Avinta Communications, Inc.

White Paper

A Concise Model For Home Electronic System

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1. Introduction

It is generally agreed that SOHO (Small Office Home Office) networking is the next communications frontier. However, after more than a decade of intensive efforts by the broadband industry, the resulting products and services still do not meet the criteria for ease of use and reliability that are commonly associated with CE (Consumer Electronics) and telephony industries. As a result, market growth has stalled because consumers are reluctant to purchase products and services that are functionally quite capable, but having many hidden issues in installation, operation, maintenance and upgrade.

This paper presents an analysis of this frustrating situation from an end-user's perspective, and proposes a model that will be able to rejuvenate the growth in this market.

2. Background

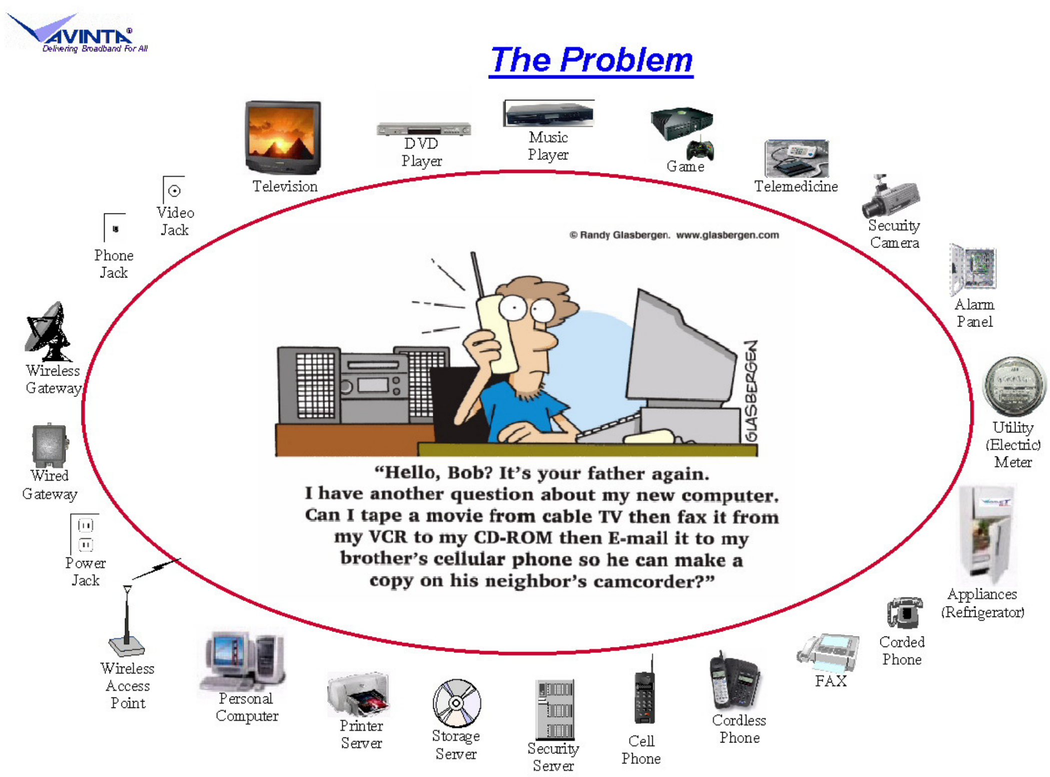

Figure 1

SOHO networking is to link up all sorts of electronic and electric devices, appliances and equipment around the residential premises. Collectively, they can be referred to as a Home Electronic System (HES). Figure 1 depicts the wide range of equipment and facility that may be present in a HES:

The most bandwidth demanding applications are video, music and interactive games, followed by PC (Personal Computer) related data processing tasks. Telemetric and Home Automation can potentially benefit every home, yet the bandwidth requirement and the frequency of use are extremely low. Telephony related services do not need much bandwidth. But, they require the most stringent QoS (Quality of Service). It may sound contradictory, but the QoS term does not exist in telephony industry simply because it is one of the unspoken fundamental requirements. Then, there is the cellular phone that operates within as well as without a home. It is becoming much more capable than just for providing voice service, while its basic performance is still to be desired.

There are basically four kinds of existing physical facilities around a home to link these up. Except video cabling, network technologies have been developed for the other three, namely, PhoneLine, PowerLine and Wireless. Recently, an inexpensive coupling device has become available to link video cable with phone line making it possible to utilize both as the physical infrastructure for PhoneLine based broadband signals.

For devices in a HES to communicate with the outside world, there are wired and wireless Residential Gateways (RGs) to provide Internet access.

Current products on the market seem to work for all of these. A closer examination reveals that they function only in specifically pre-defined and limited configurations. Often, minor changes result in operation difficulties, not to mention the challenge in attempting to interoperate these. However, in a consumer's mind, these should all be transparently interconnected, performing respective functions when desired and not interfering one another, just like how multiplicity of CE devices utilize electricity.

The 1996 cartoon (copyright royalty paid for showing with Avinta's USA Registered Trademark) in Figure 1 depicts the fundamental hurdle for current broadband products to meet consumer expectation. One of the simplest facts eluded by this cartoon is the evolution of FAX protocol that went through four generations of improvements during the last two decades while requiring neither PSTN (Public Switched Telephone Network), nor subscriber phone line equipment to make any adjustments except replacing FAX machines with newer versions, only if a consumer desires to enjoy the improved performance.

