EFFICIENT SERVER DISTRIBUTION IN ALL DEMAND SYSTEMS

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Abstract

AllDemand systems are systems that only carry services on the plant when some client demands (tunes) them. VOD (sub)systems are the closest well-known analogy to the AllDemand system. Although AllDemand systems are similar to VOD systems, there are differences between the two. These differences require an AllDemand system designer to consider several potential architecture models in order to assure efficient media server distribution.

When considering server distribution in AllDemand service environments, one must take into account the types of AllDemand services that will be offered as well as the bandwidth available at different points in the network. This paper provides an overview to help in the selection of a trade-off of AllDemand system facets. A summary of AllDemand service types, and architectures is provided.

AllDemand SERVICE TYPES

In addition to the standard VOD, SVOD type services that exist in current systems, new service types are possible in AllDemand systems.

Broadcast AllDemand

Broadcast AllDemand services save plant bandwidth by only carrying a service on the plant if some set-top device has actually tuned the service. Once the service is tuned, it is placed on the plant. Every client then accesses (tunes) the same copy of the service. There is no motion control or time shifting of these services.

AllCached

AllCached services break the service schedule paradigm by allowing the subscriber to watch programs on an as-desired basis over some time period. All services delivered as AllCached are cached (surprise!). Tuning a service causes it to be played from the caching device to the viewer.

Network PVR

Network PVR can be approached two ways. One can think of providing a virtual disk in the network for use by the client. One can also think of it as adding motion control, and longer-term storage to the AllDemand service type.

Points of Note:

1. Broadcast AllDemand saves plant bandwidth. Other service types require more plant bandwidth;
2. The first 'tuner' of a Broadcast AllDemand service experiences two-way communications latency. Other service types carry two-way communications latency with every tune;
3. Broadcast AllDemand services are shared between subscribers. Other AllDemand services are served uniquely to each subscriber;
4. Local Insertion into cached material (e.g., locally-sourced advertising) must be accounted for in each of the service types, although it is not directly analyzed here.

ALLDEMAND ARCHITECTURE TYPES

Centralized Architecture

Figure 1 provides schemas for centralized architectures. The media servers are co-located in the head-end, and their content is distributed from the head-end to remote hubs. The re-multiplexing, encryption, QAM modulation and up-conversion equipment can be co-located with the media servers or located within a remote head-end. Centrally located equipment that requires skilled technicians to operate and maintain is a major benefit of a centralized architecture. The downside of the centralized architecture is the need for high bandwidth, high reliability, and low delay variation (i.e. jitter) connections to remote hubs. Usually, these kinds of networks are expensive; however, many of the larger MSOs have already deployed these high capacity networks. Customers with SONET rings with data capacities to OC-48 or OC-192 are not uncommon. Dense Wave Division Multiplexing (DWDM) over dark fiber is also gaining favor. This is because it is comparatively less expensive to deploy than SONET or ATM networks.

