Residential Internet-Ready Buildings (IRBs)

Definition

Internet service in residential multidwelling units (MDUs) is about to become the next utility after gas, water, and electricity. *Internet-ready building* (IRB) is defined as making an MDU ready for high-speed broadband services using Internet protocol (IP) with the entire required infrastructure, network, operation, and service functions.

Overview

The deregulation phenomena taking place in the telecommunications world will allow different business entities to penetrate the residential and commercial environment through the access network, with either a copper wire, coax, fiber, or wireless infrastructure.

As a result of the Telecommunications Act of 1996, the IRB creates an untapped business opportunity for service providers. In relation to the last mile, the IRB resides at the last drop of the subscriber network, which may be beyond the point of demarcation. Access to the IRB may be by wireless or by wireline connection. This feeding mechanism enables a point-to-multipoint service, creating a central pipe serving many customers. The uplink connection can be terminated at the building's point of demarcation, thus enabling IRB services over the telephone copper wires.

Building a broadband access network that relies on IRBs and is complemented by wireline and wireless last-mile technologies creates a new service model with some exciting business opportunities for the traditional service providers as well as for new competitor carriers.

This tutorial will present a new model for creating a residential IRB that relies on a new service-switching concept.

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2. The Last-Mile Picture
3. Implementation Examples
4. The MDU/MTU Market Segmentation
5. Issues Involved with Converting a Building into Internet-Ready
6. Splitterless System Installation
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Glossary

1. The Competition

Today's Internet revolution is the first step toward a fully interactive multimedia broadband service. The world community is facing a future in which commercial and residential data connection (i.e., the Internet) will be a utility like water, electricity, and gas are at present. This will require renetworking of the multitenant environment, creating the IRB.

The deregulation phenomena taking place in the telecommunications world will allow different business entities to penetrate the residential and commercial environment through the access network, either with copper wire, coax, fiber, or wireless infrastructure. This will be highly motivated by the business opportunity seized by supplying on-demand services. The major players in this arena will be incumbent local exchange carriers (ILECs), interexchange carriers (IXCs), post telephone and telegraph administrations (PTTs), Internet service providers (ISPs), competitive local exchange carriers (CLECs), cable television (CATV) operators, very-small–aperture terminal (VSAT) operators, etc.

Manufacturers and standards bodies initiated many activities related to the copper wire and digital subscriber line (xDSL) technologies. The Institute of Electrical and Electronic Engineers (IEEE) as well as the Multimedia Cable Network System Partners Ltd. (MCNS) are among the leaders. MCNS is working on hybrid fiber/coax (HFC) cable issues. The full-service access network (FSAN) initiative is working on the futuristic field of fiber-to-the-home (FTTH), using asynchronous transfer mode (ATM) technology over fiber, with copper—using very-high–data rate DSL (VDSL) at the last drop—an answer for a future killer application. On the other side of the wireline solution, wireless manufacturers are working on new, high-capacity solutions, including direct broadcast satellite (DBS) and local multipoint distribution system (LMDS), which were licensed for a new spectrum by the Federal Communications Commission (FCC) and are going to boom in the coming years.

The deregulated point of demarcation in risers, industrial campuses, hospitality units, and garden-style complexes, plus the results of the Telecommunications Act of 1996, create an untapped business opportunity with new revenue streams for service providers. Complementing an IRB with a wireline, fiber, or wireless uplink converts the building into a business unit.

2. The Last-Mile Picture

Let us begin by looking at a general picture of a common serviced network. The service itself is a starting point and may be broadcast video, Internet, data, etc. that is transported to the last mile through the core network. This core transport may be the metropolitan, national, or international backbone carried over different kinds of network technologies. The last mile or the subscriber network starts at the central office (CO) in the telephone-company case or at the head end in the cable multiple system operator (MSO) case. In the satellite case, the ground dishes pointed to the satellite may be considered the beginning of the last mile. For terrestrial wireless, such as LMDS, the last mile starts at the feeding point to the base stations. To generalize the last-mile architecture, it must be divided into the primary and secondary access networks. The primary access network starts at the CO or the head end and runs to the neighborhood or building. According to modern architectures such as HFC in cable or fiber-in-the-loop (FITL), a fiber runs across the primary access network, feeding a remote node such as digital loop carrier (DLC) in a street cabinet or an optical network unit (ONU) in cable. In the case of a full-copper last mile, the remote node might be the street intermediate distribution frame (IDF). The secondary access network is where the distribution takes place. Distribution takes place in the coax wiring in the case of cable and in the copper wire in the case of the telephone system. The last drop is beyond the point of demarcation that brings the service wire into the customer premises. *Figure 1* describes the last-mile topography:

Figure 1. The Last-Mile Picture

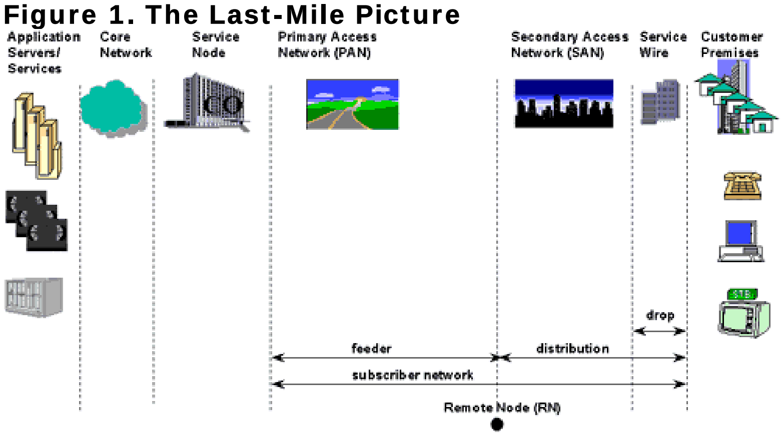
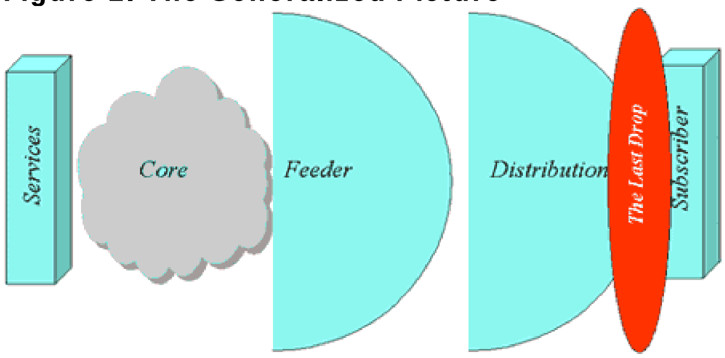


Figure 2 generalizes the picture and locates the IRB.

Figure 2. The Generalized Picture



The IRB resides at the last drop, starting at the point of demarcation and terminating at the customers' premises. Getting access to the IRB requires a complementary fat uplink pipe from the core network through the primary and secondary access networks. In many cases, a single feeder from the core network to the last drop may be used.

The following sections will cover implementation examples with different infrastructures.

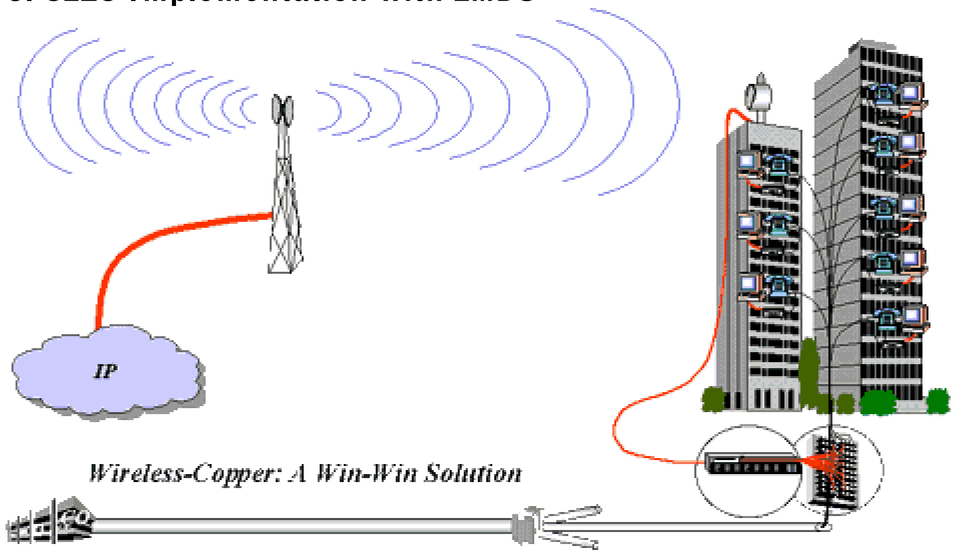
3. Implementation Examples

Feeding an IRB enables a point-to-multipoint service, creating a central pipe that serves many customers. The uplink connection may be terminated at the building's point of demarcation, enabling service over telephone copper wires.