Being for still graphics, FAX is technically far simpler than moving video. But, it is not much different in principle from an ordinary user's perception (Movie is produced from fast advancing frames, each made of slightly changed still pictures.). So, the consumer's question has been; Why is the much more capable broadband technology not able to achieve the equivalent? With ICs (Integrated Circuits) now capable of supporting self-contained end user products, this has become a nagging issue.

The remainder of this document describes a practical system architecture and product partitioning that will present HES to end-users as a set of very simple, reliable and affordable black-box type modules and appliances that will enhance daily life yet without burdening users.

3. The Ideal Home Electronic System (HES)

It would be natural for a human to have a universal broadband "pipe", similar to the distribution facility for traditional utilities, such as water pipes, gas pipes, electrical cables and telephone cables around a home, so that every appliance can be plugged into any "outlet" on this pipe whenever needed. And, any of these appliances, either in use or on standby, should not interfere the operation of others.

Figure 2 depicts a conceptual setup of this system from consumer's perspective that a single broadband pipe links up every electronic device around the premises.

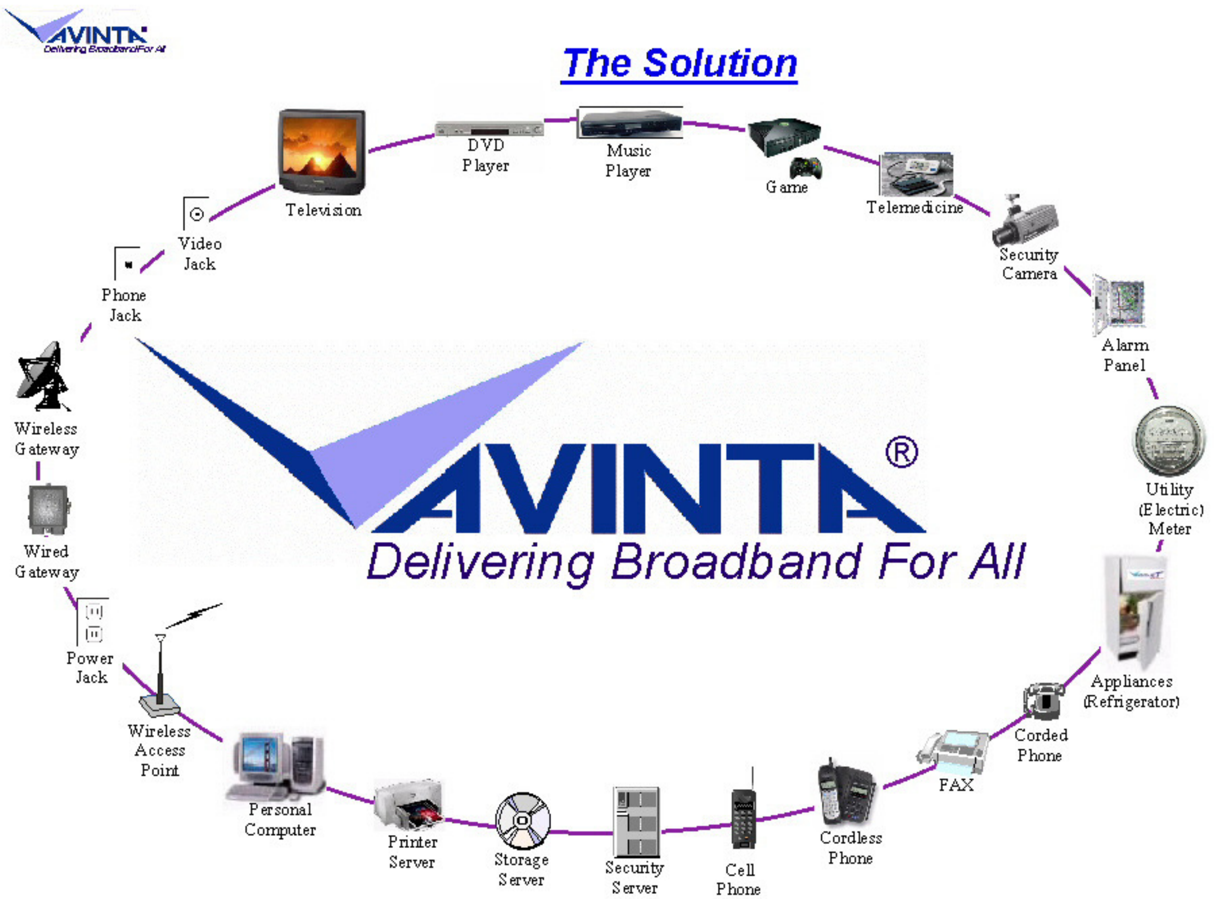

Figure 2

Technically, we need to address several issues before this can become a reality:

- This pipe has to have sufficient bandwidth for carrying the maximum traffic that is expected, so that users will not be confronted with resource allocation.
- The bandwidth used by each application should be protected from interference by other services, so that performance of each is independent of others.

- This pipe has to support free-style routing, multi-drop connection and peer-to-peer communication, because consumers would not want be constrained by lacking of these flexibilities.
- Address of each appliance or device should be directly controllable by owner, so that users can be more confident with operation and maintenance activities.
- Network diagnostic capabilities must be available from one or more frequently used devices, so that ordinary users can easily perform troubleshooting whenever needed.
- Consideration must be given to the fact that there are many different types of networking facilities on any given premises, either already in use or may be deployed in the future. Most of them are not directly compatible with one another. The ideal HES must have an integral scheme to harmonize these with minimal demand on end-user's knowledge and skill.
- Similarly, there are numerous access technologies that connect a SOHO network with Internet. Even though they may be individually capable of delivering all of the services needed by most customers, the option for a subscriber to access multiple services, if desired, should be part of the HES design.
- Provision toward future evolution must be built in this solution so that new generation of products and services can be designed to be backward compatible with those already in use to prolong their service life. On the other hand, there should not be any implied expectation for the new products to enhance the performance of the older ones through networking.
- Last but not the least, a long term HES model must also provide clear responsibility division lines among various parties involved, particularly, between ASP (Access Service Provider) and subscriber to alleviate most of the ASP's Tech-Support burden and customer's frustration. Building upon this principle, responsibility of application and service vendors can also be clearly isolated to improve customer's enjoyment of the products.

