct functions in an advanced smart home. How they're built is something of a moot point, but logically, you have two major classes of controls here"

- The switch – it can send a command to the network, which could be "on", "off", "toggle", or a dimmer level, depending on the nature of the switch. Unlike the usual controls in conventional home, of course, the switch is only sending information to the network. Because of this, any other item – a control panel, a PDA, an appropriately authenticated message via the Internet, etc. can send the same message and achieve the same result.
- The other major part is the actual plug, socket, or lighting fixture that contains the item addressed. It's here that the actual command takes effect. That is also a network command (not necessarily the same one sent by the switch), and can also be entered into the network by any participant in that network.

Control over all house lighting

The basics of this can be simple. In the X-10 case, it may be as simple as setting a device code on your switch, and the same device code on your plug. There are two basic ways to coordinate this: If there's a central sever in the system like the UR, it is the repository of all such knowledge. The switching nodes are fairly simple: they send their state, to the UR's IP address, any time that changes. They might respond to an inquiry from any network device about their current switch position, but naturally, that position isn't inherently applied to the device controlled. That's probably about all, since the switch itself would be identified by its return TCP/IP address. The UR would receive this command, look up that switching device in a user-defined table, and then send the corresponding outlet/light/dimmer command to the appropriate unit. This isn't

necessarily limited to the UR – a smart control panel could, for example, ask for a switch list, a room map, any kind of abstraction from the UR, to display at local access points.

The second approach is the peer-to-peer approach. In this case, the switch would have some local memory. After being set up, it could describe itself to anyone making an inquiry on the network, and it would perhaps have a pre-programmed destination for its "push" output, such as the IP address of the thing controlled.

It is our opinion that the peer-to-peer approach is less desirable, and here's why: global effects become difficult. Let's say one presses the "romantic mood" button for the living room. This puts Barry White on the sound system, lowers the room lights, etc. But then the timer switch in my kitchen goes off and turns on the dishwasher. Ouch! Or an automatic action: when the TV is on in the home theatre, the room lights to go to 1/3 brightness. When this is coordinated through a central UR, there's the chance to take that input as a request, not a command, and modify it. And, basically, it allows for the global monitoring of such activities.

For Web access, one would log into the home UR and basically enable a Java version of the PMC, or something similar, and make inquiries, send commands, etc. As shown in the component list, the phone line(s) are in the UR, so remote control can be fairly automatic. For remote phone access, you call in. If the phone is managed by the UR, you'll get your answering machine. Either via access code, or via caller ID from a cell phone, you'll get a voice-prompted menu of options. Those would include inquiry or change of any switch settings.

Control is defined as...

The standard controlled light or wall outlet would naturally support on/off. The ability to dim would vary by outlet. That's a more expensive feature, for example, and it only works on some kinds of lights (incandescent - yes, fluorescents - no). The various switches and outlets/lights would be set up by location, either in the central UR or in each unit itself, and the relationships established (e.g., this switch controls that light) as a standard part of the set-up process. Given either a central UR or a smart enough PMC, it would be simple enough to establish emergency settings (panic button, etc.), timed options (lights out at 10PM in the kids' rooms), event-driven options (no television until they've practiced piano for 20 minutes, outdoor lights on at dusk, etc). Again, we like the central UR for flexibility, especially because the commands are always abstracted. Any event into the UR could be programmed to cause any number of actions. Switches in the house could ever change their functions based on the time of day.. again, the notion of a global perception.

Climate Control

Basic climate control is as simple as adding smart heating and air conditioning switching to the system. It can be coordinated much the same way as lighting, with a few exceptions. Obviously, you have a "set" function that's based on temperature, the low-level functions of "heat" and "cool," and perhaps a persistent or fail-safe setting in the "networked thermostat" that ensures you keep heating in the event of a power failure. As with the lighting, it is suggested to separate control from action. So the state of the home could be as simple as networked temperature sensor placed anywhere in the home (in the sockets, etc.). It would be simple and inexpensive to put temperature sensors in every switch, for example, so that the whole house temperature could be used for input. Add an outdoor sensor or two, and now there's no longer any need to decide if you want heating or cooling, simply set up the limits, and let the system decide things based on the difference. This could also be used to ensure that "Room R" reached "Temperature T" by "Time t". Zones per furnace/AC unit are trivial, but it's quite possible to go beyond this. For example, networked vent doors in each room, coupled with the temperature sensors in each room, would allow individual temperature settings to be worked out with good accuracy, and based on the ability to spot-monitor it all. This goes beyond the capabilities of current systems.

In short, technology wise, there's very little difference between this technology and the lighting technology. The actual switching and sensing would vary a bit, but the network interface hardware, which is the bulk of the complexity, would not likely change.

Multimedia and Information Management

The need to support multimedia networking is important to consider. This is where both realtime/QoS and bandwidth become real issues.