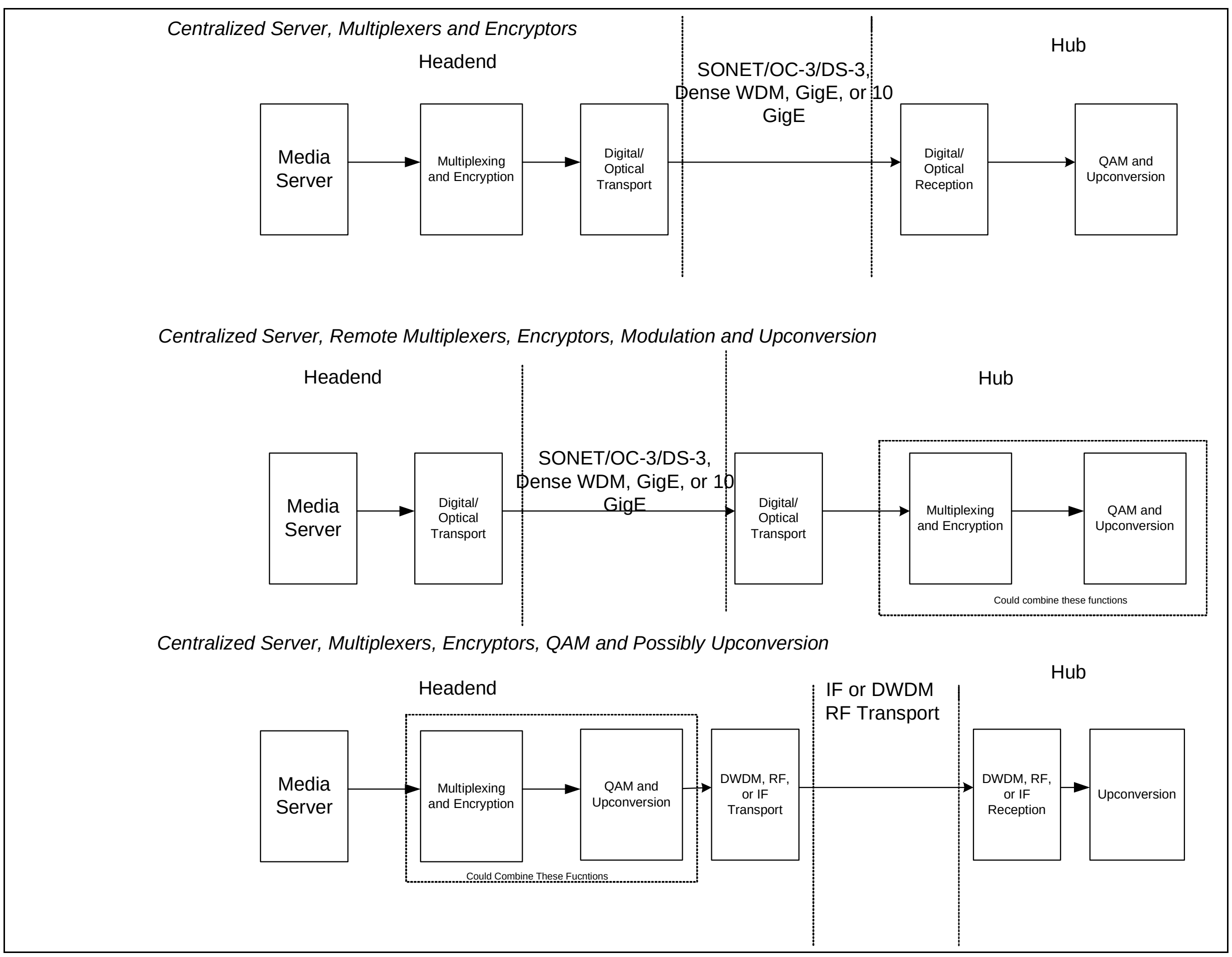

Figure 1 - Centralized Architecture Schemas

Physical Transport Type Comparison

Table 1 and Table 2 compare the number of physical transport channels required when distributing content using GigE, 10 GigE, ASI, and DS3. Table 1 is based upon a digital penetration rate of 60% with an on-demand usage rate of up to 80%. Table 2 is based upon a digital penetration rate of 30% with an on-demand usage rate of 30%. In each case, it was assumed that each user would require 3.75 Mbps of capacity for their on-demand service. Table 3 provides nominal assumptions about media server characteristics. With actual media server values, the media server resource requirements for a give system can be sized to the degree that it is the number of simultaneous streams that drive media server needs, rather than aggregate storage requirements.

Homes Connected	Digital Connects	Simultaneous Users	Number of (Gig Es)	Number of 10 GigEs	Capacity (ASIs) [2]	Capacity DS3s [1]	OC-192s Required	SEMs w/ GigE	SEMs w/ ASI	SEMs w/DS3
5000	3000	2400	15	2	58	232	2	15	15	58
10000	6000	4800	29	3	116	464	3	29	29	116
15000	9000	7200	44	5	174	696	4	44	44	174
20000	12000	9600	58	6	232	928	5	58	58	232
25000	15000	12000	73	8	290	1160	7	73	73	290
30000	18000	14400	87	9	348	1392	8	87	87	348
40000	24000	19200	116	12	464	1856	10	116	116	464
50000	30000	24000	145	15	580	2320	13	145	145	580
60000	36000	28800	174	18	696	2784	15	174	174	696
70000	42000	33600	203	21	812	3248	17	203	203	812
100000	60000	48000	290	29	1160	4640	25	290	290	1160
250000	150000	120000	725	73	2900	11598	61	725	725	2900
500000	300000	240000	1450	145	5799	23196	121	1450	1450	5799

Table 1 - Comparison of Transport Types (60% Digital Penetration, 80% Usage)