4. Elements of the Solution

4.1 Speed / Bandwidth

There are several transmission technologies that are capable of delivering one or more HDTV (High Definition TV requiring 19.96 Mbps per channel) programs. Examples are, Optical Fiber (many HDTV channels), Digital Cable (multiples of HDTV channels), ADSL2 (about 20 Mbps), VDSL (26-52 Mbps), Ethernet (10/100 Mbps up to 1000 Mbps or even higher), FireWire (100 to 1200 Mbps), USB2 (480 Mbps), HomePNA3 (128 Mbps to 240 Mbps), 802.11g (54 Mbps), etc. All of these are already more capable than most consumer would need. As time goes on, they will become even more powerful. Therefore, to plan a practical system, there is no more need to be concerned with competing for limited bandwidth among multiple simultaneous applications.

4.2 Isolation Between Applications

Several of the above technologies can deliver digital signals in channelized form with blocks of 64 Kbps data stream that is the basic unit for one digitized voice. Multiple channels can be aggregated together to carry applications requiring more bandwidth, such as video and interactive gaming. This characteristics allows multiple applications to be simultaneously transmitted over the same physical medium simplifying handling, yet as if they were independent of one another. This offers users the same experience as traditional CE devices consuming electric utility. Examples are, ADSL2, Long Range Ethernet, FireWire, HomePNA3, USB2, etc.

4.3 Network Architecture

Because networking in a home normally would start from simple cases such as sharing a printer among PCs, enjoying music or video played from a central server, there is no reason initially about making them all work together sharing the same physical medium. Thus, a viable HES model should allow an "*Ad-Hoc*" configuration ("Free-Style" routing, "Multi-Drop" connection, and "Peer-to-Peer" communication) at the beginning and support its growth to become an organized "*Infrastructure*" configuration when sharing local resources and accessing Internet become desirable that requires certain coordination.

4.4 User Controlled Device Address

It is much more natural for a user to have explicit control over the address of appliances and devices being used than to follow the randomly created and unexpectedly changeable data terminal addresses assigned by electronic equipment through a process commonly referred to as DHCP (Dynamic Host Control Protocol). This is analogous to parents are clear about which child is the first born and who is the second and so forth, but not comfortable with the citizen identification numbers assigned by the government, such as the Social Security Number (SSN) in the USA, let alone if the government decides to occasionally reassign the SSNs for its own reasons without notifying the parents! A simple method allowing the owner of any HES equipment to assign location address such as room number or any code with special meaning to family members (a built-in security measure against external intrusion) is now available. With this, address of HES components becomes deterministic and routine because it is under consumer's direct control.

4.5 Diagnostic Capability

For a consumer to feel comfortable about a service, it is very important to have means to verify its operation is normal. Ideally, such process should be part of a device's ordinary operation procedures. One of such CE devices is the common telephone set. Its basic operations such as, listening for a dial-tone, calling a neighbor and receiving a call are the same as the primary telephony service diagnostic procedures. Extending such capability into the broadband environment would significantly improve the enjoyment by removing uncertainties in verifying the service status.

4.6 Technology Harmonization

The fact that there are many types and vintages of facilities interconnecting different devices in the residential environment is a clear indication that broadband networking has to adapt to and interoperate with them, instead of mandating their changes to become a uniform network. A generic model identified in the next Section will facilitate this goal.

4.7 Multiple Internet Access

Due to the wide spread of subscriber needs, ranging from simple single person room to multiple high demand applications or operating home based business, a viable HES model must support both ends of the spectrum and everything in between. That is, one HES may be perfectly content with only dial-up connection, while the other may demand for multiple types of access to Internet. The solution proposed in the next Section will address this need.

4.8 Evolution Toward the Future

The ongoing development of new technologies is numerous and there is no way to stop their proliferation in an open market. However, the goal of enabling them to work together will be met after the above two aspects have been addressed, because the difference among the three is only with respect to the reference of observation.

4.9 Responsibility Division

A definitive separation of responsibilities among several parties involved in an event will expedite the resolution and lead to simpler and more cost-effective actions. Overall in the long run, this benefits everyone involved. This goal can be achieved between ASP and subscriber as a natural consequence of resolving the above cases. Similarly, vendor responsibility for application devices and services can be clearly established, as well.

5. HES Model

Julius Caesar's famous statement for military maneuvering, "Divide and Conquer." can be applied to system engineering work in a much more constructive sense. Instead of wrapping ever more complex functions and features into products with the hope for getting the job done by one piece of equipment, a properly designed system should partition its capability and functionality into modules that are clearly associated with responsible parties. This is not to say that the more subsystems the better. Rather, any line where parties on both sides of it can equally check its performance should be identified and preserved throughout system integration. This allows quick and precise comparison of performance data to facilitate diagnostics and resolve disputes. This concept can be summarized into a terminology, Demarcation that has been utilized extensively in the traditional communications industry. The HES model presented below will take advantage of this principle to achieve these goals. It will then be a business decision as to how to make use of this facility.