Wireless and Powerline LAN

The 802.11g protocol can, certainly, deliver 54Mb/s of throughput. But that is a peak; the throughput drops off with distance. This may be supported via repeaters in the home, but that does get expensive. Powerline LANs are not terribly fast yet (the HomePlug 1.0 standard, for example, peaks at 14Mb/s). They're better suited to the home controls aspect of the network. If you could ensure 54Mb/s throughout, here's an example of what's possible in multimedia terms:

Item Type Speed % 54Mb

- AAC Audio Stereo Audio 64Kb/s 0.12%
- MPEG Layer 3 Audio Stereo Audio 128Kb/s 0.25%
- AC-3 Audio 5.1 Audio 448Kb/s 0.83%
- Raw CD Audio Stereo Audio 1.5Mb/s 2.78%
- VHS-Quality MPEG-1 Video, SD 1.5Mb/s 2.78%
- DVD-Quality MPEG-4 Video, SD 1.5Mb/s 2.78%
- SVHS-Quality MPEG-2 Video, SD 2.5Mb/s 4.63%
- DVD-Quality MPEG-2 Video, SD 5-8Mb/s <15%
- HDTV MPEG-4 Video, HD 5-8Mb/s <15%
- HDTV MPEG-2 Video, HD 19.4Mb/s 35.9%

In truth, you don't get full throughput in any practical 802.11 system. The implication is obvious – HD is a problem, and even SD with many simultaneous sources can be an issue. It also may be worth looking at MPEG-4 encoding, if this system will be doing the encoding. MPEG-4 Simple Profile and even maybe H.264 (MPEG-4 Part 10) decoders are fairly inexpensive, some now integrated as a "free" bit with some of the MPEG-2 decoders.

As mentioned, naturally, 802.11b/g radios are still the most expensive piece of a network. Single chip wired 100-Base-T Ethernet is down below $5.00 parts cost, HomePlug currently offers fairly low cost MAC/PHY parts that hook to the MII interface of any old embedded Ethernet implementation. But the wireless is still relatively expensive, and so is development, if you're making your own radio pieces (as opposed to using PC-Card or CompactFlash modules, as projects have done).

If you're doing the wiring at build-time, a modern house with modular wiring probably already has the 100-Base-T CAT5 in place. There may not be a great need for WiFi in every case, though it's clearly the winner to retrofit existing homes. And as well, when you do have 802.11g access points, they need to be coordinated throughout the home if there's more than one, and located in a proper way, with proper antennas, perhaps up in the some of walls, not down on the floor.

In short, define what the network needs to do, then adopt the technology for each piece that does that job well and cost effectively, and let the UR do its job when things must run between networks.

Ability to transfer data

In the multimedia world, we envision the UR is not as necessary. Basically, once you establish a player (data source) and a receiver (data destination), you'd like to think these directly and remove connections with the UR. Wireless is an option, however you can have only three non-interfering channels with 802.11b/g, which in theory could allow multiple wireless networks within the home. But it doesn't address another issue – what about neighbors?

Sound isn't terribly challenging. A UR with hard drive could provide a massive jukebox, serving 10+ streams to 10 different rooms (or more) without taxing the system. The one question to ask, sound-wise, is what kinds of sounds can your "player" nodes handle. MP3 is obviously the popular standard. AAC can be smaller, and it's also popularized on the iPod, and the emerging MPEG-4 video market. AC-3 and DTS are available digital bitstreams from DVD.

Intercom and phone are largely the same, with the qualification that the phone, obviously, is bridged to a POTS line somewhere via the voice modem. One issue is the entry point – do I have a conventional VoIP phone, or something else? We are assuming that the system has the ability to use normal phones, hence the RJ11 inputs. The PMC and Home Switch Control are assumed to be also a phone/telecom. When you have a smart central UR, you can also do very clever things, such as virtualizing outgoing calls across your existing phone lines, and intelligently routing incoming calls to individuals, based on called ID indexed against the on-line family phone book. Alarms, too, like any other sounds, can be routed to the appropriate audio output devices (wake-up, smoke/fire, etc).

Control over whole home audio/video

Basically, each remote (PMC, etc.) contains its own ID, which ideally, indexes the user in the UR's database. The command protocol can be Internet based, so it could not only be generated by a TCP/IP client, but by Java programs, even Web pages to an extent. An approach like this can work, not only for A/V control but all of the home controls, via PCs, PDAs, smart phones, etc.

A device like the PMC and Home Switch can offer voice input. IR would certainly work fine, though you'll need to use something like the Sharp or Sony consumer IR protocols; IrDA is more capable, but it's not long distance.

On possibility is Bluetooth, for a few reasons other than the audio support, RF simply works better than IR – you don't have to aim (this can be combined with a Bluetooth Receiver, attached to the home theatre components). In addition, one can track the room and the remote device in use. Tracking the room allows some "Jetsons" features. Example: One is watching TV, gets up to make coffee. Since they have the remote with them, they enter the kitchen, the "radio" comes on with the audio from the TV program they were watching (assuming no TV in the kitchen). If there were controlled lights, they'd detect them entering the room, automatically, and turn on. Or, let's say the kids are watching TV in the parents' room. The system automatically goes into "kid safe" mode, since they use their [probably wearable] control units. One walks in, the TV automatically goes to their TiVo'd show. All of this is fairly simple to do, via preferences software. Recognition could also be completed via RFID tags or key fobs.

