SMALL SYSTEM ARCHITECTURE FOR DIGITAL CABLE

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Abstract

This paper focuses on the basic architectural elements required for digital cable service with an expandable architecture that makes it economically advantageous to deploy in a cable headend with as few as 1000 basic subscribers. This assumes 20% digital penetration or approximately 200 digital subscribers.

INTRODUCTION

A truly successful architecture must, of course, be economically sound, but further must allow for anticipated growth – both in number of subscribers and in variety of service offerings. The architecture described here accomplishes both. Set-top terminal cost becomes a major consideration to support a low-cost headend architecture with anticipation for growth; the architecture outlined in this paper supports a refurbished to like-new DCT1000 set-top terminal in the $100 range. Of course, any of Motorola's digital set-tops can be deployed in this system. These set-tops allow the operators to offer their customers many choices in their digital experience such as 256QAM reception, expandable application memory, integrated Hi Definition decoding, Dolby 5.1 Surround Sound support, integrated Tivo and REPLAY like digital recording support, and a variety of I/O options such as IEEE1394, SPDIF, TOSSlink optical, and USB are some of the exciting features that can be deployed on any system. System services can be grown to support VOD, internet access and interactive services (games, weather, etc.).

WHY DIGITAL?

According to Kagan Media (June 5, 2001), digital cable subscribers will increase more than 7 fold from about 10 million at the end of 2000 to over 70 million in 2010, DBS subscribers will almost double from under 15 million at the end of 2000 to about 27 million while analog-only subscribers will decline from almost 60 million to a mere 3 million subs. With these projections, it is clear that digital will play a part in almost every subscriber's suite of services delivered to the home. The lion's share of video service revenue will go to whoever is the provider of digital - whether it is the cable system or a DBS service. With growing availability of local programming from DBS services in many areas, subscriber defection could increase substantially.

Revenue is a major reason for deploying digital services. Digital generates revenue because it gives subscribers three things they are willing to pay for – higher quality, better choice and greater convenience. Digital television provides far superior picture quality compared to analog. With digital cable, up to 10 or 12 video programs occupy the same 6 MHz channel bandwidth that currently provides one analog service. The virtual expansion of an existing plant provides a more compelling package to consumers. Digital music, integrated guide, digital off air, and enhanced PPV offerings are just several of the most basic services available. It has been shown that digital systems enjoy increased Pay-Per-View® (PPV) revenue and premium-tier penetration.

With a low cost digital deployment, a cable system can protect and grow subscriber base and reduce subscriber defection. Small cable systems can offer services every bit as compelling as the competition and eliminate the reasons for subscriber defection to DBS. The architecture takes full advantage of ***proven components*** in a ***proven system*** that is servicing over 6 million set-top terminals today. The headend architecture is ***fully expandable*** taking advantage of every bit of capital equipment investment. Growth of the service offerings to exceed the competition is readily available.

Lastly, by protecting subscriber base, small cable systems can protect the value / net worth of the system. Cable system values have been demonstrated by recent consolidations. At $3000 to $4500 per subscriber, a small system of 1000 basic subscribers could be valued between $3 and $5 million dollars. The bottom line is that by ignoring digital cable deployments in smaller markets, there is a substantial risk of erosion of the system's market value.

BASIC ARCHITECTURE

Basic Elements of a Digital Cable Television System

The basic elementary services in a digital cable television system include analog video services, digital video services, pay-per-view (call ahead and impulse) and an interactive electronic program guide (IPG). Enhanced digital services could also include Video on Demand (VOD), Internet Based Services, Interactive Games, etc. Services, including data services, can also be encoded locally or delivered via satellite. Since this paper is focused on the ability deploy to smaller cable systems, it will primarily focus on digital cable services distributed via satellite, as they are the most economical available today. However, the architecture detailed below is readily expandable to include virtually any service including web access, VOD, home shopping, and interactive games.

As illustrated in figure 1, functions needed to control and distribute the basic services include access control, configuration, collection, service reception, decryption, encryption and the associated RF elements required to transmit the selected services on a cable plant. These functions are required to securely receive a service (or group of services) via satellite and distribute and control reception on a cable plant to selected subscribers. The return paths illustrated are strictly for the collection of impulse pay per view (IPPV) events.

Signal Flow – Video Services are digitally encoded and uplinked for satellite distribution. Each encoder output constitutes a transport stream and will consume 6 MHz of bandwidth on the cable plant. The encoder converts an analog signal to an MPEG-2 format; it also encrypts the digital signal for secure delivery to designated cable systems. Data for an IPG can also be carried on one of the satellite transport streams; the data can be extracted after the downconversion of the RF signal in the headend.

On the downlink, the video service is downconverted and decrypted. The services on the transport are then re-encrypted to control access on a subscriber-by-subscriber basis. They are then QAM modulated and upconverted for distribution on the cable plant. The program service providers (who run the encoders) control the decryption function in the headend while the cable system conditional access system controls the encryption (can be one in the same as the program service provider).