Access for Wireless Operators

For wireless CLECs, LMDS is one of the leading technologies, enabling quick market penetration. CLECs' initial target market is the corporate sector, which may require symmetrical characteristics of traffic. However, CLECs can use their LMDS capacity to provide high-speed Internet services to residential buildings and complexes as well. Through an installed antenna and terminal at the building top, they may connect via a dedicated wire to the IRB network by dropping a single fiber or Category 5 (CAT5) to the telco room at the basement. This enables a high-resolution service from a single connection at the point of demarcation (see *Figure 3*).

3. CLEC Implementation with LMDS



Using the existing legacy copper wire with DSL transport techniques for implementing the IRB provides CLECs with a wireless copper architecture that represents a win-win solution. This configuration converts the building into a business unit, thus making it broadband-ready for service. This type of architecture is an excellent business case for cellular operators who are looking to extend their business activities. Using the cellular base stations as an infrastructure for deploying the LMDS service drastically reduces the required investments.

For wireless VSAT operators, the story is the same. However, the traffic is not symmetrical, and an additional uplink connection does not necessarily exist. In the latter case, a wireline uplink mechanism is needed, making this application problematic.

Access for Wireline Operators

For ILECs, PTTs, and CLECs, asymmetric digital subscriber line (ADSL) services in mass numbers to MDUs (where the digital subscriber line access multiplexer [DSLAM] is located in the CO) seems impractical and overly expensive from a technological point of view. Extending the service to the building's point of demarcation is far more robust and economical.

Implementation is accomplished with the installation of one or more xDSL lines to the IRB. With this configuration, only the nonvoice, high-quality copper pairs can be selected to feed the IRB, as the bundle from the CO usually has more than enough extra copper pairs. Nevertheless, the xDSL connection can be installed over four wires rather than the usual two, thus improving transport capabilities.

In the case of higher-bandwidth requirement, an additional xDSL connection can be installed.

Again, feeding an IRB enables a point-to-multipoint service, creating a central pipe that serves many customers. When the IRB is implemented through the legacy copper wires, the building is broadband-ready for business.

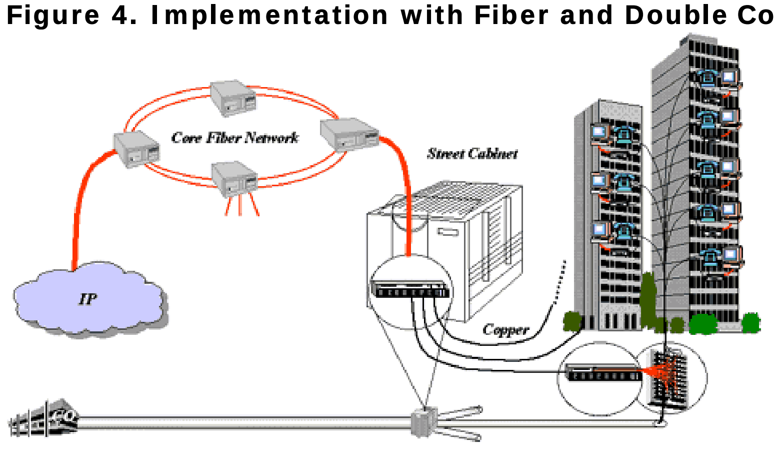
An ISP or a CLEC can adopt this application by leasing the unbundled copper from the local telephone company at the CO. Working with IRBs reduces the overall cost, as only a few copper wires are required for leasing; distribution is done at the IRB. In the classical ADSL solution, leased copper is needed per customer. Moreover, with the IRB, the single pipe with the service is multiplied now by the number of subscribers, which brings it to an economical solution.

Access for FITL and Double Copper Tier

For ILECs, PTTs, and IXCs, fiber-in-the-loop is the most advanced architecture for neighborhood services. Fiber can reach the curb, the street cabinet, or the building basement. In this case, the IRB is connected with an uplink, which confirms the service carried by the fiber (either ATM, packet over synchronous optical network [SONET], future passive optical network [PON], etc.) With this configuration, the provider can have a very-high-speed service, aggregating the IRB's subscribers. Again, the building is broadband-ready for service.

Of course, the simplest case is when the fiber reaches the building's telco room. However, when fiber feeds the street cabinet or the DLC, copper wiring is needed to distribute the service to the IRBs (see *Figure 4*). In this case, high-quality, nonvoice copper wire can be used to extend the accessibility to the building, creating a double copper tier architecture. The first tier goes from the street cabinet to the building's telco room, using only the nonvoice, high-quality, extra copper pairs, thus feeding the IRB. The second tier is inside the IRB where the service is implemented by using DSL techniques.

