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Project:

Middleware for the Futuristic Home

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1 Problem Statement:

Object based middleware for home network supporting the interoperability among heterogeneous devices with a particular insight on performance prediction.

2 Abstract

The bridgehead established in this paper will elaborate a system that will allow the home environment to be interactive, aware the various user models in context of the individual home within its community and integrate with other urban environments throughout the world. The system will attempt to integrate legacy systems with potentially new systems, since the inevitable possibilities of new hardware, and the plausible possibility of new interface requirements, and the less likely case of new middleware exists.

3 Introduction

From the philosophical context, the system can be viewed as people who wish not to be governed by computers, but instead to use them to facilitate their needs in their environment. This type of system will need to have a robust platform that is responsive to the needs of the people they serve. Within this context the project will explore the capabilities of a responsive platform for individuals and families using electronics to create a habitat based on their preferences. The futuristic hardware presents a problem in the sense of uncertainty in which interface capability is a major hurdle in conjunction with existing hardware interfaces [1].

Other potential problems represent considerable challenges. There is constant change in user requirements due to infinite human needs and interaction in the surroundings they encounter in their environment. These challenges summarized in the user requirements impact compiler, language binding, design patterns, scalability, and interactions. There will be many variations of the hardware implementation in which some appliances will possess more processing and available memory, in both the short term and the long term, which will drive their respective client / server models.

The given historical context of a typical housing unit has been a place to feast, entertain, sleep, raise a family, and protect oneself from the elements and hostility of others. The appliances that have been produced so far facilitate the overall housing experience towards more time to entertain, raise a family, and pursue interests within and outside the scope of routine activities surrounding the main requirements for household activities. The current appliances have been refrigerators, lighting, heating, cleaning, entertainment in the form of audio and video, and security systems.

Another important historical aspect to realize is that even in most the trying times, the population and overall commodity needs continue to increase, straining current living and working conditions to a point where smart systems become increasingly needed to limit the impact of a housing unit. Its impact in this scenario becomes a larger integral value, becoming ever increasing in causing serious fluctuations in supply and demand of commodities and services. This, in our opinion, is currently a major factor in much of the difficulties in the world. Another way to examine this problem is many individuals within the housing unit are essentially unaware of potential consequences of their actions when obtaining lines of credit or using cash, resulting in the demand of goods and services to facilitate their lifestyles.

The current usage model is problematic and requires a bridgehead or a quantum leap in achieving its noble goals. This is so as there are really no commercially available products for the integration of devices with some remote control capabilities to control home appliances. The appliances are unaware of each other, and of the residents' needs for a given time. Such overall actions are inefficient and burdensome to the occupants of the housing unit. Accommodation of the resident to the housing appears to be a significant enough demand to explore and address the need [1]. We can speculate that a resident would like the lights to turn on when their presence nears the housing unit, for the gate to open in a timely fashion to facilitate an improved security situation, to heat the house to a comfort level of the resident, to turn on the music to create ambient environment, and maybe even turn on the television or start boiling water for preparation of food. The possibilities for an immediate satisfaction of demand appear to be aplenty of opportunities. The system we will suggest result in the improvement of efficiencies in time and make the user aware of the goods and services requirement and the consequence of those demands in the overall system.

The current research we were able to discover have a focus on the connectivity of appliances as network devices, but very little research has been done on the system integration efforts which include middleware specifications and use case models that provide intelligent services [2].

Much of the research concludes that the key element for success in the digital home is interoperability between devices functioning on a common home network system. The benefits from interoperability for consumers provide consumers with increasing flexibility for developers will accelerate even more demand for devices and applications at home, in transportation, and in the work place.

The current technological products and software that can be a good starting point for addressing this set of problems are the Java Enterprise platform software also known as J2EE, MetaData implemented as XML, networking protocols such as IEEE1394 (FireWire) and 802.11.a/b/n (WiFi), and middleware technologies such as OSGi [2] and CORBA.

4 Architecture and service scenario

These are examples of one or many possible use case scenarios in which the design requirements design goal and service scenario can be specified.