5.1 Transmission Technology Unification

Although the number of transmission technologies available to the SOHO environment is nearly countless, one commonality does exist. That is, they all are either derived from Ethernet, or can be adapted to it through the use of signal and protocol converters. This baseline provides a unique opportunity to simplify the otherwise extremely diversified and confusing landscape. In Figure 3, three general categories, WAN, HAN and PAN summarize all known SOHO technologies based on their primary characteristics.

Note that the conventional LAN (Local Area Network) in business environment has been divided into two categories, HAN and PAN. This is because the environmental constraints around the residential premises. Not only the cosmetic finish of homes is difficult to restore if it is disturbed, but also a large percentage of residential property owners are not comfortable with setting up a networking infrastructure by themselves, nor willing to pay for professional installation. Therefore, only technologies that can promise “no cosmetic disturbance” and meet the criteria of either “no new wires” or “no wires” are accepted into the HAN category. Naturally, these technologies must also support *Ad-Hoc* interconnect configuration.

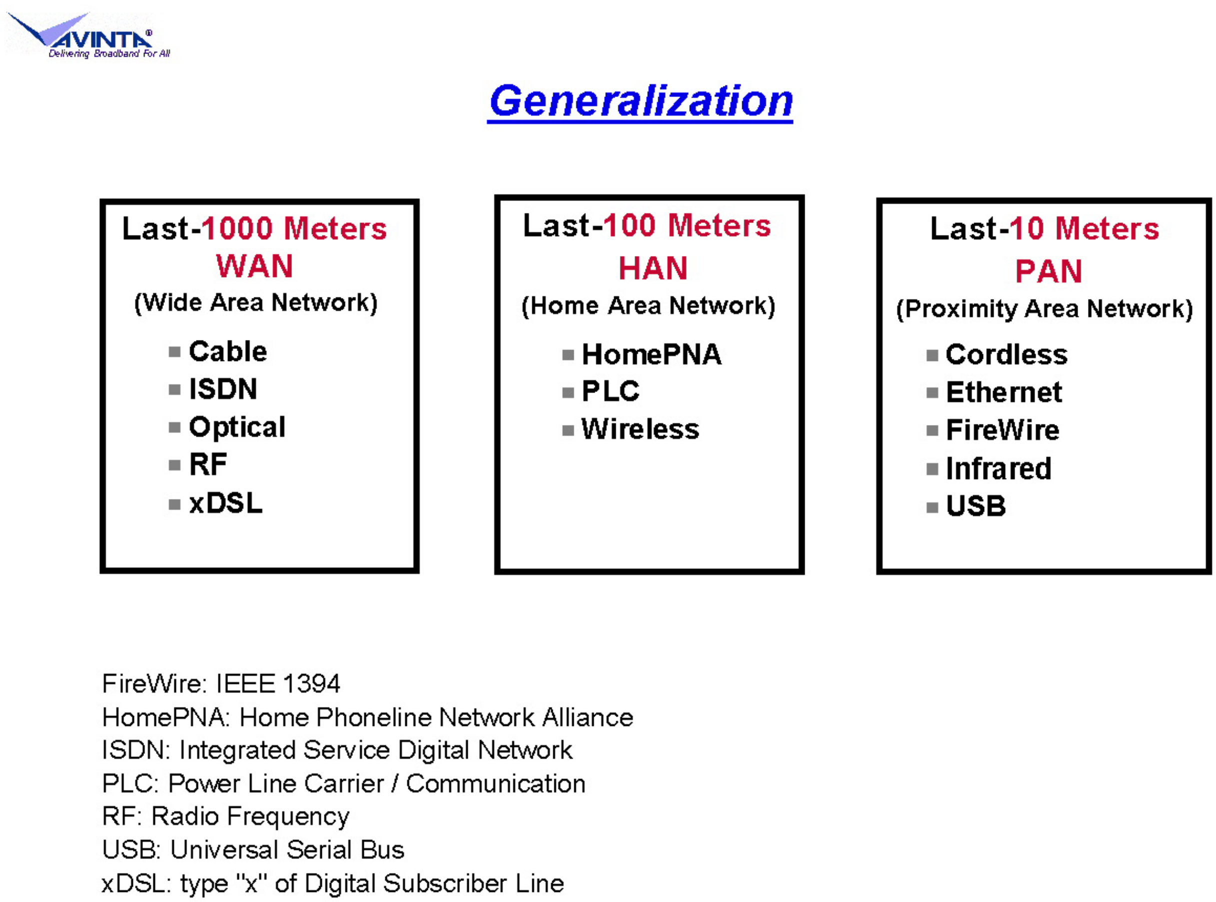

Figure 3

5.2 Basic HES

With these fundamental ingredients, we can proceed to construct a basic HES model, as shown in the upper part of Figure 4, consisting of:

A. One section each of WAN, HAN & PAN pipes with

B. One electronic module to convert the signal at the junction of each pair of them. These would commonly be known as Residential Gateway (RG) and Network Adapter (NA), respectively. Then,

C. Connect a EUT (End User Terminal) device at the end of a PAN pipe to provide specific services to the end user. Most of the devices shown in Figures 1 & 2 belong to here.

D. Of course, on the far end of the WAN pipe are the PSTN and Internet that connect to service provider equipment.

This completes a schematic presentation of a very concise HES model.