Figure 4. Implementation with Fiber and Double Copper Tier



4. The MDU/MTU Market Segmentation

The market for multitenant buildings is divided into three major segments:

- The largest segment is residential MDUs and includes consumer multidwelling units from the size of skyscrapers to garden-style complexes. These MDUs are spread throughout the world. The residential market requirements are well-defined for Internet services.

- The second-largest market is for commercial multitenant units (MTUs) and includes business MTUs consisting of skyscrapers down to commercial campuses and strip malls. These MTUs are usually concentrated in downtown areas, business districts, and industrial campuses. In many cases, the fiber infrastructure reaches the building basement or the street cabinet. One interesting segment of this market is the executive office suite—a fast-growing and dynamic area. The MTU market is very versatile from a service perspective.

- The third market is the hospitality segment. This market includes hotels, dormitories, and hospitals. According to an *America's Network* article, it is estimated that nationwide in the United States there are more than 3.5 million hotel properties. Currently, in hotels, Internet service is mainly a demand of business travelers and is quickly becoming a necessity for middle- to high-value hotels.

Other niche segments can be found, including commercial and educational applications in schools, clubs, and marinas.

5. Issues Involved with Converting a Building into Internet-Ready

Creating a functional Internet-ready building is not a trivial task. The following is a list of issues raised when investigating the requirements and functionality needed by the tenants of various buildings:

Infrastructure Issues

- copper wiring category

- number of twisted pairs for each tenant

- distance from the basement to the customer premises

- apartment internal wiring topology

- splitters and filters

Networking Issues

- bandwidth allocation
- symmetrical versus asymmetrical
- caching
- IP addressing
- VPN, routing, tunneling, intrabuilding switching, and virtual local-area networks (VLANs)
- frame versus cell (IP versus ATM)

Operation Issues

- accounting and billing
- distributed operations, administration, and maintenance (OAM)
- user self-configuration
- piracy prevention

Service Issues

- termination—Does the service provider support customer home area network (HAN)?
- regulation issues (ISP, CLEC, ILEC, ILEC.NET, tariffing)
- integrated services (voice, Internet video streaming, data): service consolidation
- dynamic Internet service selection
- portal services
- user analysis

A flexible model for creating IRBs will address the relevant issues related to each segment—residential, commercial, hospitality, or other.

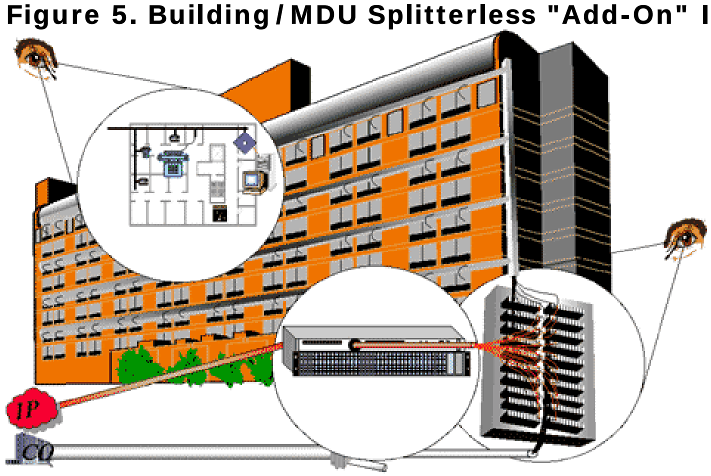
6. Splitterless System Installation

The advanced DSL modulation techniques usually use higher frequencies of bandwidth. Transmitting low-frequency legacy voice at the same time with high-frequency broadband information requires splitting the signals. In the residential environment, the traditional ADSL techniques use a splitter at the root of the internal wiring of the apartment. As the topology of the internal wiring is unknown, where it might be star, buss, or daisy-chained, the only place to install the splitter is in the root of this topology. This splitter eliminates the negative impacts of the internal wiring on the broadband signals, including reflections. However, by keeping the broadband signals far enough in the spectrum from the voice signals, the traditional splitter can be replaced with a micro low-pass filter in each of the telephone jacks in the apartment. This low-pass filter eliminates the high-frequency spikes that happen during the on-hook/off-hook transition of the handset. The penalty of moving the broadband signals far away from the voice is in the low achieved transmission bandwidth.

Installing a splitter in the user apartment requires additional wiring for sending the broadband signals to the customer premises equipment (CPE), which connects the user's computing devices in one of the rooms in the apartment. A great advantage would be to create a splitterless environment, without the need for either splitters or filters. Splitterless installation avoids the need for a truck roll—i.e., sending a technician to the customer—which increases the installation cost by hundreds of dollars.