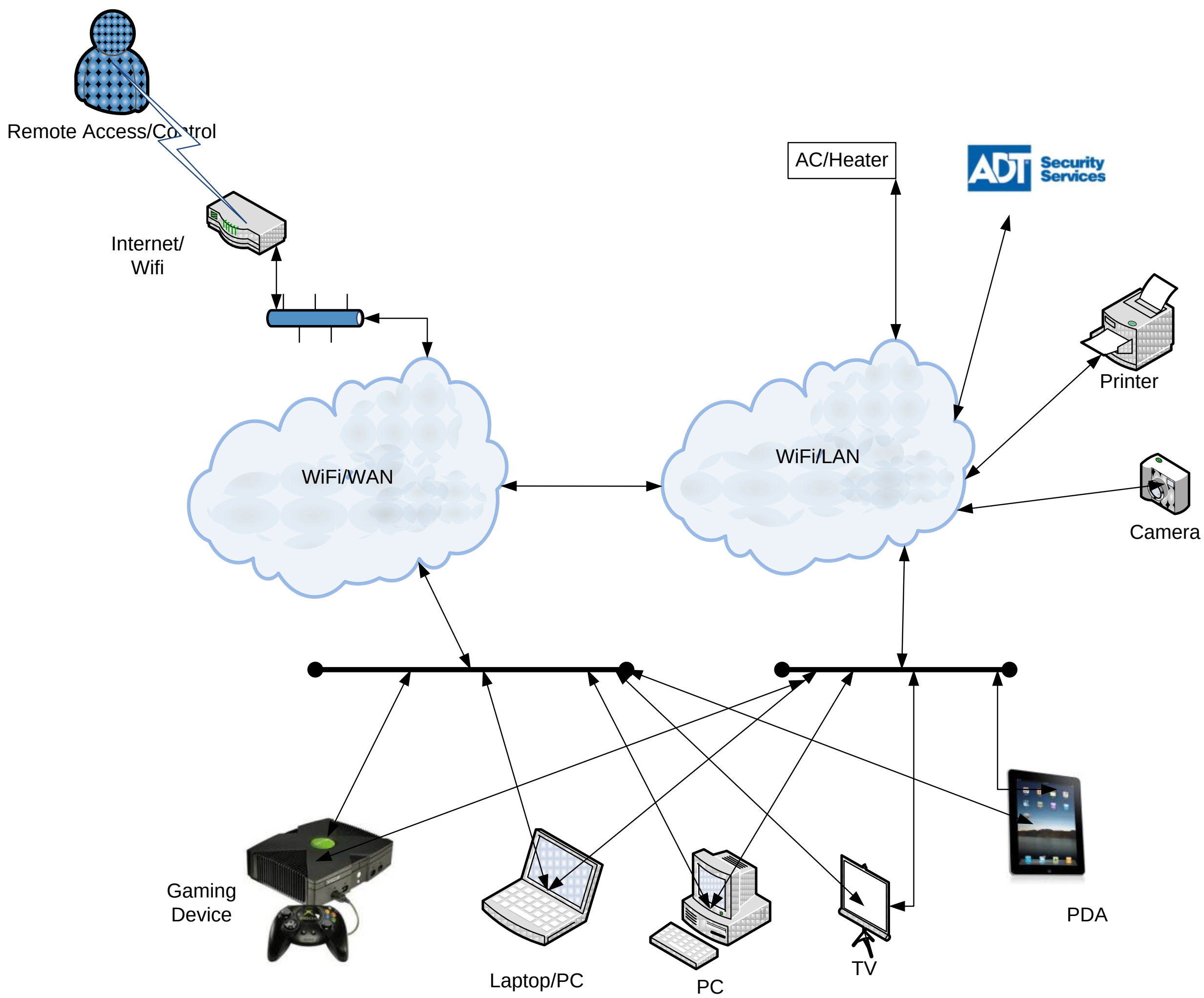

Figure 4.1: The Conceptual Architect of home Network system

4.1 Design Requirement

The design must support the legacy systems permitting existing standards of living to continue. The communication system must be able to recognize existing appliances and allow introduction of new appliances. There will be a need to decouple the hardware solution to the software solution and the networking solution. There must be a graceful error-recovery mechanism with robust reporting and diagnostics. Having a control interface to override automation, and facilitate installation and learning will provided a multitude of users to interact with the system for many possible user case scenarios.