Homes Connected	Digital Connects	Simultaneous Users	Number of (Gig Es)	Number of 10 GigEs	Capacity (ASIs) [2]	Capacity DS3s [1]	OC-192s Required	SEMs w/ GigE	SEMs w/ ASI	SEMs w/DS3
5000	1500	450	3	1	11	44	1	3	3	11
10000	3000	900	6	1	22	87	1	6	6	22
15000	4500	1350	9	1	33	131	1	9	9	33
20000	6000	1800	11	2	44	174	1	11	11	44
25000	7500	2250	14	2	55	218	2	14	14	55
30000	9000	2700	17	2	66	261	2	17	17	66
40000	12000	3600	22	3	87	348	2	22	22	87
50000	15000	4500	28	3	109	435	3	28	28	109
60000	18000	5400	33	4	131	522	3	33	33	131
70000	21000	6300	39	4	153	609	4	39	39	153
100000	30000	9000	55	6	218	870	5	55	55	218
250000	75000	22500	136	14	544	2175	12	136	136	544
500000	150000	45000	272	28	1088	4350	23	272	272	1088

Table 2 Comparison of Transport Types (30% Digital Penetration, 30% Usage)

The Gigabit Ethernet solution requires the fewest number of physical interfaces. ASI requires four times as many interfaces when compared to GigE, and DS3 requires a 14 to 16-fold increase in the number of interfaces as compared to GigE. GigE is also considerably less expensive than either DS3 or ASI.

Parameter	Value	Notes
Interfaces	Up to 5 Gigabit Ethernets Up to 8 ASIs	
Transport Streams	Up to 16 Transport Streams/Gigabit Ethernet Output Up to 4 Transport Streams per ASI	Each TS is a 38.8 Mbps multiplex
Stream Rate	3.75 Mbps	

Table 3 – Media Server Assumptions

Building Blocks

AllDemand systems require different building blocks than 'broadcast-based + VOD' systems. The needs of AllDemand services require that the dense mux/mod chain packaging used in the VOD environment be extended to the entire system. Real-time encryption devices are needed to protect content served from the media caches with encryption that is associated with the access control scheme of the client set-top devices. Also, depending upon the scale of the system, switching between the media servers and the encrypt/mux/mod chain may be needed. Switching allows the media servers to scale naturally, rather than having to devote separate media servers to specific encrypt/mux/mod chain.

The centralized architecture schemas are fleshed out below. In current VOD environments the mux/mod chain is often integrated tightly with the VOD server. In the AllDemand system, the tight integration may lead to less than optimal media server scaling. In the AllDemand system, encrypt/mux/mod chain is split out. It can then be used for any service type in the AllDemand system (Broadcast AllDemand, VOD, cached, Network PVR etc), and it can scale with the transport needs of the network itself. A description of the building blocks used in building the following architecture diagrams follows:

SEM - Super Encryptor Modulator

The Super Encryptor Modulator (SEM) combines session-oriented encryption multiplex creation and QAM modulation in a single device. This gives the functional density needed to support the number of streams required in an AllDemand system. For this analysis, the SEM is assumed to support 16 QAM outputs (the number of outputs supported by an actual SEM may be different). Multiplex management is included in the SEM.

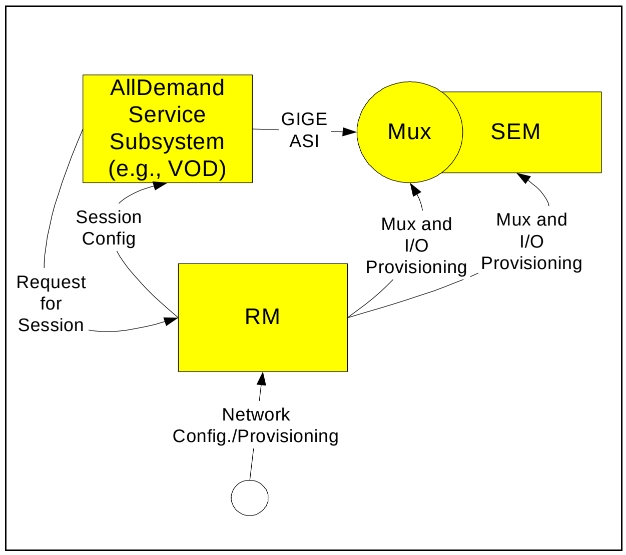

Figure 2

Resource Manager (RSM or RM)

The Resource Manager (RSM or RM) controls the SEM. It also performs bandwidth management. It provides an interface to the Service subsystems that allows sessions to be established between media servers and client devices.

Figure 2 shows a high-level view of the flows between a typical AllDemand service subsystem, the RM, and the SEM. The Mux circle in front of the SEM is normally part of the SEM. In some environments it may be desirable to have a separate Mux block.

DWDM Transport Carry Options

DWDM technology can be used to carry baseband digital, IF or RF modulated signals over the transport network. This provides flexibility in selecting locations for equipment in AllDemand systems. Of course other transport types can be combined to yield the same effect.