Access to specific services is controlled by the access control function. Subscriber equipment configuration and upgrade services are also required to support the system. Configuration sets the set-top filters and controls to receive specific signals, functionality, and code objects. Upgrade services allow the quick, inexpensive deployment of code for new services as well as enhancements to existing functionality. Code Upgrades can be targeted to a single set-top terminal, a group of terminals for test, or to an entire population.

All the specific information required to provision both services and set-top terminals are contained in the access control and data base functions. The business office and billing system connect with the data base interface to allow the cable operator to assign specific configurations and authorizations to a particular subscriber and bill for the services received. The access control function provides the authorizations (keys) to decrypt the subset of services a particular subscriber is entitled to receive.

A given digital PPV service can be locally configured for impulse with later collection via RF return, impulse with later collection via telco-return or call-ahead-PPV. The functions at the bottom of the figure illustrate two-way communication (call ahead not illustrated as it is a pre-authorized event similar to a subscription service). Telco takes advantage of an existing infrastructure and is therefore more economical to deploy. Either method provides reliable timely collection of IPPV revenue. The Return Demodulator and Modem functions provide the physical transport; the Data Collection function is common although there are slight differences in the collection process due entirely to the difference in the transport. For enhanced interactive services such as VOD, RF return is required. Enhanced services will be briefly discussed as part of the expandable architecture at the end of the paper. The small plant architecture either uses telco-return or is configured for CA-PPV.