Open API

This is a key consideration. One possibility is to use a standard PC as the UR, running Linux, and make this a platform. Even more fundamental, considering all of the bases this touches, is the whole room full of appliances needed to make this a fully functional system. If you're not a huge organization, you're going to have to decide which products to do when, even if they share some basic pieces between them. Which pieces must you offer, which pieces might you offer, which

pieces are you doing just because they have to be there? Is there any benefit to be a technology OEM, instead of a complete systems manufacturer?

Telephony Access

You should be able to talk on the telephone anywhere there's a microphone, speaker, and keypad (i.e. PMC, Home Switch, etc.). In fact, the microphone and speaker alone would do it, once you have voice recognition on the UR. The key thing to recognize in such a system, no matter the specific details, is that data is data. Anything that plays music will play telephone, intercom, or TV. Any button panel can dial a call. When this is largely brokered by a central UR, the satellite devices don't necessarily even know they're doing it – they can be quite simple.

Safety

Besides integrating with existing alarms, one option is aligning with an existing security company. That gets you their reputation, proper interaction with their security network, monitoring, etc. Naturally, this represents just a number of additional devices, very similar to what's already on the network. If you have window switches as in current security systems, they're still just switches. At some point (probably not on a switch-by-switch basis, but ganged in some way) they present changes to the network, which are interpreted as such by the UR. All of the usual control means, actions (does it ring your cell phone? Call the police or fire? Turn off the AC when the window is open?), etc. The view is much the same as looking at the switch status of the whole home control network, only just a different sort of switch (and, of course, all logged, so you can tell what set it off).

Heart of the System

Universal Router. This can be the form of a custom solution, or a basic PC, which would boot from Flash memory or optional hard drives. The standard PC architecture provides plenty of power for routing between networks (wired, 802.11, Powerline), command routing and abstraction, etc. Regarding cable input, getting direct connection to a digital cable system is the hard part, unless this is for a cable company, or it's someone very closely associated with a cable company – one big enough to get Motorola or Scientific Atlanta helping out here.

One approach with digital cable/satellite (after all, there are many cable systems, and yet, not everyone has cable) was the aforementioned digital access point: digital or analog audio/video can be brought into the system as a network node, and of course, controlled via infrared or Bluetooth (this being abstracted in the system: one value brought to this was the plan to abstract every device in a standard, on-screen view, so that it would actually be dramatically better than the typical non-integrated media experience).

Portable Master Control (PMC)

The PMC is certainly going to be capable device, and no reason it shouldn't be able to handle any multimedia, switching, or other network activity. The main issue is unit expense. This is a networked remote control unit. You don't get any real benefit from 802.11g here vs. 802.11b on a small device, even if you allowed, say, TV previews. Support of a real Web browser and real compressed video on this is going to push the cost up toward that of an actual laptop computer, or at least a higher end WinCE-style PDA. USB makes sense – that's how the PC updates the unit, as that's needed. A good option here would be to have the UR actually run the web browser, and simply can the display for the handheld in some reasonable way. This is actually compelling if you think about it – now the same web browser is available for any other device running the home control software. And you're paying for this in cheap computation in the UR/router closet, not the expensive, battery-powered computation on the PMC. We suggest to certainly check the patents here, there might be a few that apply to this problem.

Another issue is battery life, between the color LCD and WiFi, which is going to be quite low on this, perhaps a matter of an hour or two, depending on how heavy it's allowed to get. One option is scaling this down to the size of a regular everyday remote, few buttons – simpler if anything. Target cost should be about $20.00, and that includes the Bluetooth wireless and phone/intercom functions. When you're near a screen, the system will know this, based on the access point (IR access point) you're using. Anything that could go onto the color LCD could certainly be displayed on-screen as well. Not as flashy, but less costly.

E/IP Home Switch Control

One can control any switch or multimedia item from either the PMC or even on-screen a menu from the UR, but it's rather appropriate to have a "quick" access panel like this for whole-house buttons, security, etc. This may not replace all the usual on/off switches - this is more of a master unit too, not much different than the PMC in pure function. It should be able to control anything that's controllable, by calling up control panels from the UR and sending switch messages back – it doesn't have to know what it's controlling, and that's abstracted in the UR.

Some issues: There really isn't the need for multiple networks here: this should live on either the Powerline or 802.11, why pay for both? Since this is wired-in, rather than battery powered, it makes sense for this to be on the Powerline network only.

E/IP Home Socket

This is now the equivalent of the $22 X-10 sockets, for this system. As specified in Section II, this is potential overkill. You certainly want this to live on the Powerline network – its supplying power, which makes perfect sense. The Powerline network, even at 14Mb/s, or 14Kb/s for that matter, is plenty fast enough for any switching you're every going to do here; the relays aren't any faster. So here's the thing... if you're running wired Ethernet at 100Mb/s or so to every outlet, you don't need 802.11g on each unit. That's probably an additional $50 or more on each node for the RF. In addition, it's also a horrible place to put an 802.11g access point – down low to the ground, in a shielded metal box, no antenna, etc. If these are fed by the Powerline network, that's certainly too slow to bridge over to 802.11g. A whole house should only need a couple of 802.11g access points for the wireless (separate or repeater, I supposed, depending on the proximity of your neighbors). A Cat5 jack is included for wired connections.