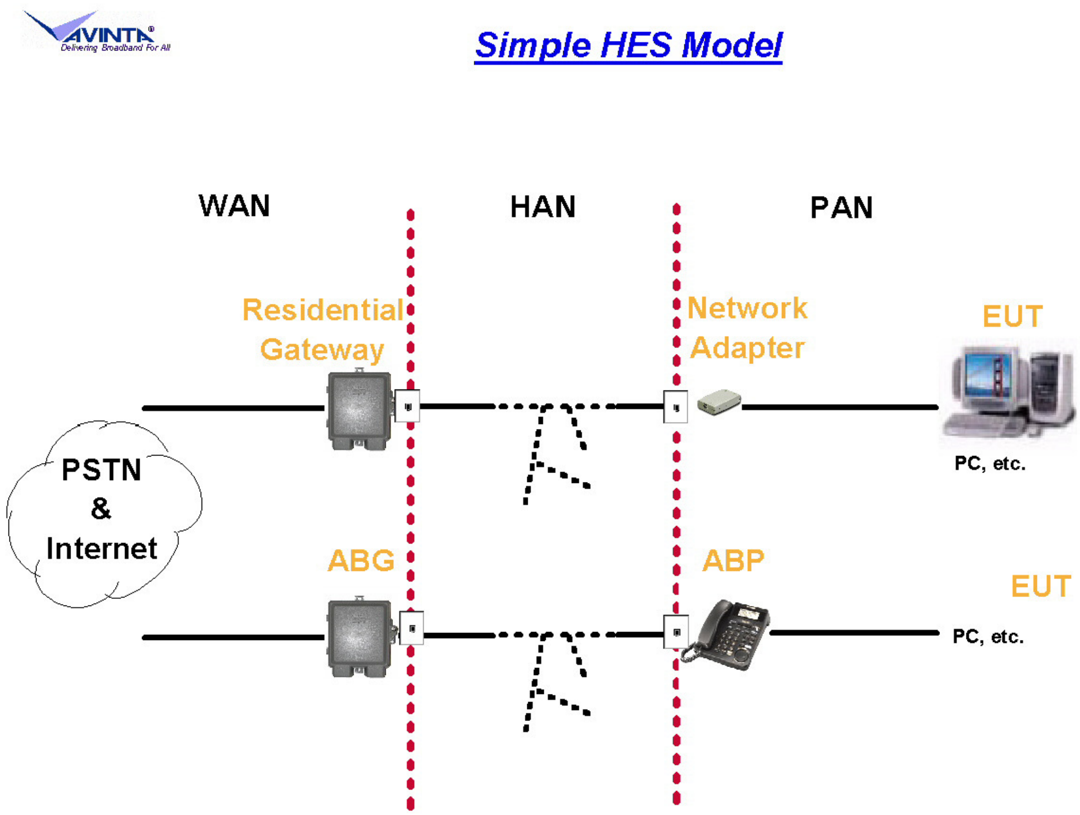

Figure 4

5.3 Node Address Assignment

The architecture of the basic HES model turns out to be very much the same as the way traditional telephony service is delivered through a residential property. However, those telephones could not contact one another because they lack of switching capability that relies on station address. US Pat. No. 5,596,631 disclosed a method of assigning extension number to each telephone set allowing them to form a dPABX (distributed Private Automatic Branch eXchange). Porting such addressing scheme into data terminal via US Pat. No. 6,721,790, an enhanced telephone, ABP (Avinta Broadband Phone) is capable of providing multi-line dPABX service, as well as serving as a NA for EUTs such as PC, TV, etc. The lower part of Figure 4 depicts this critical system technology advance that provides the linkage between the traditional narrowband analog telephony with the modern broadband digital data technology. To serve this voice and data converged HES, ABG (Avinta Broadband Gateway) houses interface circuitry for both narrowband telephony and broadband data traffic to and from PSTN and Internet, respectively.

5.4 Gateway Made of Half-Gateways

Upon reviewing the physical construction of commercial RGs between WAN and HAN, it is apparent that the most flexible configuration is to build it in two modules (or, subsystems). The first is a Modem that terminates the WAN signals, such as those from xDSL, Cable, Optical or RF, etc. The second is a Bridge or Router that distributes the broadband signal to one or more nodes, respectively, on the premises via one of the HAN technologies. For maximizing interchangeability to meet customer's diverse demands, most of these modules are designed with Ethernet as the interface between the Modem and the Bridge/Router.

Since NAs are commonly designed with Ethernet interface as a PAN connection to EUT as well, it follows that if there exists a device that can convert a transmission technology's signal to Ethernet, that technology could be easily interfaced with many others that also have a similar conversion device.

A terminology, HG (Half-Gateway) has thus been created to represent a class of signal converting devices of this kind that have been called many other names based on their primary functions, ranging from Adapter, Bridge, Hub, Router, Switch to Gateway. Attached with this paper is a SpreadSheet file, HalfGate.XLS that has collected a representative set of these devices. As can be seen in it, the most prevalent common transmission technology capable of serving this function is Ethernet. The current runner-up candidate is USB. We shall classify these as GL (Gateway Link).

Consequently, a Gateway between any WAN and any HAN can be easily assembled by using a GL to connect two HGs, one from the WAN, the second from the HAN.

5.5 Linking up Disparate HANs

Since residential environment is under individual owner's control who has very little training, if any, to set up a HES, most would start from linking a few CE devices together for a specific purpose. Initially, there is hardly any intention to join several applications together to share a common broadband pipe. So, they are set up and operated independently in an "*Ad Hoc*" configuration. When some of these setups need to communicate with one another or outside world such as sharing local resources or Internet access, respectively as well as combined, a coordinated "*Infrastructure*" must be established to share the transmission facility. This transition has created a serious challenge to the current approach, and has been identified as interoperability issue. With the proposed HG configuration, a HES owner can handle this by simply purchasing an appropriate HG Pair and connecting it between two HANs to link them together. So that local EUTs can communicate with one another over different HANs. As long as one of the HANs is connected to the Internet, both of them can share the access. Figure 5 depicts schematically how to implement such a configuration. It also shows one form of sharing multiple WAN services by accessing through corresponding HAN segments.