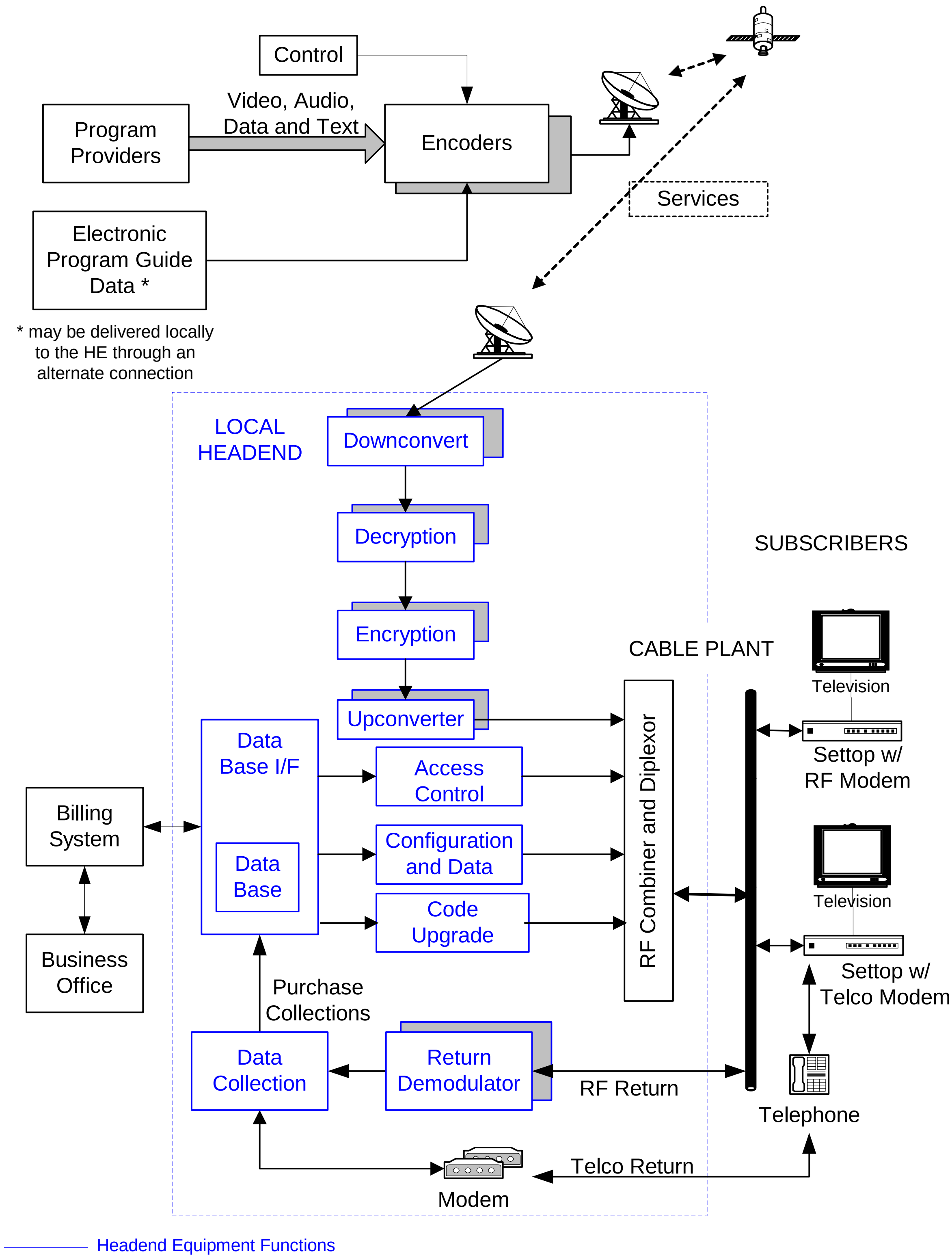

Figure 1 Functional Block Diagram for Basic Digital Services

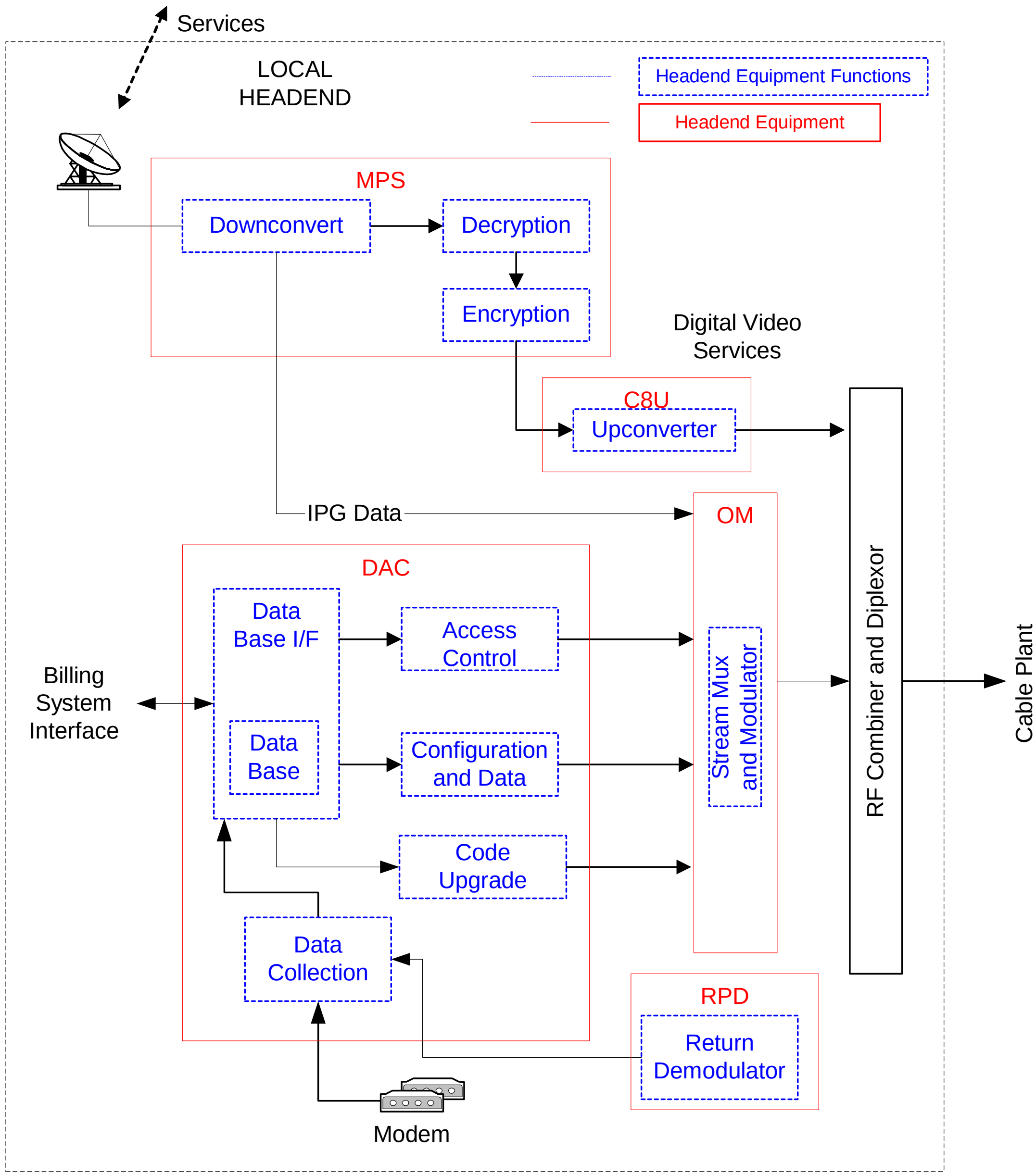

Figure 2 Basic Equipment Functions in a Local Headend

<u>Functions Mapping to Equipment</u>

Figure 2 illustrates how the functions fit into the equipment required for the most basic, locally controlled headend. There would normally be multiple Modular Processing Systems (MPS) and C8U's to provide more programming. Return Path Demodulators (RPD) provide for RF return (RPD's are completely eliminated with telco-return). Depending on the number of headends being controlled from the Digital Addressable Controller (DAC), the size of the plant and total number of set-tops, there might also be multiple Out of band Modulators (OM). All functions, definition of services to be delivered, equipment configuration, code upgrade, and collection responsibility are coordinated and controlled by the local operator through the DAC. Only signal flows are shown. The Operations, Administration, Maintenance & Provisioning (OAM&P) 10baseT network is not shown above.