The E/IP Home Socket shows up as a TCP/IP node (ideally, just one, and there would be a small microcontroller that can accept very, very, very slow TCP/IP commands that say "switch", "what are you", "what's you current state", maybe a few others like "software version/revision"). These would be standardized commands across the network, potential IEEE1394 remote control commands, maybe something in XML or SOAP, maybe a private protocol.

Aftermarket Socket Dongle

The unit is inherently limited to Powerline networking, at 14Mb/s. 802.11g is eliminated for the same reasons as specified above.

In-Wall WiFi/Powerline Wiring Dongle

This is essentially an addressable small block of relays, which should (with proper software) manage heating and cooling and other small power devices (like sprinklers, garage door openers). Given the nature of those devices in particular, there is no point of 802.11g here. These devices will be placed in remote locations, underground, in walls, in places 802.11g doesn't go very well. Cellars in particular are bad for 2.4GHz, or for that matter, any radio – you have duct work providing an excellent Faraday cage.

Meanwhile, all of these get power – you need power to run the access point, anyway. If you have the power, you have the Powerline network. These are devices that literally would function fine at 110 baud. The only reason to not use Powerline networking, and only that, would be the existence of something cheaper.

For in wall lighting, the wiring dongle/junction box needs to have the following: on/off and dimmer. The reason for this is that a dimmer, using Thrysistors or maybe even iGBTs, will probably cost about twice the price of a relay-based unit. You don't necessarily want every light to be dimmed, especially because some can't be.

Switches

Will an E/IP Home Switch Control in every room? While that would technically work, there are two problems with it. One is simply replacing $1.50-$3.00 worth of switches with a $350-$500 color LCD display unit. Second thing is that people tend to want to walk into a room and "just flick the switch". If you had to call up a program (in the dark?) and find the room you need, etc. then you would reject the system. Maybe a less expensive Home Switch Control is offered, with LCD, temp sensor, etc. but simple enough that its basic function is "flick a switch" when tapped.

Bulk interfaces

This relates to switches, but goes past it. If you look at regular switches or X10, they're still largely using full house wiring. That's copper, 14 or 12 gauge, and not free. So while you won't get praised for replacing $3.00 worth of switches with one $500 switch, you might get lots of recognition for replacing $3.00 worth of switch and $100 worth of wire with a $20 switch. What if you had an optional "smart plug" that offered, as well as the plug itself, a DC supply and hub? So basically, put in one of these, which not only manages my TCP/IP connection via Powerline networking, but say, a 20V RS-485 4-wire bus. This runs to every switch in the local area (each of which has its own serial number, for later identification). You've replaced the 14ga ROMEX with, say, 4 conductor phone wire, which is all that has to be bussed from switch to switch. The RS-485 protocol can be run for this use, and it's good for about a mile. So technically, you'd only need one per house for all your switches or other similar devices.

Another kind of bulk interface would be the alarm hub. It would be impractical to run wireless Ethernet, or wired for that matter, to every window in your house. So why not run conventional alarm wiring, and then bus the buttons together, similarly to the room switches? They'd terminate in one or more hubs, which then process the switch input and send it to the UR.

V. Revised Component List and Feature Set – post Feasibility Study

Based on the Feasibility Study above, the component list and feature set needed to be modified. Below lists the components with additions/deletions based on need and cost. This new list was used as the basis for the Development Cost and COGS outlined in Section VI.

Internet/Phone/Cable/Powerline Universal Router

The Universal Router (UR), or central server, is the 'heart' of the E/IP home. All data from outside sources is fed into this unit, and made available throughout the home network. The device has the following I/O:

- Co-axial cable
- RJ45 Cat5
- RJ11 Phone
- Wall socket, Powerline
- WiFi via 802.11b/g

- USB

All inputs are converted to the appropriate TCP/IP, and are transmitted via WiFi or Powerline over the WiFi/Powerline network. Most home switching functions are transferred over Powerline. Data includes:

- Internet Data
- VoIP
- Home switching functions

The device is assumed to be of standard size, with space for multiple inputs of each type. There is some opportunity to use a standard PC for this function.

Portable Master Control (PMC)

The PMC is a movable device that has the ability to control all house functions (note that Master Control software/control can also be loaded on home PCs). The complexity and cost is reduced on this, from what was first envisioned. A goal is to get the cost down to approximately $20. Revised features include:

- Small backlit grayscale LCD
- Speaker phone for VoIP and Intercom
- Temperature sensor
- Universal Remote Capability via Bluetooth and IR
- USB docking station and charger

E/IP Home Switch Control

The E/IP Home Switch Control is a backlit LCD-based wall mounted unit that replaces current mechanical switches. The unit provides the user with complete control over home functions. Features include:

- Backlit grayscale LCD touch screen
- Speaker for VoIP and Intercom
- Temperature Sensor
- Powerline I/O

E/IP Home Socket

The E/IP Home Socket is a multifunctional electrical socket that replaces current wall mounted sockets. The unit provides the user with:

- Cat5 I/O
- RJ11 I/O
- (2) 110V electrical sockets
- Powerline I/O
- IP addressable for control of plugged-in appliances, lamps, etc.

Aftermarket Socket Dongle

The Aftermarket Socket Dongle provides the user with the same capabilities as the Home Socket, which plugs into existing wall sockets. Features include:

- Cat5 I/O
- RJ11 I/O

- (1) 110V electrical socket
- Powerline I/O
- IP addressable for control of plugged-in appliances, lamps, etc.