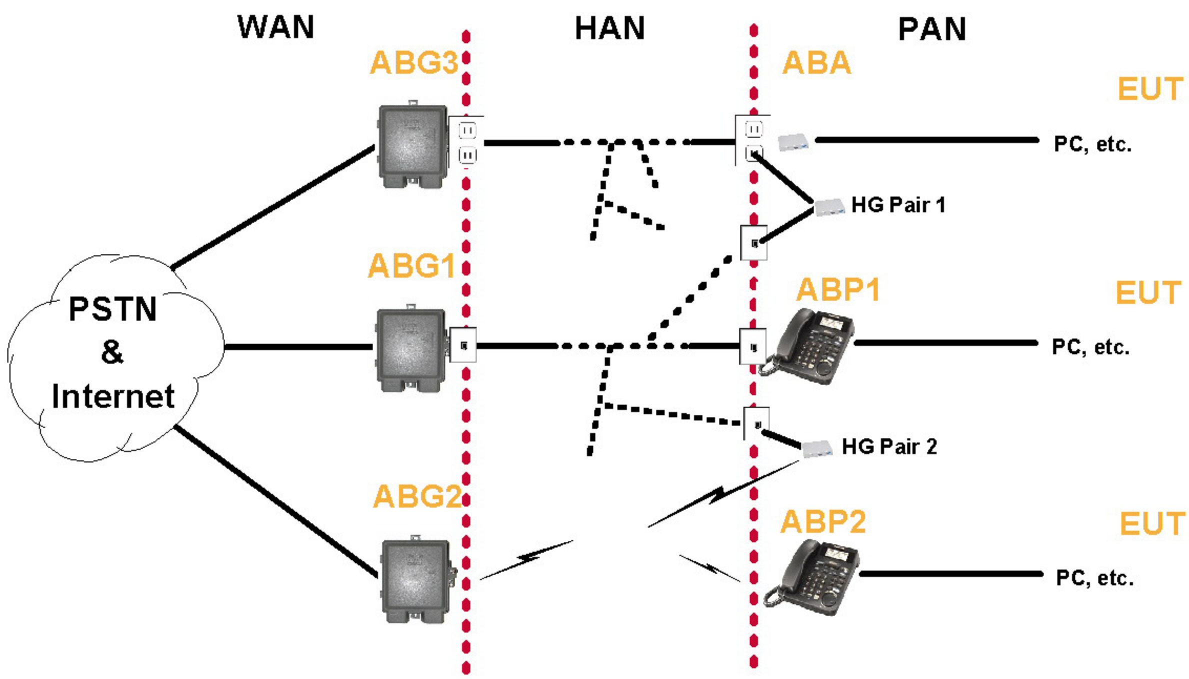

Figure 5

5.6 Backbone HAN

One interesting consequence of the proposed HES model is that it is possible to access multiple WAN services with respective ABGs through one single HAN that is called "Backbone HAN". This is made possible by configuring the Router part of ABG as one of the peer-to-peer nodes on the Backbone HAN, instead of the current convention that sets a Gateway as the Master of a HAN resulting in contention when multiple Gateways are present on the same HES. Figure 6 depicts such a configuration that a HES consists of the Backbone HAN (HomePNA) interconnecting 3-WANs (Satellite, ADSL & Cable) and 2-HANs (HomePlug & Wireless).

The GLs and ABAs on the right side of the Figure 6 detail the HG Pair subsystems shown in Figure 5.

5.7 Service Modules

The HES model presented thus far is based on a distributed system architecture with one or more broadband pipes supporting free-style routing, multi-drop connection and peer-to-peer communication. The only requirement is that each node should possess a unique address code that is assigned by the premises owner. This allows common facility to be conveniently located while easily shared by all EUTs. Examples are shared Printers, Storage Devices, DVD Players, Music Servers, Security Cameras, etc. With proper routing rules, even an encryption/decryption module can be added to this system whenever secured communication between two sites is desired. The ABS (Avinta Broadband Sentry) module in Figure 6 demonstrates this capability.