Figure 3 illustrates the basic equipment in an end-to-end local digital cable headend. Again, typical installations include multiple MPS's, C8U's, and RPD's. Depending on the cable plant topology and number of headends being serviced by the DAC, multiple OM's may also be controlled off of the single controller. In the figure below, the headend OAM&P network connections are shown (10baseT Ethernet).

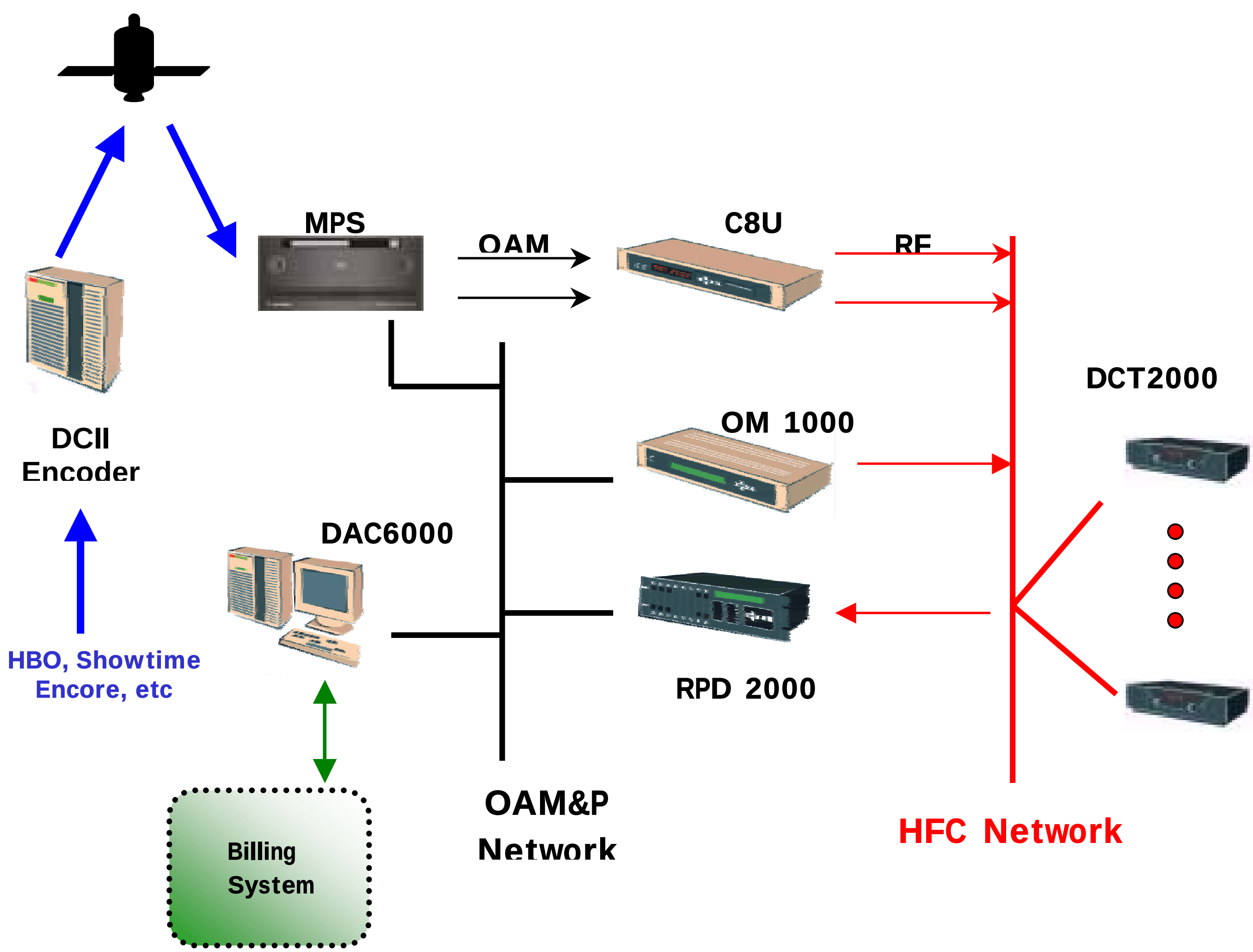

Figure 3 Local Control End to End Digital Cable Equipment

Taking the Cost Out

It is possible to centralize several of these functions in a national center to gain economies of scale. It also provides a central controlling point so that extensive in depth operational knowledge is not required of an operator to deploy digital cable in an existing analog system. Centralizing the most complex functions (the access control, set-top and headend equipment configuration and upgrade functions) provides the most benefit to the local operator.