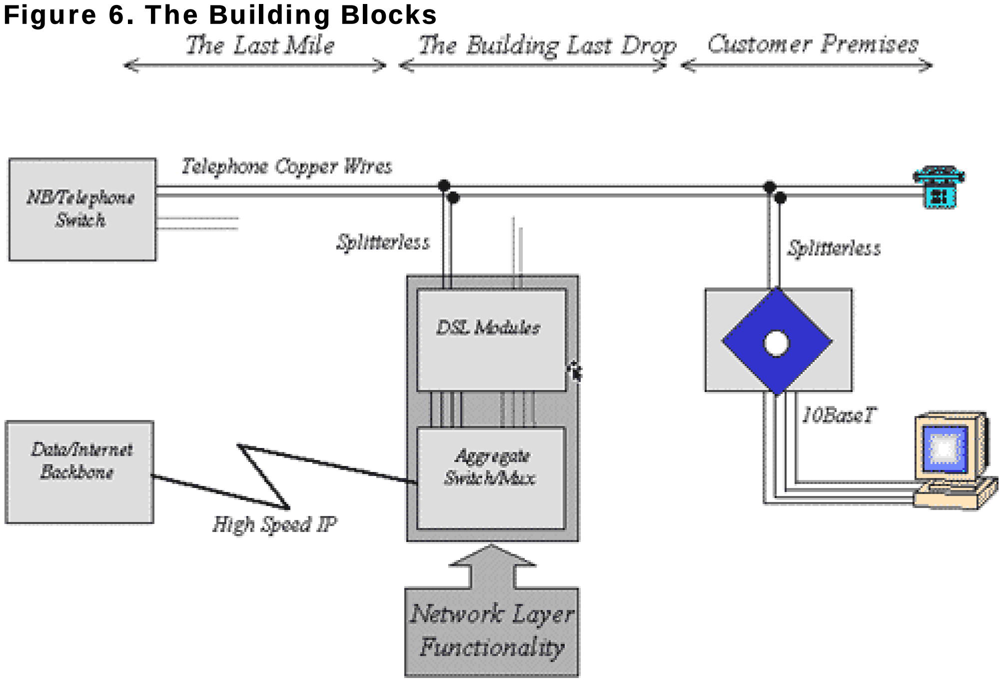
Figure 5 demonstrates a residential MDU system installation, where the link modules at the building's wiring closet are attached, in a splitterless configuration, to the plain old telephone service (POTS) lines:

Figure 5. Building/MDU Splitterless "Add-On" Installation



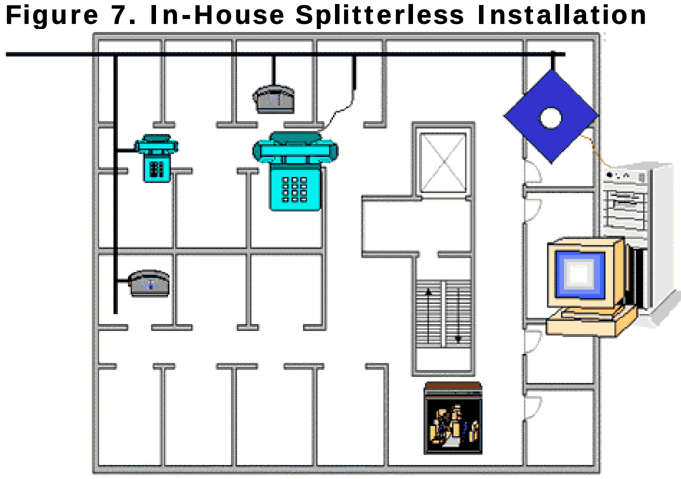
Notice the wiring closet connection bridged onto the existing legacy voice lines without cutting them. The building blocks of the splitterless installation are included in the service switch (which will be explained later on) at the wiring closet and the CPE modem (see *Figure 6*).

Figure 6. The Building Blocks



The following diagram explains the CPE modem in-house installation. Because the CPE offers splitterless connectivity, the in-house wiring topology is transparent to the CPE modem installation and can be installed by the customer—just like a regular telephone.

Figure 7. In-House Splitterless Installation



7. Service Switching—A New Suggested Model for Creating an IRB

The Target

Recently, a new approach for creating IRBs was developed. The concept, making buildings internet ready, presents a new high-speed Internet access model, focused on urban areas consisting of commercial and residential MDUs. The concept addresses an untapped business opportunity for service providers and carriers (ILECs, CLECs, IXCs, ISPs, and PTTs).