In-wall WiFi/Powerline Wiring Dongle

The In-wall Wiring Dongle is allows the user to integrate 'hard wired' systems such as furnaces, alarms, sprinkler systems, etc. into the E/IP network. Features include:

- Powerline I/O
- Interface for items such as furnaces, sprinkler systems, water softeners, pool pumps, pool heaters, hot tubs, etc.
- IP addressable
- Designed for out-of-sight installation

VI. Estimated Development Costs and COGS

Development Costs

In order to figure the work load, it needs a bit of a breakdown. We have to define the basic software environment, and that itself may not be the same on all hardware. For example, we do not expect Linux to run on an E/P Home Socket device (maybe on the PMC or UR). We would define the basic network protocols for the control layers, and implement those on a PC, maybe a PDA, while the hardware is in development.

Once the basic layers are in place, they can be tested, and further software developed, without hardware actually complete for testing. On the hardware side, we think a common architecture can support most of the smaller unit needs here. I would look to optimizing the cost of wireless for the nodes that really need it, and not worry about 802.11b vs. 802.11g for that, if 802.11g really does support 802.11b nodes well enough.

The Powerline networking we believe to be too slow for media transport, so it's probably best optimized for cost, as speed probably won't matter at all. The difficult aspect will be sorting out the multimedia aspects, the players, any encoders needed to bring content into the network in real time, and of course, the legalities of digitizing DVD, etc. We suggest using an encryption if possible on the media content, simply to appease anyone who was to come after you. Technically speaking, if you were to encode video (say, from VHS or DVD) that had the Macrovision analog copy protect on it, run it via the network, and not re-apply the copy protection on any analog outs, someone might come after the company.

The following represents the basic R&D (includes cost of man hours), but does not factor production issues (casework, testing, UL and FCC certifications, etc).

Estimated Development Costs

Job Type	Description	Development Time (wks)	Estimated Cost
Software	Define Command and control protocols	4	$ 56,000.00
Software	Define Multimedia protocols	8	$ 112,000.00
Software	Implement Command and control protocols on PC/UR	30	$ 420,000.00
Software	Implement Multimedia protocols on PC /UR	30	$ 420,000.00
Software	Implement User interface on PC/UR	30	$ 420,000.00
Software	Implement Command and Control, OS, Basic networking on Universal Router	4	$ 56,000.00
Software	Implement Command and Control protocols on Basic Network Prototype	8	$ 112,000.00
Software	Implement Command and Control protocols on E/IP Home Socket/Dongle from Basic Network Prototype	2	$ 28,000.00
Software	Implement User interface/OS /Network on PMC	30	$ 420,000.00
Software	Implement User Interface/OS/Network on E/IP Home Switch Control from PMC	4	$ 56,000.00
Software	Implement Multimedia support on Universal Router	4	$ 56,000.00
Software	Implement Command and Control, OS, Network, and Multimedia protocols on Player Access Point	30	$ 420,000.00
Software	Implement Command and Control, OS, Network, and Multimedia protocols on Playback Access Point	8	$ 112,000.00
Software	Tweak multimedia performance, system wide	8	$ 112,000.00
		Subtotal	**$ 2,800,000.00**

Job Type	Description	Development Time (wks)	Estimated Cost
Hardware	Define Basic Network System	4	$ 80,000.00
Hardware	Implement Basic Network Prototype	16	$ 320,000.00
Hardware	Define and Implement Universal Router/Server (from PC parts as possible)	10	$ 200,000.00
Hardware	Implement E/IP Home Socket/Dongle from Basic Network Prototype	8	$ 160,000.00
Hardware	Implement Wiring Dongle from Basic Network Prototype	8	$ 160,000.00
Hardware	Implement Lighting Switch from Basic Network Prototype	8	$ 160,000.00
Hardware	Implement PMC (Revised Version)	8	$ 160,000.00
Hardware	Implement E/IP Home Switch Control from PMC	12	$ 240,000.00
Hardware	Implement Player Access Point	48	$ 960,000.00
Hardware	Implement Playback Access Point from Player Access Point	12	$ 240,000.00
		Subtotal	**$ 2,680,000.00**
		Estimated Total	**$ 5,480,000.00**

Figure 7.

Listed below are estimates for tooling costs for each of the components.

Model	Tooling Estimate**
Universal Router	$57,500
Portable Master Control	$27,500
Home Switch Control	$18,500
Home Socket	$15,000
Aftermarket Home Socket	$12,000
Wiring Dongle	$10,000
TOTAL	**$140,500**

****Assumes steel tooling, overseas manufacture.**
Figure 8.

Undoubtedly, there are additional project tasks. The software, naturally, can evolve in time. The estimates are based on re-using existing software pieces, such as Linux, for the more complex hardware items. Additional adapted modules, perhaps hardware reference designs or other existing pieces, etc. will lower the overall cost and time. Naturally, if you started entirely from scratch, the process could take much more resources.

COGS

The rough estimated COGS are based on the revised component list. All components are assumed to be purchased in high volume. Estimated retail pricing can be assumed to be 5X COGS.