By removing these functions, not only is a significant up front capital cost burden removed, but also significant ongoing operational costs are shifted to a central organization. Those central operational costs are shared among more than one thousand headends and millions of set-top terminals. The actual cost burden isn't based on an individual headend, but rather upon a per-set-top terminal cost so that an operator is only burdened with the operational cost associated with a given revenue-producing unit (in this case, the set-top terminal). Headend cost would otherwise make this architecture economically unacceptable for a smaller system.

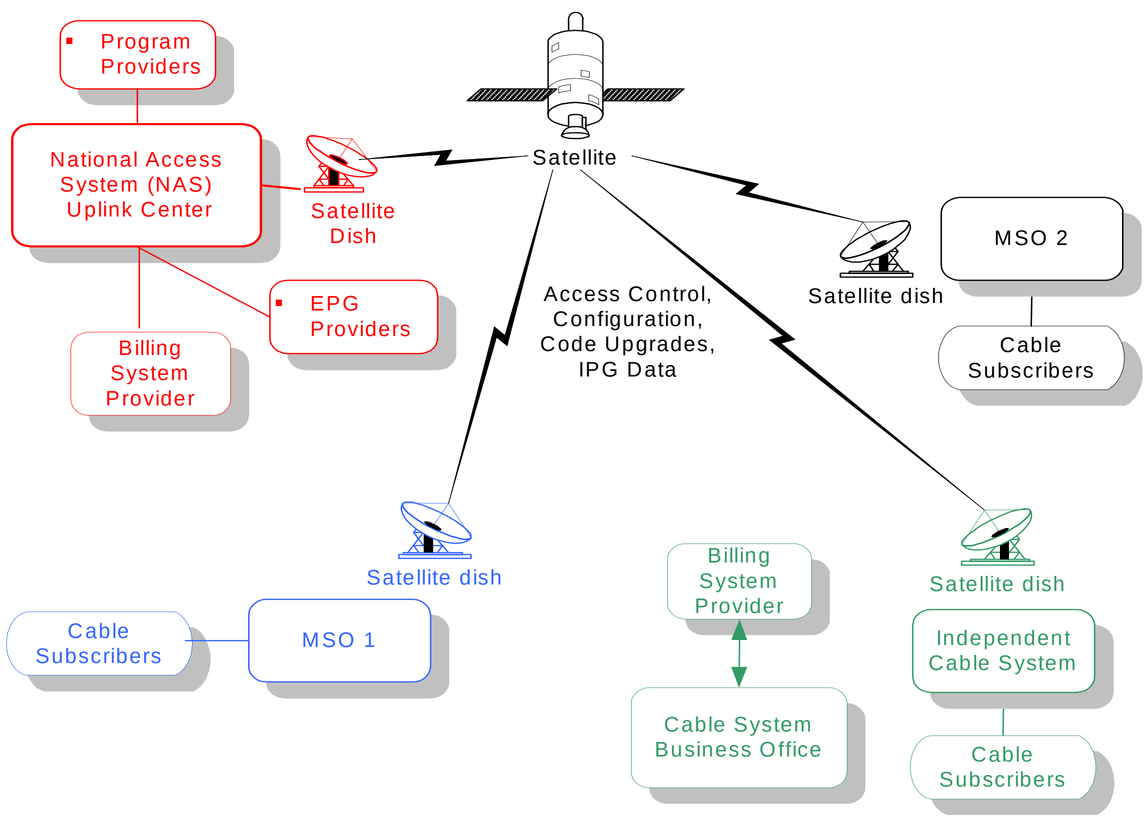

Figure 4 National Control Operational Costs Shared Across Multiple Systems (per Set-top Charge)

The access control function provides for configuration of the MPS encryption function as well as the authorizations for the cable subscribers (set-top terminals). The configuration items outside of the set-top terminal access control functions is also controlled and distributed from the national center. Lastly, the code upgrades are largely driven from the national center although it is also possible to drive the upgrade from a local source as well for early deployments or other MSO/Cable System desired activities.