4.2 Design Goal and Architecture

4.2.1 API provided.

The intention of such software architectures is the ability to have a standard interface in order to provide a customization of consumer based appliances. This API will be given to anyone who wishes to obtain a development license in order to develop an appliance to integrate into the architectures.

4.2.2 Plug & Play

This is characterized as any consumer based appliance's driver that is automatically recognized, initialized and able to participate in the home networking environment with no extensive configuration setup procedure.

4.2.3 User Interface

A few user profiles may be required for maintenance of the various appliances, personal preferences that override the system suggest use case, and to permit utility companies, and companies that produced the consumer appliances to download drivers, or obtain power usage statistics.

4.2.4 Scalable

The amount of devices could range from zero to the number of devices the user requires.

4.2.5 Responsive

Response time should be close to real time for the middleware, and varied depending on the consumer electronic devices. In other words, the goal is to minimize the amount of overhead that a middleware layer injects in the overall system and the burden any one appliance or group of appliances imposes through the middleware layer.

4.2.6 Performance Prediction

Based on the principle of the Quality of Service (QoS), in which activities have requirements with respect to time, these bandwidth intensive appliances are outside the scope of the middleware system. Essentially, an outside component will deal with data intensive appliances such as a router system, or some bandwidth divider. Our system will enforce packet size to be small enough to marginalize the QoS requirement [3].

4.2.7 Accessibility

The private cloud computer environment will be the basis of the home networking environment. The model is based on Software as a Service (SaaS) user experience. Internet accessibility for limited information regarding utility services, and consumer company notifications of requested driver upgrades, are also provided.

5 Architecture and service scenario

These are examples of one or many possible use case scenarios in which the design requirements design goal and service scenario can be specified.

5.1 Entering the residency

Use case ID: 001

Description: The resident approaches the residence

Pre-condition: No resident is around or in the residence.

Post-condition: The residence environment has accommodated the resident.

Primary actor: The resident.

Secondary actor: None.

Procedure: A PDA device or some wireless device on the car or person signals to the residence that the resident is approaching.

The system would recognize and request the login information and retrieve the meta-data and take the appropriate actions to accommodate the resident.

Possible systems involved are lighting, HVAC, entertainment, security, irrigation, and kitchen appliances.

5.2 Navigating the residence

Use case ID: 002

Description: The resident enters and leaves an area in the residence

Pre-condition: Resident has already programmed the preferences.

Post-condition: The residence environment has accommodated the resident.

Primary actor: The resident

Secondary actor: Possible feedback scenario, and other residences in the room or rooms.

Procedure: A PDA device or some wireless device on the person signals to the residence that the resident is approaching or departing the room.

The system would recognize and request the login information and retrieve the meta-data and take the appropriate actions to accommodate the resident.

Possible systems involved are lighting, HVAC, entertainment, security, irrigation, and kitchen appliances.

5.3 Home Invasion

Use case ID : 003

Description: A foreign person attempt to enter the residence with no resident present in the residence.

Pre-condition: Resident has already programmed the preferences.

Post-condition: The residence environment has accommodated the resident.

Primary actor: The foreign person who would enter the residence.

Secondary actor: Security personnel and feedback.

Procedure: Security system takes actions to facilitate and arrest of the foreign person by identity and proof of actions. Then security system will attempt to deter property theft by securing valuable items specified by the user and an attempt is made to convince the foreign person to expedite their departure from the residence to prevent property damage, and an attempt is made to arrest the person for the crime to deter further patterns of behavior deemed inappropriate in the given structure of the law.

5.4 Garage

Use case ID: 004

Description: Electric cars and forms of hybrids such as electric - gasoline engines will attempt to recharge the battery pack in the car.

Pre-condition: The user has been notified that vehicle requires a charge and maintenance check.

Post-condition: The car will be recharged and a maintenance check done on the system.

Primary actor: The vehicle.

Secondary actor: None.

Procedure: The owner of the car will plug in the hybrid or electric vehicle into the garage system once the system notifies that the system is ready to begin the charging and maintenance. The system will notify the owner once charging is complete.