Universal Router	
Component	**Cost**
Injection molded housings	$ 4.25
Power supply	$ 2.00
CPU, Misc. PCB	$ 45.00
802.11b/g Module	$ 45.00
Hard drive	$ 10.00
Connectors/jacks	$ 10.00
Intellon Chipset (INT5200)*	$ 7.50
TOTAL	**$ 123.75**

Home Socket	
Component	**Cost**
Housing	$ 2.25
PCB	$ 3.50
(2) 110V sockets	$ 1.20
Cat5 port	$ 0.30
RJ11 port	$ 0.20
Intellon Chipset (INT5200)*	$ 7.50
TOTAL	**$ 14.95**

Portable Master Control	
Component	**Cost**
Injection molded housings	$ 2.25
LCD display	$ 11.00
MIC/Speaker	$ 0.75
PCB	$ 3.50
RF Module	$ 5.00
Keypad	$ 0.75
TOTAL	**$ 23.25**

Aftermarket Home Socket	
Component	**Cost**
Injection molded housings	$ 1.75
PCB	$ 1.75
(1) 110V sockets	$ 0.60
Cat5 port	$ 0.30
RJ11 port	$ 0.20
Intellon Chipset (INT5200)*	$ 7.50
TOTAL	**$ 12.10**

Home Switch Control	
Component	**Cost**
Housing	$ 2.25
LCD display	$ 13.00
MIC/Speaker	$ 0.75
PCB	$ 3.50
Temperature Sensor	$ 5.00
Keypad	$ 0.75
Intellon Chipset (INT5200)*	$ 7.50
TOTAL	**$ 32.75**

Wiring Dongle	
Component	**Cost**
Injection molded housings	$ 1.75
PCB	$ 1.75
Wiring	$ 0.50
Intellon Chipset (INT5200)*	$ 7.50
TOTAL	**$ 11.50**

***Intellon chip quoted at volumes above 50,000 units.**
Figure 9.

Conclusions

This project is certainly possible technically, and the estimated COGS are in the right "ballpark." However, it's hard to resist biting off more than one can chew, especially when you're at the project definition stage. We think the scope of the controllers needs to be scaled down as shown in the revised Component list, and let the UR do most of the heavy lifting, since that piece can be based on commodity PC technologies, which will inherently offer a cost advantage over anything designed as a custom part of the project.

Certainly the cost of developing a complete home automation system is high. One primary problem is the fact that such networks don't get interesting to a consumer until you have many pieces in-place. Initially trying to do everything in-house could be a problem, depending on the resources available. Building a useful subset, and aggressively licensing other pieces, and maximizing partnerships may realize this much faster, at lower development costs.

Our recommendations are as follows:

1. Continue refinement of specifications/features/expected costs
    a. Refine component list
    b. Refine development and COGS estimates
2. Study the market in detail
    a. More complete investigation into target market, desired features, etc.
    b. Total market size and potential
    c. Price points and packages
    d. Study potential outlets
        i. Lowes
        ii. Home Depot Select
        iii. Smarthome
        iv. Distributors
        v. Established large scale residential contractors
3. Concentrate on the UR
    a. PC-based or new component?
    b. Investigate potential of starting out using home owners existing PC
    c. Develop test bed based on PC-based UR
    d. Develop WIN/CE based PMC
    e. Develop/license integrated VoIP functions
4. Concentrate on two features
    a. 802.11b/g wireless networking
    b. Powerline based switching
        i. Home Switch
        ii. Home Socket

iii. Aftermarket Dongle

5. Defocus on costly total multi-media functionality (at least in the beginning)

Assuming successful completion of steps 1 and 2, and a project green light, we would suggest a minimal technical team of about 10 people, and a budget on the order of $0.75M - 1.0M to start software development and limited hardware (per number 3). Implementing the whole-house network in stages as mentioned in 4 and 5, might allow for some of the components to reach the market first, minimizing the cost hit (particularly when developing costly integrated multi media).

Appendix A: Potential Concept Designs

E/IP Universal Router

The Universal Router (UR), or central server, is the 'heart' of the E/IP home. All data from outside sources is fed into this unit, and made available throughout the home network. All inputs are converted to the appropriate TCP/IP, and are transmitted via WiFi or Powerline over the WiFi/Powerline network. Most home switching functions are transferred over Powerline.

PC tower-like design

Convenient location for multiple inputs (RJ11 for phone, Cat5-RJ45, coaxial, USB, RCA)

Portable Master Control

Acts as portable phone (VoIP), master control with Home Switch functions, and Universal Remote

User friendly interface (includes iPod-like wheel), all controls similar to Home Switch

Includes belt clip, and audio jack

USB docking/charging station connected to users PC or Universal Router

E/IP Home Switch Control

The is a backlit LCD-based wall mounted unit that replaces current mechanical switches. The unit provides the user with complete control over home functions.

E/IP Home Socket

The E/IP Home Socket is a multifunctional electrical socket that replaces current wall mounted sockets. The unit provides the user with:

- Cat5 I/O
- RJ11 I/O
- (2) 110V electrical sockets
- Powerline I/O
- IP addressable for control of plugged-in appliances, lamps, etc.

9/14/10

Appendix B: Existing Technology, Solutions, and Links

Within the home automation space (HA), there exist a number of existing entrants, each covering pieces of the feature set listed above. Below is an excerpt from Smarthome that provides a good summary of the current features of HA (http://www.smarthome.com/homeautomation.html).