The following figures show architectures transporting different signals over DWDM. These diagrams also show different options tradeoffs in equipment locations. Fig. 3 shows GIGE over DWDM, with some level of switching available in the remote hub. Fig. 4 shows IF over DWDM, with just an optical to IF conversion and up conversion in the remote hub. Fig. 5 shows ASI over DWDM, with QAM modulation and up conversion in the remote hub.

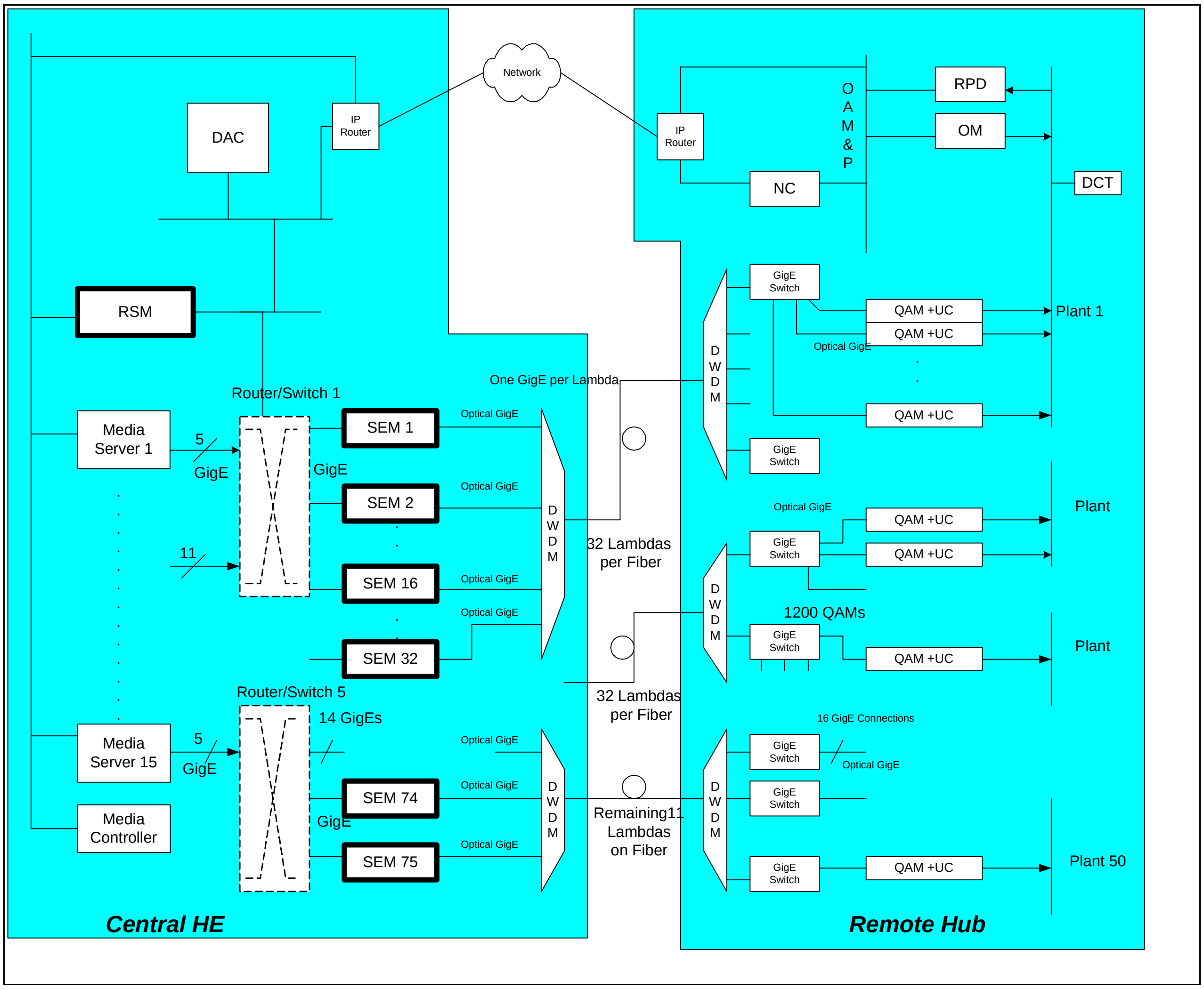

Figure 3 - Centralized Multiplexing, Encryption, and Gigabit Ethernet Transport

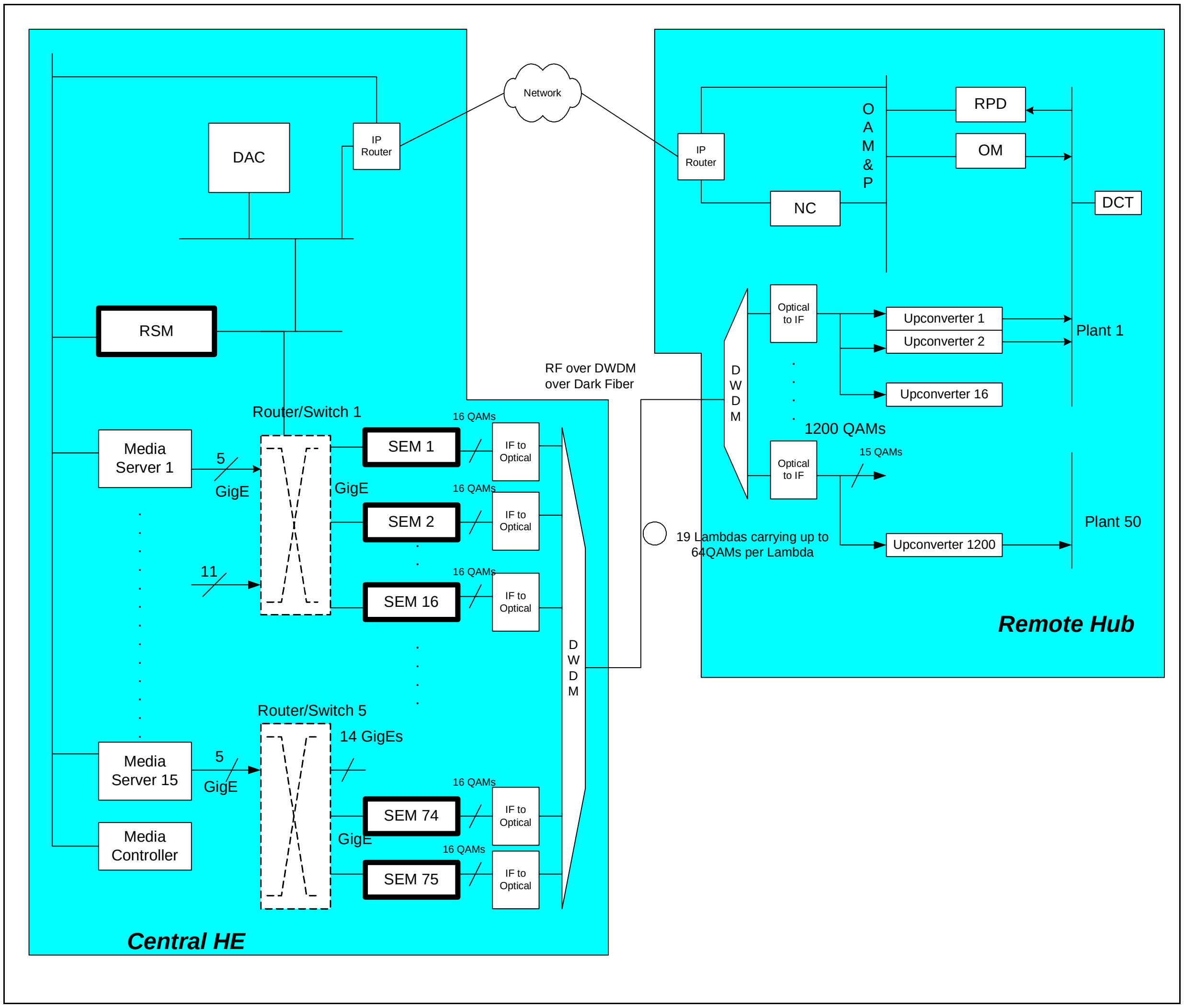

Figure 4 - Centralized Multiplexing, Encryption and QAM – IF over DWDM

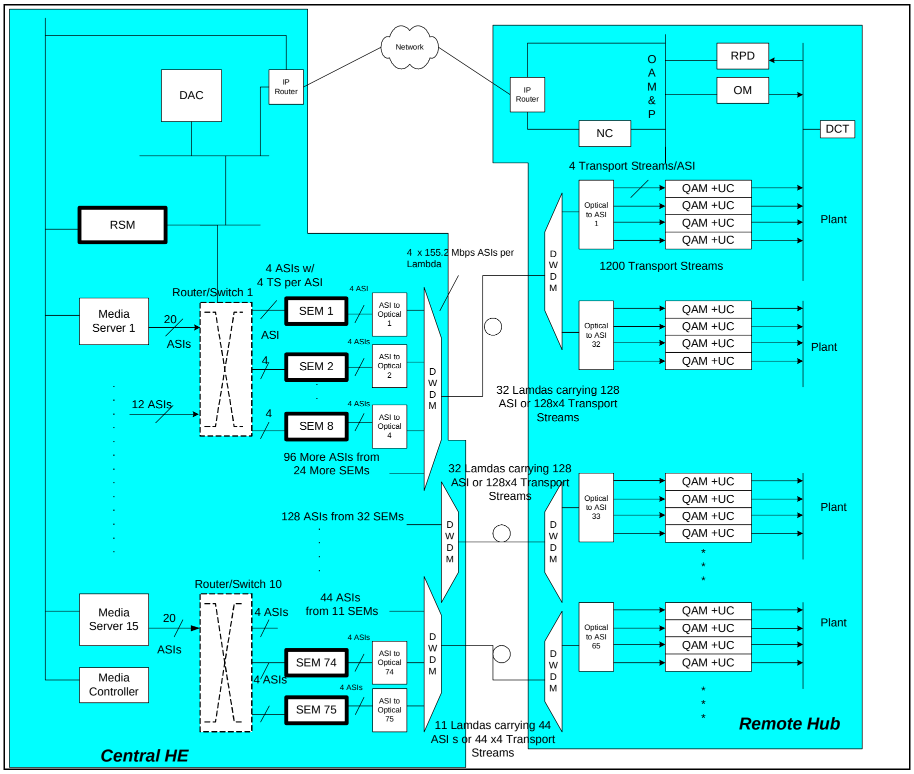

Figure 5 - Remote QAM Modulation – ASI over DWDM