In order to implement IRBs, a new concept defined as service switching has been introduced. The service-switching concept includes a low-level hardware implementation and a higher-level software, which, when combined, create a service-switching system. The access service switch implements a secured, switched, symmetrical, and full 10–Mbps Ethernet DSL per tenant, over the existing twisted copper pair, while carrying the legacy voice, in a splitterless fashion. Thus, it emulates a local-area network (LAN) environment over the existing legacy wiring in a building.

Installed in a building and complemented by a wireline or wireless uplink, the service-switching concept converts the building into a revenue opportunity for the service provider. Together with a service-layer software, it offers a flexible business model and control over IP services (ISP selection, bandwidth, portal, etc.) and billing.

The Marketing and Business Implications

Installing a service switch in a building enables the service provider to offer a flexible service model. This model is defined by the provider's marketing requirements and enables advanced services, which maximize profits and decrease costs. All service providers have the freedom to create their own business and marketing surveys with their customers and configure the service switch to address specific customer needs.

In order to save expenses and cut costs on the service provider’s customer-support staff, the customer configures the service switch. This is accomplished as a result of the fact that the service switch has internal hypertext transfer protocol (HTTP) capabilities, which enable self-configuration by the customer. A customer initializes the service with any standard browser. An initial portal initiates the service options, which have been defined by the service provider. This includes such things as ISP selection, bandwidth requirements, and billing. After an authentication procedure, the user is connected according to the selected service.

This model creates a new, flexible business model for service providers—both new and traditional.

User Self-Configuration

User self-configuration for high-speed Internet access presents a new approach and added value for service providers. User self-configuration cuts service fees and tariffs associated with traditional high-speed, Internet access solutions, which require customer-support staff. This decreases the cost of ownership and improves customer service from a provider point of view. The ability to control the customer through a browser-based menu/portal enables the service provider to initiate the service according to its own business interests. This will allow the service provider to increase and maximize profits from the existing infrastructure.

Smooth Migration to the ISP Billing Environment

Moving a service provider from a dial-up model to an always-on model requires support for a smooth billing mechanism migration.

The service-layer software records the user activity and reports it to the billing infrastructure and database through the remote authentication dial-in user service (RADIUS) server that provides the authentication, authorization, accounting (AAA) functionality. This is the existing billing and accounting database, which the ISP maintains for the dial-up world.

As a result, the ISP need not add anything to its existing service-provisioning model.

Once a user usage information record is recorded within the RADIUS database, different billing models can be applied. The usage information record may be recorded within the appropriate provider: CLEC, ISP, or the ILEC, which may help in creating a consolidated bill.

Other Required Functions from the Service-Layer Software

As mentioned, servicing the residential community with always-on connections requires the development of a new and flexible service model that will address the service provider's business and regulation requirements as well as operational and customer needs. To implement these requirements, a functional service layer software should be developed. This service-layer software enables such functions as the following:

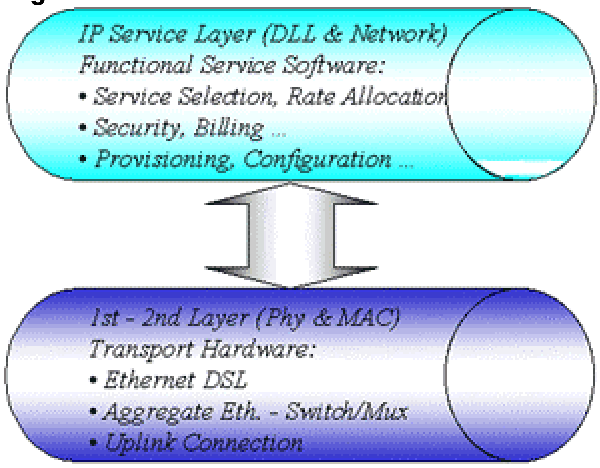
- **dynamic service selection**—This is the user ability to choose between different ISPs during a session initialization. This feature enables a CLEC to wholesale the Internet service to the tenants, creating competition over the building's access.
- **automatic user self-configuration**—This is the user ability to change service profile, which may include billing schemes, ISP, uplink/downlink rate, etc. This is done without the intervention of the service provider's support staff.
- **flexible bandwidth allocation**—This is the user ability to choose the profile of his/her connection rate with parameters such as fixed rate, minimum rate, and maximum burst rate. A round-robin mechanism between tenants might be applicable for such a requirement.
- **security accounting and billing mechanism**—This is accomplished through the existing AAA–RADIUS server, which exists within the ISP infrastructure.
- **standard addressing and configuration model**—This uses the standard IP addressing and configuration protocols such as dynamic host configuration protocol (DHCP), NAT, etc.
- **portal applications**—This initializes sessions through preferred portals.
- **standard operation model**—This uses the standard OAM&Ps such as signaling network management protocol (SNMP), HTTP, Telnet, and RADIUS.
- **user statistics**—This involves gathering information regarding user activity (such as Web surfing information) for traffic optimization as well as business-oriented applications.
- **addressing regulation issues**—Such issues include the building point of demarcation, CLEC/ISP relationship, tariffing, etc.
- **other services**—These may include services such as voice over IP (VoIP), virtual private networking (VPN), caching applications, piracy usage prevention, intelligent fault management, and much more.