A Basic Definition

For some it may be something as simple as remote or automatic control of a few lights. For others, security may be the central application. Still others may choose to install advanced controllers or use voice recognition. As a very basic definition, we tend to refer to home automation as anything that gives you remote or automatic control of things around the home.

What Can I Control?

Lighting
Probably the most popular control category and a great way to get involved with home automation. Starter kits begin at $10 or so and are plug-and-play easy to install. Dim fixtures you could never dim before, control them from anywhere in the house (or world via the Internet).

Security Systems & Access Control
Have your home call you and/or loved ones if there is an alert status. You can save money on security monitoring services or even monitor for non-traditional security events like water in the laundry room or basement. Additionally, Smarthome products include devices which will allow you to unlock the front door to let friends in or close the garage door from your office via the web.

Home Theater & Entertainment
Just imagine replacing that pile of remotes with just one controller. Now, imagine not having to know all 10 steps to starting up your home theater - just press the HBO icon and your home automation products/system will do the rest. Built-in speakers are especially popular with homeowners as they provide beautiful sound throughout the house while adding no clutter whatsoever.

Phone Systems
Phone systems which are usually used for small business applications are surprisingly convenient in the home. With caller ID and a home automation controller you can even screen your calls for only those you wish to cause your phone to ring. Voice control software turns every phone in your home into a remote controller.

Thermostats
Remote control thermostats allow you to adjust the temperature from bed at night or even from a cell phone while on your way home (or to your 2nd home!). They can even trigger a notice to you if the temperature gets too low (freezing pipes) or too high (pets, plants, etc.).

Networking
Home automation can be accomplished using various types of connectivity. What's great is that many of today's home automation products need no new wires - so they are perfect to retrofit into an existing home. If you are building new, or doing a major remodel, please consider adding networking, audio, video and control wiring while it is easy and relatively inexpensive, later on you'll be happy you did.

How Can I Control Them?

Remote control
There are several different "methods" of controlling devices remotely. Below we highlight the pluses and minuses of each.

Remote Technology	Advantages	Disadvantages	Popular Applications	Cost
Infrared	Affordable	Line-of-sight	TV / consumer electronics	$10 & up
X-10	Affordable + whole house	May need noise filters & phase couplers	Lighting, appliances and security	$10 & up
Radio-Frequency (RF)	Works through walls	Long distance issues, more expensive than X-10	Garage doors, computer networking	$40 & up
Hardwired	Speed and reliability	Cost & difficult to retrofit	Video, networking & high-end applications	$1,000's & up

Table 1.

The current market entrants are broken down into major categories:

Home Wired Ethernet

"Category 5" or more commonly Cat5, is a defined standard for the design and performance of a point-to-point twisted pair cabling link for the purposes of computer networking & telecommunications. It follows on from the previous standards, Cat3 and Cat4, which are physically similar but have inferior performance and bandwidth. For people unfamiliar with computer networks, they all look like telephone cables.

Cat5 provides standards for a four twisted-pair cable using RJ45 type termination giving eight wires in all. There are two (separately defined) standards for precisely how the wire-pairs and color-codes are terminated at the connectors, but "258A" is most common for networks and "USOC" for some telecoms applications, though mixing the standards on any one site is very unwise. The performance standard is defined from end-to-end so that it also includes any patch leads etc. required to connect to equipment at either end. The overall length should not exceed 100 meters including these patch leads, so it is usual to limit the fixed component of the cabling to around 90 meters. Each individual component of the link should be specifically certified for use at Cat5, otherwise the link will be considered only as good as the poorest component within the link.

-Twisted-pair cable is either unshielded or shielded. In many areas, unshielded cable is suitable for business, commercial and industrial installations. Shielded cable reduces EMI and security problems, and is very desirable near heavy electrical equipment and where installations are close to residential areas (local regulations may require it in some areas).

Cat5 defines the performance of the link up to a frequency of 100MHz. ATM, Fast Ethernet (100Mbit), Ethernet (10Mbit) and Token Ring each have suitable interfaces designed to use Cat5 cabling. Adapters and Baluns are available to connect RJ45 outlets to a variety of other interfaces (but not usually to full Cat5 standards, though it isn't relevant in most practical cases).

New Categories of cabling standards are currently in development to extend the performance of copper cabling to 300MHz and even to 1000MHz.

Source (http://www.spearfern.com/cat5.htm)

Wireless Ethernet

Wireless Ethernet, commonly referred to as WiFi is based on the 802.11 standard (2.4 GHz). There are four 802.11 standards (http://www.80211report.com/topics/80211.html)

802.11

The IEEE developed the 802.11 standard for wireless local area networks (WLANs). There are four specifications including 802.11, 802.11a, 802.11b, and 802.11g. Each 802.11 standard operates in a different GHz range and/or offers a different speed. 802.11 applies to wireless LANs and provides 1 or 2 Mbps transmission in the 2.4 GHz band using either frequency hopping spread spectrum (FHSS) or direct sequence

spread spectrum (DSSS).