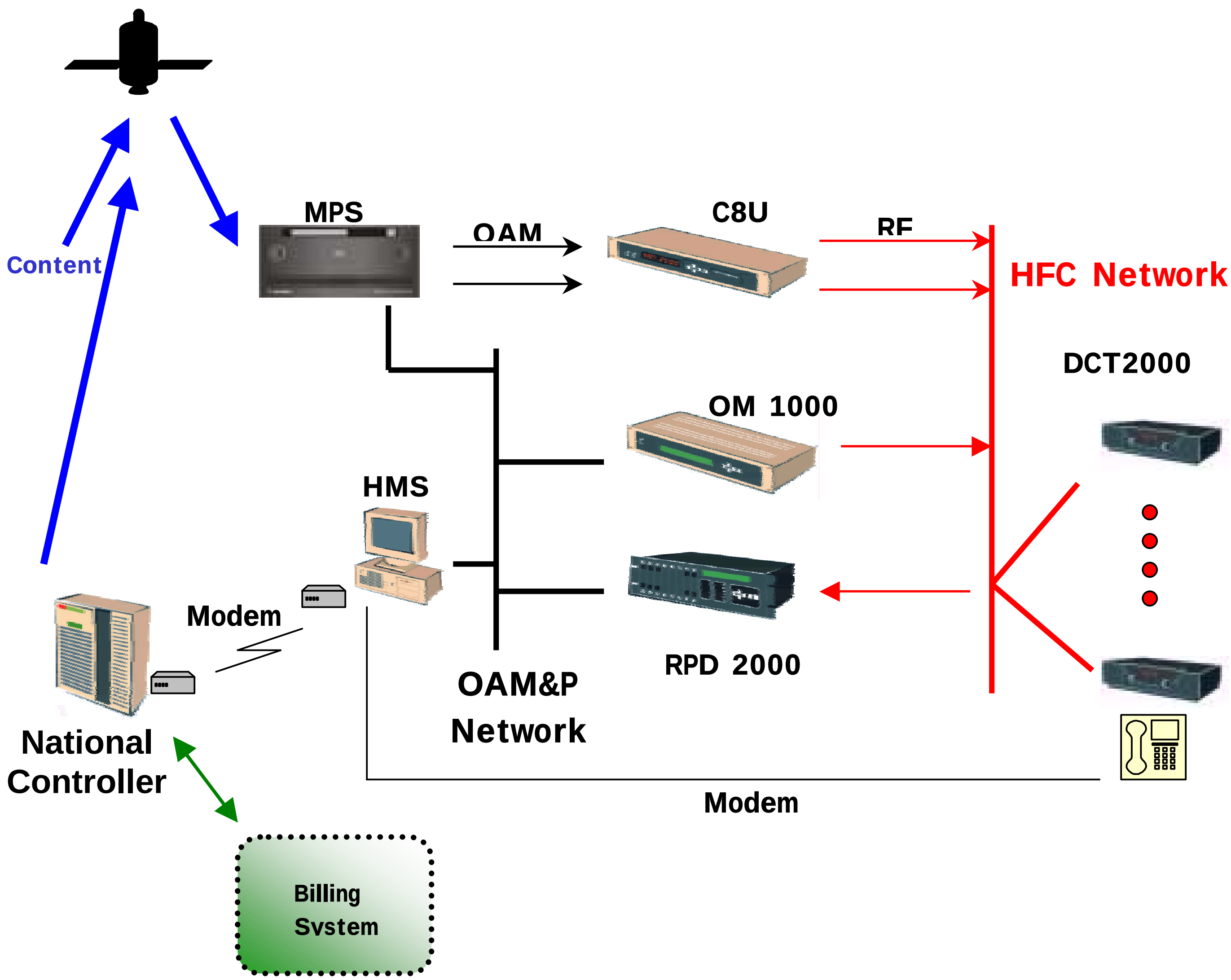

Figure 5 Standard Headend Architecture with National Control

The standard architecture for a National Control Headend includes a Headend Management System (HMS) device. The device has three functions…bootp server, headend device configuration control, and poll collection for IPPV.

Through a dial-up connection to the HMS, a national control specialist is able to check, verify or correct configuration settings with equipment on the OAM&P network including configuration of new equipment. Expanding service offerings becomes simple and low cost.

Headend equipment can be added or firmware updated through the bootp functionality in the HMS. Specific equipment configuration follows.

The billing system interface is through the national controller – not the local headend. In the standard configuration, purchase collection messages originate in the HMS; the return can be RF or telco-return. If telco is employed, the call-in number can be a local phone number or a toll-free phone number. Collections are stored locally and forwarded to the national controller periodically. From the national controller, purchases are authenticated and uploaded to the billing system. Purchases are not cleared from the terminal until the purchase is authenticated which prevents loss in the data collection path (DCT → HMS → National Controller).

SMALL SYSTEM ARCHITECTURE

Taking More Cost Out

With an HMS in the headend, the headend cost can be prohibitively expensive for smaller cable systems. Small system architecture shown in figure 7 further removes cost from the headend by centralizing the HMS functions. The equipment represents the minimum headend functionality required to provide digital cable TV. The only way to minimize the headend cost further would be to put the functionality in the set-top. Such a move would price the low-end set-top too high and not allow for growth of services within the given architecture.

A simple bridge is used to allow the same configuration and bootp functions to be hosted by a centrally located HMS. The specific headend configuration is loaded on a central configuration HMS prior to an attempt to connect to the local headend network. The central architecture includes a (second) dedicated central purchase collection HMS. Purchase collections are slightly different in that the actual poll messages originate from the national controller (rather than the HMS) and the terminals are directed to call a toll free number connected to the central purchase collection HMS. Purchases are handled the same way as a standard configuration (stored in the HMS and forwarded to the national controller; authenticated at the national controller, uploaded to the billing system and cleared from the terminal,).