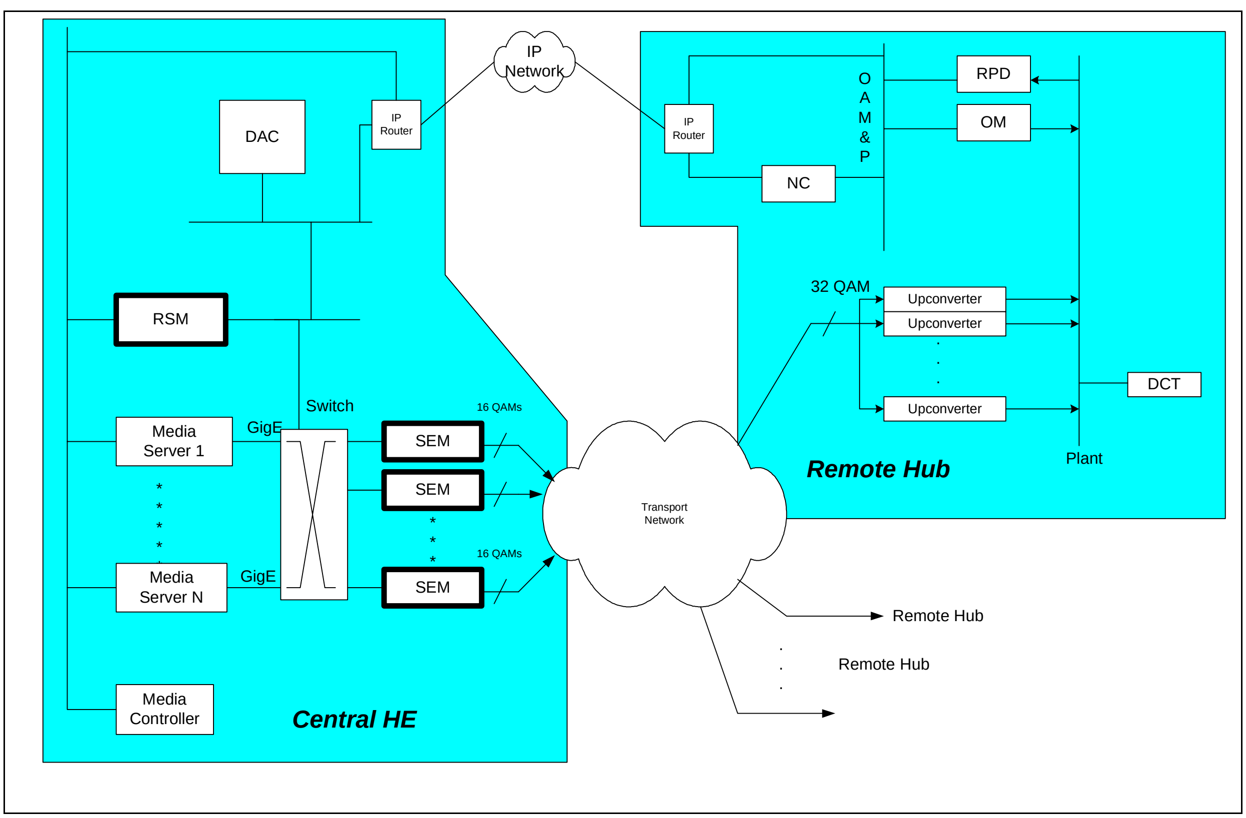

Figure 6 - Centralized AllDemand Nominal Architecture

Figure 6 shows the nominal Centralized AllDemand system architecture. This architecture supports the most flexible, efficient use of media server resources. It requires a high-capacity transport network, but it gains ease of support as well as low support overhead.