802.11a

The 802.11a specification operates in the unlicensed 5GHz range and offers data speeds up to 54Mbps. The 5GHz range is not yet crowded so it offers advantages in speed over the 802.11b specification which uses the more crowded 2.4GHz range (which can interfere with cordless phones, microwaves, etc.). However, the range and speed of 802.11a are inversely related, which means that 802.11a offers a smaller, more targeted footprint than other 802.11 technologies. 802.11a uses a modulation scheme known as orthogonal frequency-division multiplexing (OFDM) versus the FHSS or DSSS. Most 802.11a products are not compatible with 802.11b or 802.11g products (although this is changing).

802.11b

The 802.11b standard operates in the 2.4GHz range and offers a data speeds up to 11Mbps. 802.11b is the de facto standard for WiFi services because of its ubiquity in the market and low price (although 802.11g will soon become the prevailing standard). While slower than 802.11a, 802.11b is still as fast as 10BaseT Ethernet service. 802.11b uses direct sequence spread spectrum (DSSS) and complementary code keying (CCK) modulation. 802.11b was certified by the IEEE in 1999.

802.11g

802.11g was approved on June 11, 2003 and offers data speeds up to 54Mbps and operates in the 2.4GHz and 5GHz range making it backward compatible with 802.11b. Even before the IEEE approval, it was clear the 802.11g would become the standard for WiFi services and leading manufacturers started to release products in early 2003. 802.11g uses OFDM modulation but, for backward compatibility with 802.11b, it also supports complementary code keying (CCK) modulation.

Powerline Ethernet

Example, Intellon PowerPacket (http://www.intellon.com/products/powerpacket/):

PowerPacket technology delivers high-speed network access through existing home powerlines. Now, virtually any electronic device in the home can be connected to another, giving homeowners access to a new realm of applications for information, data, entertainment, security, energy management, and more.

PowerPacket enables the fastest and most robust powerline products in the home networking market. At speeds of up to 14Mbps, homeowners enjoy the advantages of Ethernet networks, but with No New Wires™. It's quick and easy to use. Simply plug PowerPacket ready devices into any power outlet in the home. Instantly, the power outlet becomes a high-speed link for sharing information from PC's, appliances, and other devices inside the home, to Internet access and broadband services outside the home.

Lighting and HA Control

X-10:

X-10 is a communications "language" that allows compatible products to talk to each other using the existing electrical wiring in the home. Most X-10 compatible products are very affordable and the fact that they talk over existing wires in your home means that no costly rewiring is necessary. Installation is simple, a transmitter plugs (or wires) in at one location in the home and sends its control signal (on, off, dim, bright, etc.) to a receiver which plugs (or wires) into another location in the home.

Universal Remotes

Combines A/V command and control via one source. Below are specifics on a leading component: (http://www.hometheatermaster.com/htm/about/index.html):

Overview
In a unique synthesis of hardware and software engineering, Universal Remote Control has revolutionized the standards of custom installers for color touch screen automation. The Home Theater Master MX-3000 offers some superficial similarities to previous touch screen offerings.

However, in this review of the hardware and software specifications, it should be clear that the power of this new design offers custom installers and end users long needed relief in a number of key areas.

Long Macros via Reliable, Robust RF/IR Repeating Add-On
The MX-3000 includes remarkable new RF technology that provides seamless communication between the remote and the components via RF. As a result, the end user no longer needs to point the remote during a long macro. Once the button is pressed, the MX-3000 transmits the macro to the MRF-250 RF Base Station (sold separately), which repeats the commands flawlessly regardless of whether the remote is even in the customers hands.

The MRF-250 Base Station receives RF signals from the MX-3000 and transmits commands to all components in the space (cabinet or room) either through the MRF-250 Base Station's Front IR Blaster or the six plug-in flashers.

The MX-3000 and MRF-250 consistently achieves a range of 75 to 100 feet without any interference, even in hostile RF environments with multiple satellite receivers, computers or PVR's (all these components generate significant interference to RF remote control). The combination of troubleshooting LED's and the easy repositioning of the base station and its antenna leads to easy, trouble free installation in the most active environments.

Interesting Links and Information Sources

http://www.ipcf.org/ - Powerline online community

http://www.asokausa.com/products2/commercial.php - OE/DM of Powerline devices

http://www.intellon.com/

http://www.lutron.com/grafikeye/

http://www.leviton.com/

http://www.ironstone.com.au/netsense/powerline.html - Powerline components

http://www.compusa.com/products/product_info.asp?product_code=310386&cm_ven=Inktomi&cm_cat=&cm_pla=&cm_ite=feed&ref=inktomi – Powerline component

http://plugtek.com/manufacturers/NP_products.shtml - Powerline products

http://hhi.corecom.com/homeplugnetworking.htm - Powerline commentary

http://ptech.wsj.com/report.html - Mossberg article, comparing Powerline in combo with WiFi

http://www.smarthome.com/x10map.html - X-10 info. via Smarthome

http://www.spearfern.com/cat5.htm - Cat 5 information

http://www.iautomate.com/companion6.html - Home automation control panel

http://www.palowireless.com/infotooth/knowbase.asp - Bluetooth resource center

http://www.80211report.com/topics/80211.html - Basic info. on 802.11

http://www.homeauto.com/ - Home automation site

http://www.crestron.com/default2.asp - Home automation company