8. The Architecture

The service-switching approach is similar to an IP switching architecture. Instead of switching the IP packets according to the IP routing tables, the switching is done according to the IP service layer. This presents a whole new concept for servicing Internet access.

Figure 8 illustrates this architecture.

Figure 8. The Access Service Switch Concept



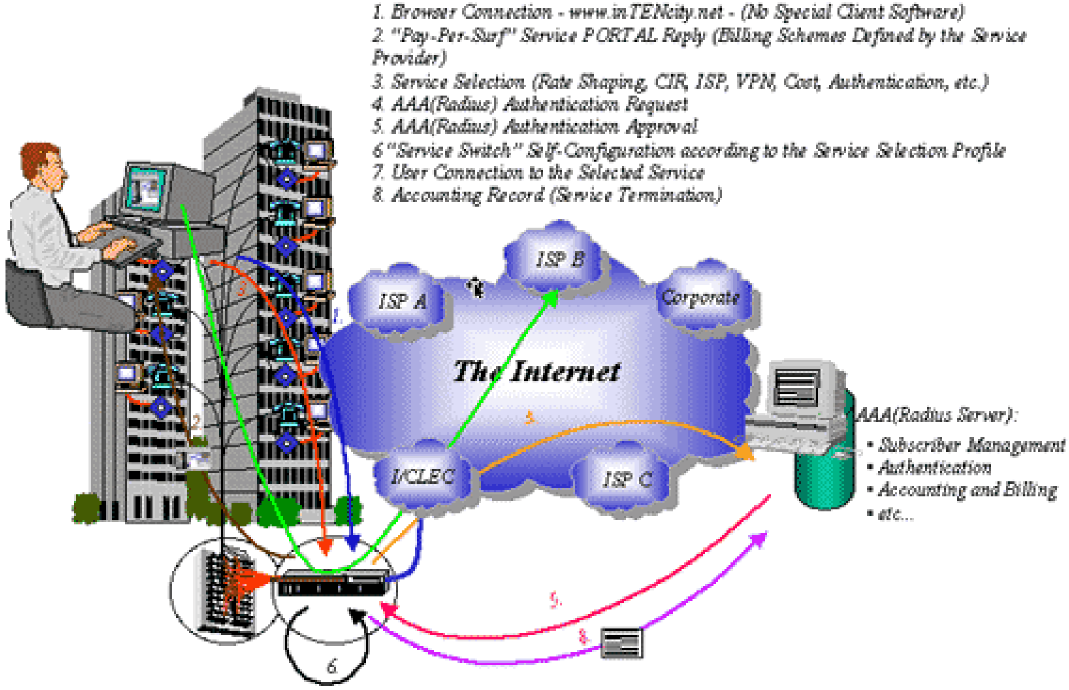
As *Figure 8* reveals, to enable a flexible service-switching functionality, the service-switch system is designed in two layers:

- **the hardware layer**—that complies with the first and second layer of the open systems interconnection (OSI) model—i.e., the DSL and Ethernet physical layer and the data link layer (DLL)

- **the functional software layers**—which implement the service-layer software concept and enable switching to the required functionality by controlling the hardware layer

Figure 9 demonstrates the mechanism that enables such service.

Figure 9. The Service Switch in Action



Once customers launch their browsers for a new service, the traffic is intercepted by the service switch that now controls the user traffic and activity (see "1" in *Figure 9*). The internal service switch that has HTTP service capabilities replies with a menu/portal that reflects the service profile (ISP selection, bandwidth, billing, etc.) defined by the service provider (see "2"). The user selects the required service by clicking the related requests in the menu/portal and applying a password (see "3"). After an authentication cycle ("4" and "5"), the service switch allocates the desired service (see "6") and creates the connection (see "7"). From then on, the service switch switches the IP packets (green line in *Figure 9*) according to the service profile. Accounting records are periodically sent to the RADIUS server for billing purposes (see "8").

As it can be seen, the service switch reflects a new dynamic, self-configured, and flexible model for creating a real residential IRB.