NON-CENTRALIZED ARCHITECTURE TYPES

Other architecture types are presented here for completeness. Although there are clear advantages to the centralized approach, there may be reasons to use a distributed or routed approach to the AllDemand system. These are summarized in Figures 7, 8, and 9.

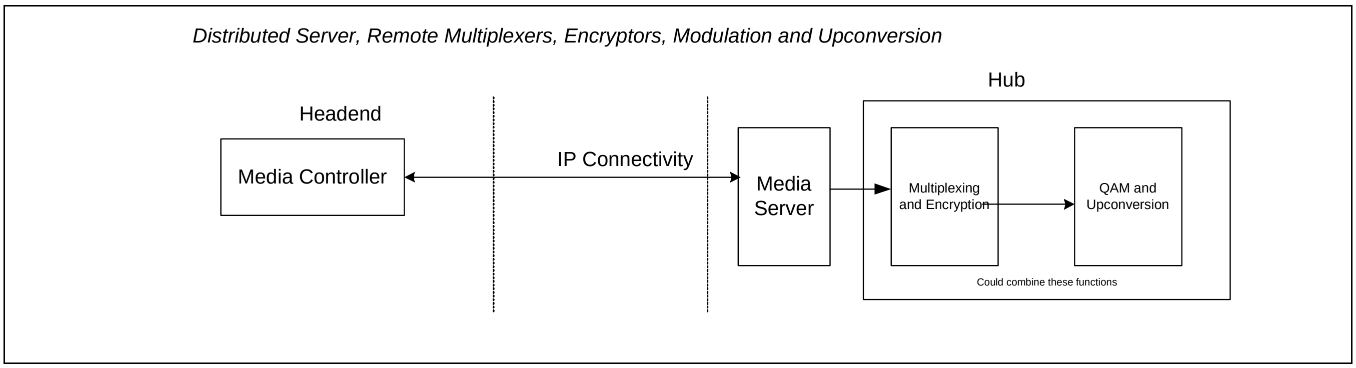

Figure 7 - Distributed Architecture Schema

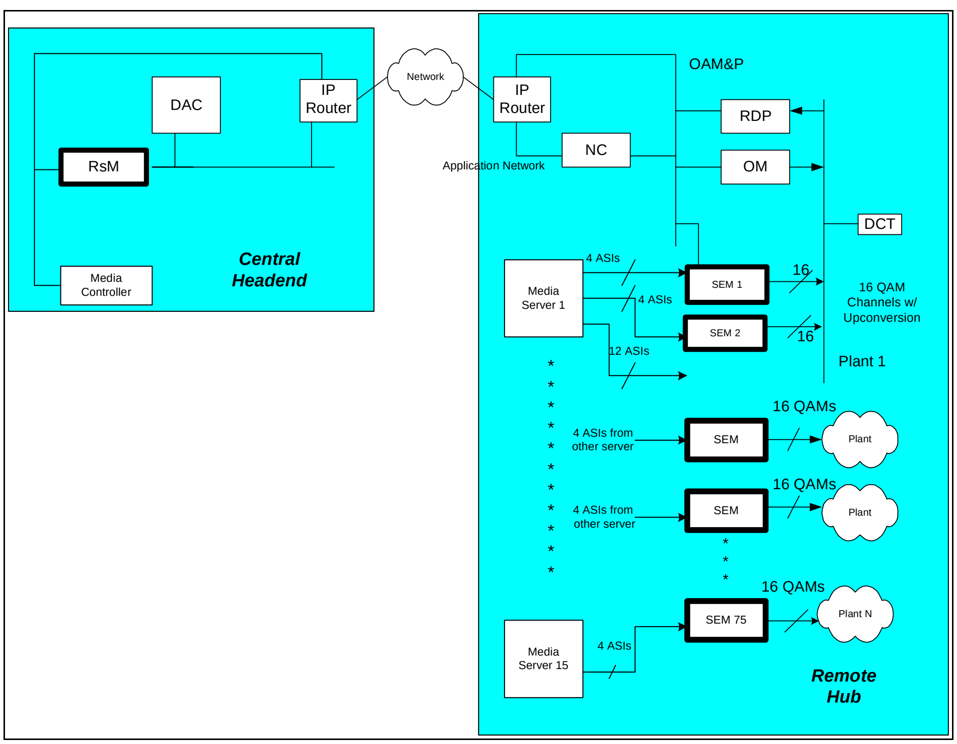

Figure 8 – Distributed System

Distributed Architecture

In the distributed architecture, the media servers are placed in the remote hubs. This may be necessary in systems that lack the transport resources to distribute streams from a central head-end. Some remote, distributed servers may also find themselves in centralized system to support regional insertion activities that are actually managed on a regional level. In general, unless the media server resources exactly match the needs of the local hub population, this scheme cannot be as efficient as the centralized approach:

- Media will need to be distributed (duplicated) in remote environments;
- On-going service, support, provisioning, and maintenance will need to be done at remote sites;
- ‘Slack’ resources to handle demand peeks cannot be broadly shared. They can only address a local population.

Routed Architecture

If the media servers support a routable output protocol (e.g., GIGE), then the output of the media servers can be routed to encrypt/mux/mod chains in remote hubs. This gives the advantages of a centralized system, but:

- Requires a transport network with QoS support at a higher protocol level (IP, or GIGE);
- Requires routing/switching hardware;
- Extends the provisioning/network management network for the encrypt/mux/mod chain to the remote hubs.

The routed architecture may be desirable in systems that are built primarily to serve IP data and media distribution over broadband environments. Systems built primarily to deliver Voice over IP (VoIP) and/or internet streaming media may already be designed in this fashion.

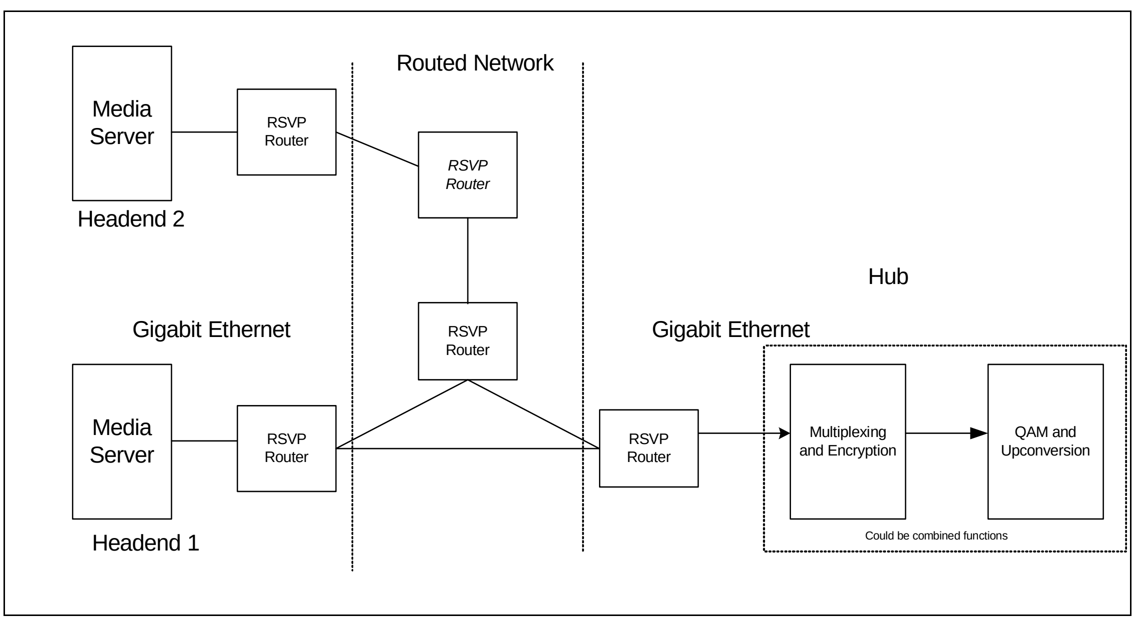

Figure 9 - Routed Architecture Schema

Summary

There are three categories of AllDemand services. Only BroadcastOnDemand saves plant resources. The rest demand more simultaneous services to the subscriber – culminating ultimately with a session per subscriber.

Network architecture drives the efficient distribution of media server resources in AllDemand systems. The GIGE protocol carried over DWDM enables a large reduction in the number of channels needed to transport fully formed streams to remote hubs. These transport improvements allow the AllDemand system to be centrally located in the head-end. Encrypt/mux/mod chains should be loosely coupled to the media servers. This allows the media servers to scale naturally – with total media storage and total simultaneous stream requirements, as opposed to being primarily partitioned by hub/transport architecture.