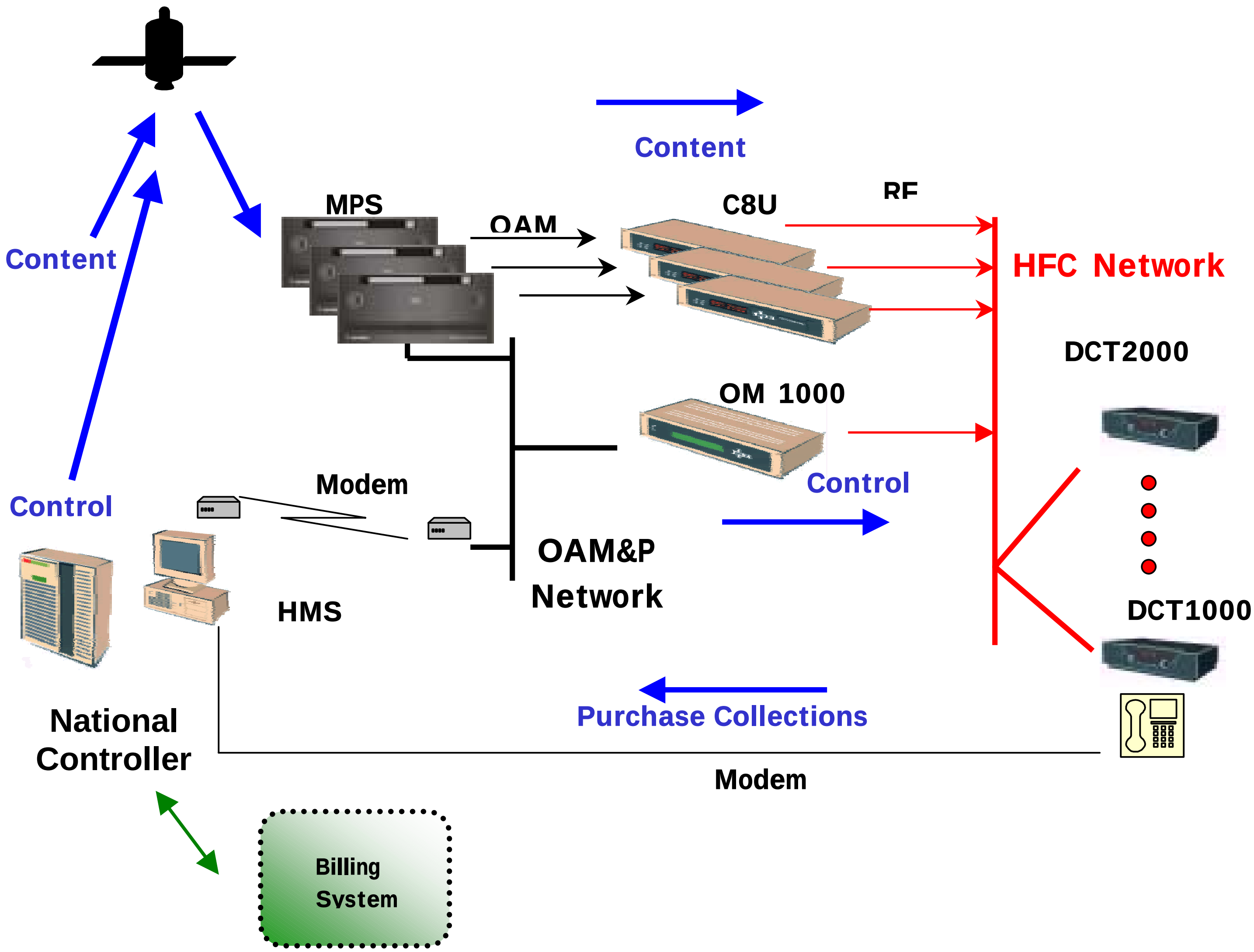

Figure 7 Small System Architecture

Configuration Support

With the small system architecture, the operator has a very flexible system for delivering digital programming. The system can be upgraded to support many different configurations that allow for the most effective use of system bandwidth. Any system can be upgraded to support service grooming, digital ad insertion, digital off-air reception, digital encoding (locally) of analog services, and 256QAM. These capabilities allow the operator to deliver more types of services in a more Bandwidth efficient manner.

Broadcast iTV Support

With the small system architecture, deployed systems need not upgrade to two-way in order to enjoy compelling interactive applications. Broadcast applications are being deployed for the DCT set-tops that will allow one-way systems to launch applications such as gaming, stock tickers, and local weather updates on demand. These applications can be delivered via local servers but will also be delivered via the National Control stream. These applications are enabled by Motorola's Horizons developer program and currently testing is underway with applications from Liberate and OpenTV. These broadcast applications offer the operator a formidable weapon in combating Dish in one-way systems.