9. Summary

Broadband access to the customer's premises is a hot market and is getting much attention from the major service providers and equipment vendors. Two major segments are being served: the corporate market and the consumer dwelling. A number of approaches are pitted against one another, with the leading ones being various types of DSL versus cable modems. One major segment that is not properly served is the multitenant market, as it is comprised of either residential or office complexes. Until today, there has been no technical solution available for enabling a profitable service model. The last drop of the last mile is a major obstacle for current approaches, as delivering broadband access to the many units in the building or complex usually requires new wiring—a very expensive proposition.

Building a broadband access network that relies on IRBs and is complemented by wireline and wireless last-mile technologies creates a new service model and exciting business opportunities for traditional service providers as well as new competitor carriers.

Using a new approach, which enables the network architects to push the functionality to the edge of the network and the ability to allocate the resources in a flexible, dynamic, and user self-configured fashion, will enable the network architects to solve the bottleneck limits of the last mile and create an intelligent network (IN) functionality. This will allow broadband services to be provided without a large increase in backbone costs, which is vital in order to increase the profitability of services.

Self-Test

1. Access to the IRB may be by _________________ connection.

    a. wireless

    b. wireline

    c. either wireless or wireline

2. Distribution takes place in the copper wire in the case of the telephone system and in the coax wiring in the case of cable.

    a. true

    b. false

3. The IRB resides at the last drop, terminating at the customer's premises.

    a. true

    b. false

4. Using existing legacy copper wire with DSL transport techniques for implementing the IRB provides CLECs with a wireless copper architecture that represents a win-win solution.

    a. true

    b. false

5. In the classical ADSL model, leased copper is needed per customer.

    a. true

    b. false

6. ______________ installation avoids the need for a truck roll.

    a. splitter

    b. splitterless

7. This is the user ability to choose between different ISPs during a session initialization.

    a. dynamic service selection

    b. automatic user self-configuration

    c. flexible bandwidth allocation

    d. standard addressing and configuration model

8. This is the user ability to choose the profile of his/her connection rate with parameters such as fixed rate, minimum rate, and maximum burst rate.

    a. dynamic service selection

    b. automatic user self-configuration

    c. flexible bandwidth allocation

    d. standard addressing and configuration model

9. The service-switching approach is similar to an IP switching architecture where the service switches the Layer-2 frames.

    a. true

    b. false

10. To enable a flexible service-switching functionality, the service model is designed in ______ layer(s).

    a. one

    b. two

    c. three

    d. both layer two and three

Correct Answers

1. Access to the IRB may be by _________________ connection.

    a. wireless

    b. wireline

    c. either wireless or wireline

    See Overview.

2. Distribution takes place in the copper wire in the case of the telephone system and in the coax wiring in the case of cable.

    a. true

    b. false

    See Topic 2.

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    b. false

    See Topic 3.

6. _____________ installation avoids the need for a truck roll.

    a. splitter

    b. splitterless

    See Topic 6.

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    See Topic 7.

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    c. flexible bandwidth allocation

    d. standard addressing and configuration model

    See Topic 8.

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    See Topic 8.

Glossary

AAA
authentication, authorization, accounting

ADSL
asymmetric DSL

ATM
asynchronous transfer mode

CAT5
category 5

CATV
cable television

CLEC
competitive local exchange carrier

CO
central office

CPE
customer premises equipment

DBS
direct broadcast satellite

DHCP
dynamic host configuration protocol

DLC
digital loop carrier

DLL
data link layer

DSL
digital subscriber line

DSLAM
digital subscriber line access multiplexer

FCC
Federal Communications Commission

FITL
fiber-in-the-loop

FSAN
full-service access network

FTTH
fiber-to-the-home

HAN
home area network

HFC
hybrid fiber/coax

HTTP
hypertext transfer protocol

IDF
intermediate distribution frame

IEEE
Institute of Electrical and Electronic Engineers

ILEC
incumbent local exchange carrier

IN
intelligent network

IP
Internet protocol

IRB
Internet-ready building

ISP
Internet service provider

IXC
interexchange carrier

LAN
local-area network

LMDS
local multipoint distribution system

MCNS
Multimedia Cable Network System Partners Ltd.

MDU
multidwelling unit

MSO
multiple system operator

MTU
multitenant unit

OAM
operations, administration, and maintenance

ONU
optical network unit

OSI
open systems interconnection

PON
passive optical network

POTS
plain old telephone service

PTT
post telephone and telegraph administration

RADIUS
remote authentication dial-in user service

SNMP
signaling network management protocol

SONET
synchronous optical network

VDSL
very-high–data rate digital subscriber line

VLAN
virtual local-area network

VoIP
voice over IP

VPN
virtual private network

VSAT
very-small–aperture terminal