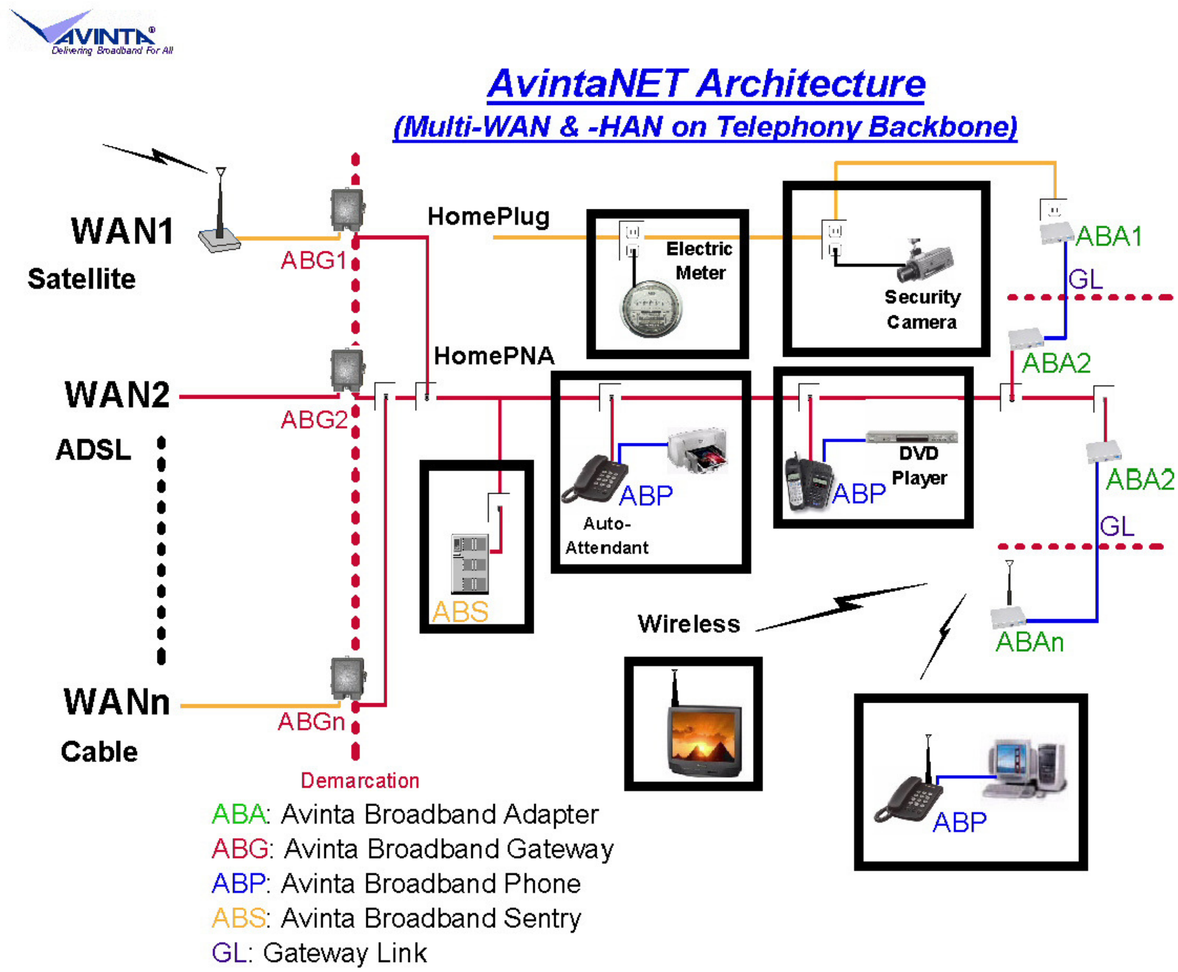

Figure 6

6. Interoperability

Once two HAN segments of different transmission technologies are linked together through a pair of their respective HGs via a common GL, their resources and capabilities become sharable between the two. However, since they were not originally designed for the same applications, much of the command, status and data vocabularies may not be the same. A Common Language (CL) need be developed to serve as the intermediate translation point between the two, very much the same as what Esperanto does for international language translation. The CL should be composed of descriptive terms (Lexicon) with the finest resolution used among all possible cases of one category (Taxonomy). For example, among light switch commands that could be either literal words “On/Off”, binary numbers “1/0”, “qualitative descriptions”, “fractional numbers”, or as detail as brightness by “one percentage” points, the CL for the light switch operation should be defined with steps in “one percent” increments. Just like a dictionary, CL will be a continuous work-in-progress despite of the most exhaustive compilation effort to set it up initially. This is because future applications may create the need for new or modified Lexicon. Therefore, all new HGs should be designed with the latest version of CL to maximize the interoperability. However, as long as a new capability is not supported by any existing device on a HAN, there is no need to upgrade the associated HG. In fact, if the premises owner has no interest to take advantage of such new feature, there is no need to replace the affected HGs already in use. This “only if needed” product upgrade philosophy would fit consumer’s natural desire well.

7. Synthesizing General Purpose RG

Taking one step further from the above derivation, we can synthesize the current generation of RGs on the market with the same HES model. That is, if we utilize the Backbone HAN technology of a HES to also serve the GL function, a general RG even with distributed components can be easily formed. For example, if the GLs in Figure 6 is using HomePNA, there is no more need for the physical ABA2s. And, the ABGs do not need the second HG portion that goes from GL to Backbone HAN because both are HomePNA. Essentially, we can treat the Backbone HAN as the internal buss of a RG with multiple-WANs, multiple-HANs and multiple-Service modules connected to it. In Figure 7, HomePNA serves RG internal buss function to link 3-WANs (Satellite, ADSL & Cable), 2-HANs (HomePlug & Wireless) and 1-Service module (Sentry) together, plus 2-ABPs that treat it as the Backbone HAN. Since HomePNA3 can carry multiple channels of HDTV, this configuration is technically capable of delivering all currently known SOHO applications while simple-minded enough for consumers to handle.

8. One Single Broadband Pipe

With ABAs transparently linking the additional HANs (HomePlug and Wireless) to the Backbone HAN (HomePNA), the interconnection media enclosed by the purple colored dotted line box in Figure 7 becomes the physical implementation of the single elliptical broadband pipe in Figure 2 that in consumer’s perception, connects all HES components together.

9. Summary and Conclusion

Most current SOHO networking products have been based on the CTI (Computer Telephony Integration) approach, in which PC driven data applications are the primary purpose, with voice, video and other services as add-on features. Because data applications have much less stringent performance requirements, a system built for it faces a number of issues when attempting to provide a generic networking service for the wide range of CE devices.