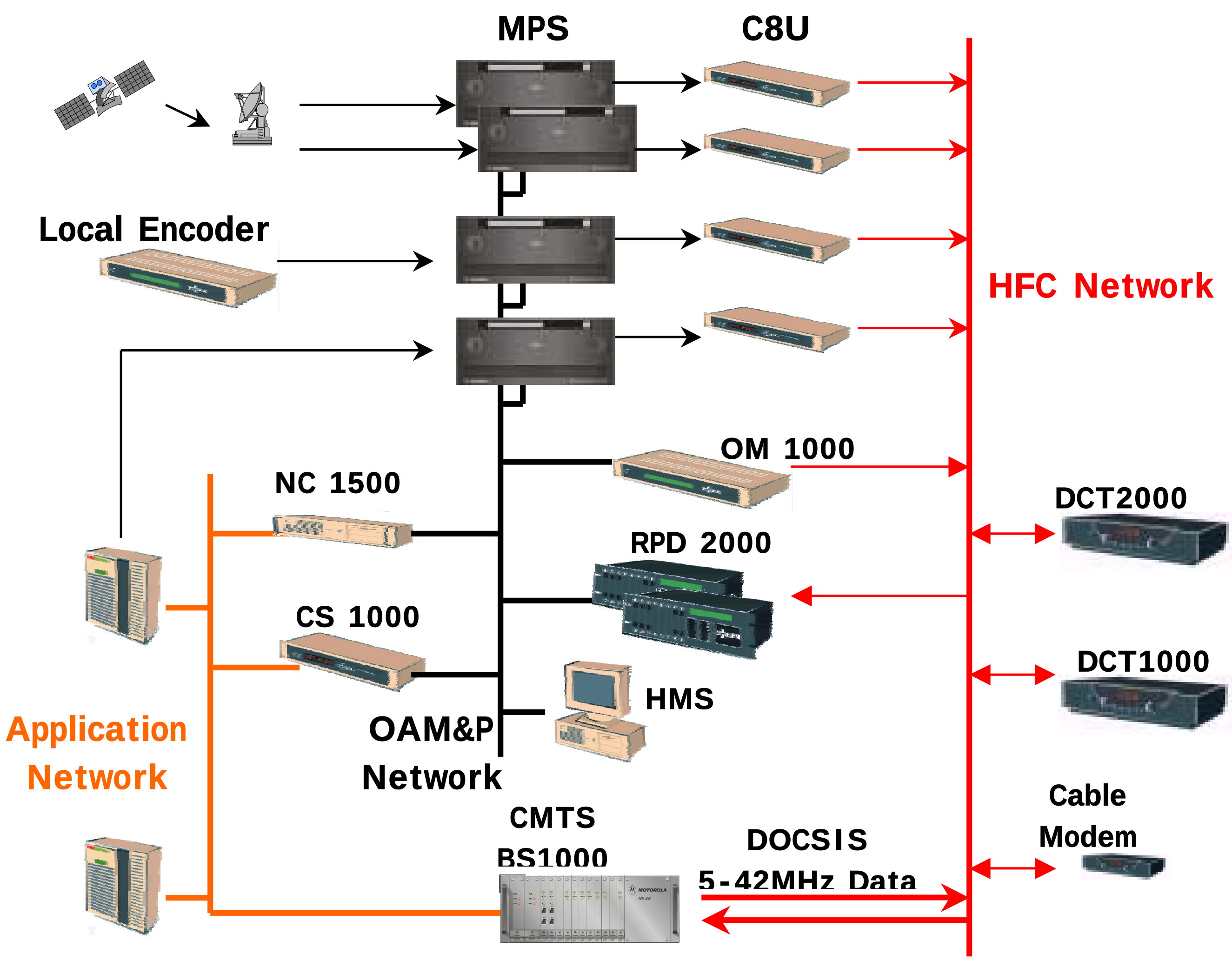

Figure 8 Headend Expanded for Multiple Services

Upgrading Services – Accommodating Service Growth

VOD, Internet Access, and High Speed Data Services (HSD) require an expanded capability and additional equipment. The final figure above illustrates the potential to grow the small system architecture to include much more comprehensive service offerings. The expansion details are beyond the scope of this article, but it is clear that none of the equipment from the small system architecture is retired as the headend expands.

CONCLUSION

A digital headend can have a small enough footprint to be self-contained in a single rack or can be integrated into existing racks. There are no compatibility issues since the digital headend is completely independent of the analog headend and also no dependency on the vendor for the analog set-tops. Most billing systems in North America are already supported.

The approach for the small system architecture is to take the cost out of the headend and provide affordable options for the set-top. Functions such as conditional access, maintenance and configuration, polling and collections are removed to a central function. Along with the functions, significant capital equipment costs are removed and the incremental operational costs are spread over a large number of set-tops. The National Control Architecture provides affordable revenue generation, competition to DBS service offerings, and service expansion options through deployment of digital cable to systems with as few as 1000 basic subscribers. As digital penetration increases, the system size where this architecture makes sense will shrink. Accomplished with a simple, reliable and well-proven architecture.

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