5.5 Watching the television

Use case ID: 005

Description: A person wishes to watch a show on the television.

Pre-condition: No one is currently watching the television.

Post-condition: The person gets up and doesn't return to watch television.

Primary actor: A current resident or authorized visitor.

Secondary actor: None.

Procedure: One of the current residents or an authorized visitor will sit down to watch the television. The user will press their thumb on a fingerprint reader or other biometric or ID device to turn on the television.

Based on previous user settings the television will present the preferred television channels and the choice to browse based on categories. If the user wants to use the television for other purposes such as DVD movies, video-gaming, or even the possibilities of using it to listen to music, they will be presented as well. When done with the entertainment the user will press their thumb on a biometric device to save the profile and turn off the television.

5.6 Air Conditioning

Use case ID: 006

Description: An efficient way to use heating and cooling of areas within the residence.

Pre-condition: Authorized to consume a certain amount of energy from the utility company.

Post-condition: The air conditioning unit is using the minimal amount of energy to maintain the current residents' needs.

Primary actor: A resident.

Secondary actor: The utility company.

Procedure: The goal of such a system will be to maintain temperature requirements for each section of the residence within 2-3 degrees of the target temperature. Presence of residents, seasonality, the time within the 24 hour period that makes up the day, and community load requirements will be factored in, along with power restrictions placed upon it by the resident and/or the utility company, if present.

6 Implementations

6.1 Message layer

The messaging layer exists to allow devices to communicate to each other and/or our system. Error recovery and the like are not covered by the messaging layer since the application will be taking care of it through the double checking of the status of a device to make sure that an event which was sent to it has been done. If not, then the application will send another message requesting another attempt at sending the message. The procedure will repeat until a configurable time-out, after which an alarm will be raised or the event will indicate a total communication failure with the device.

The following figure illustrates the components that make up a message within this layer.

Header	Source Add	Destination add	Message	Parity

Figure 1.1

Source Add: Machine Identification for source of the message, i.e. the MAC address of the device.

Destination Add: Machine Identification for whom the message was intended for, i.e. the MAC address of the device.

Message: The data, which could be commands, information, or a query.

Parity: Content integrity.

6.2 Header

(See Figure 1.2)

The header of the message can be further broken down to the following.

Message Number	Message Length	Message Type

Figure 1.2

Message Number: Indicates the sequence number between two or more devices participating in the user sequence. This is to determine the order of execution of messages taken for a given use case.

Message Length: The length of the message. It is also for validity of message.

Message Type: Reply, Request, or Information Request.

6.3 Event manager

The event manager handles the list of events provided by a use case, then navigates through a list of events and negotiates with other event managers for power usage and possibility interaction with other event managers. It also provides error recovery in case of event failure, such as resetting appliances that have locked up, or resetting the system to retry another attempt at an event. They can vary based on the type of failure.

It also handles basic functionality actions, such as power up sequences, registrations, removals of a device, transmits, queries, etc…

6.4 Configuration Manager

Envisioned as residing in a database in which the contents contained are the metadata pertaining to each appliance. The metadata will provide such features as what software version is installed, and the characteristics of the device.

6.5 Resource Manager or Device Manager

Its main purpose would be the requesting of memory usage, power consumption, bandwidth, priority of device reservation, status of devices, and direct management of shared resources.

6.6 Adaptor (Wrapper Pattern)

This will be a software API layer that other middleware platforms must implement to interact with the base middleware platform. It is essentially a conversion layer to deal with the uniqueness of each middleware platform.

7 Conclusion and future work.

A system that is scalable, plug & playable, interactive, and aware of its impact on resource consumption, will provide a better community environment, and a higher quality of life; not only for the individual, but also the community at the local and state level. This was intended to describe metaphorically as a bridgehead to a better future where resources are not squandered on self-absorbent activities that indirectly impact the world in unforeseen and often negative ways in terms of quality of life. It will, in our belief, provide the current status-quo legacy systems to exist in a futuristic undetermined system.

Future work would involve investigating remote access layers, dealing with security, bandwidth, and quality of service issues. This may address observation of children while away, chores like feeding the animals while away for extended periods of time, and access to information stored at home such as bank account cards, or other information deemed private enough to avoid theft.

8 References

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