The HES model presented in this paper starts from satisfying human’s first communications need, the voice based telephony. In delivering such service, most of the critical networking parameters have been properly set and configured according to human preference and time-tested communication practices. Because this TCI (Telephony Computer

Integration) process builds a network from the most critical communications foundation, appending other applications, even those bandwidth thirsty video and game services, is straightforward.

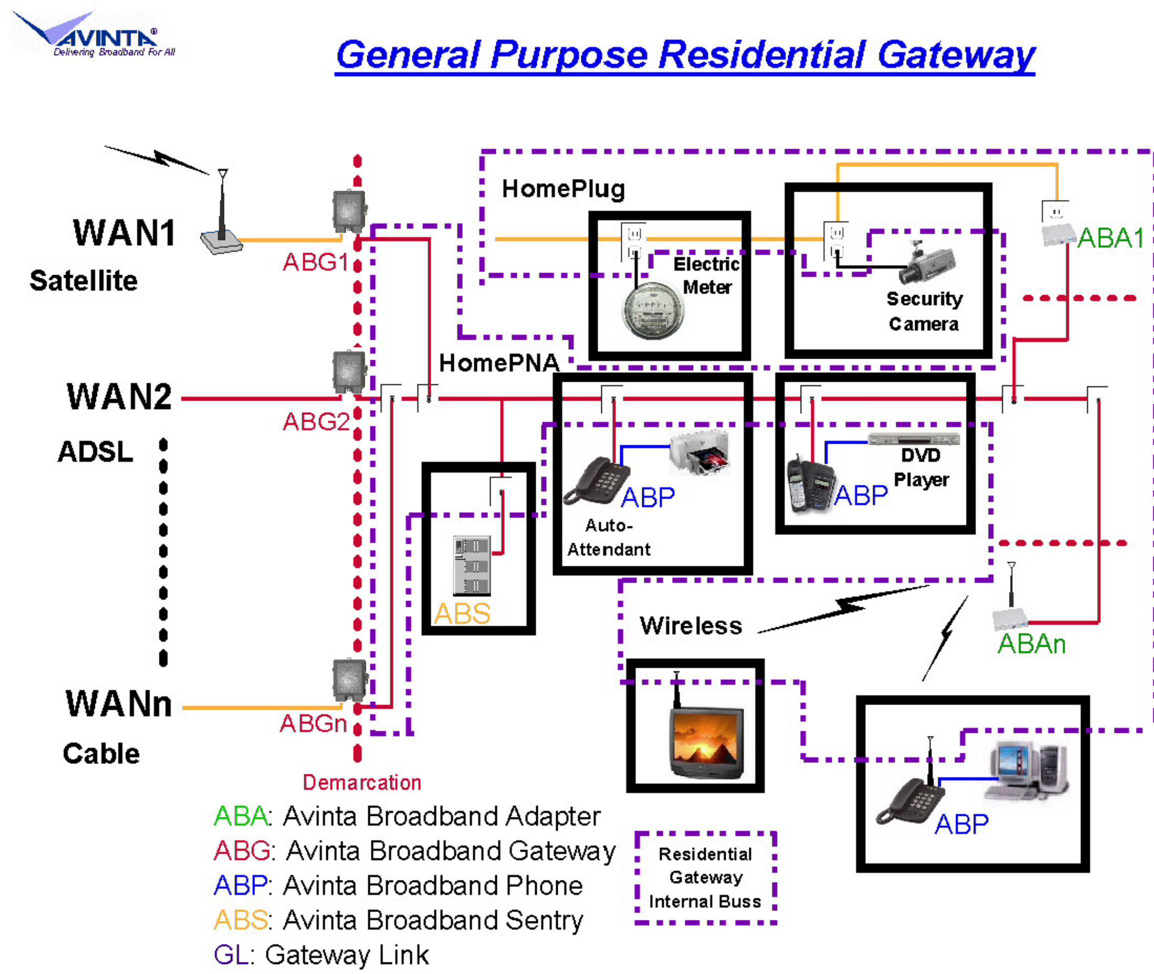

Figure 7

This proposal reduces the seemly very complicated HES environment to one single type of interface module, HG (Half-Gateway). With properly designed HG, each transmission technology will be able to develop its products and deploy its services as if it was on an isolated island. Yet, it is always ready to inter-operate with any other technologies, current as well as future ones.

These modules further facilitate accessing to multiple WAN services whenever needed. Based on this architecture, even service modules can be simply plugged into the HES where and when desired. This avoids the complexity currently built in basic system modules such as RG, even though few consumers may ever need such capability.

A general purpose multi-WAN, multi-HAN and multi-Service distributed RG can be easily synthesized from the proposed HES model, as well. This is accomplished by utilizing the same Backbone HAN transmission technology as the internal buss of the RG.

In conclusion, a HG based HES offers consumer the black-box convenience with much better control of the home networking than current approach. ABP empowers consumer with confidence by being his/her own IT (Information Technology) manager. With Demarcation line concept, the interface between end-user and ASP (at ABG) or application vendors (at ABP or ABA) becomes clear-cut, avoiding much of the current confusion, frustration and hidden costs endured by all parties.

By concentrating the interoperability tasks in the HGs, deployed HES components will not be disturbed, neither now nor in the future. Because, any change will only be implemented in the affected HGs. Furthermore, only if the premises owner wishes to take advantage of the new features on another HAN, will there be any need to replace the affected HG with an updated version. Even so, the update would most likely be limited to a simple firmware download of the new CL.

Attachment: HalfGate.XLS