CRITIQUING THE LAYERED REGULATORY MODEL

DAVID P. REED*

INTRODUCTION

Today there is considerable debate regarding the application of a "layered model for regulation" of telecommunications services.[1] A layered regulatory model establishes a set of layers, each with its own set of permitted functions, to serve as a guide to regulatory decision-making. Roughly speaking, most of the proposed frameworks include four layers: 1) a physical network layer, 2) a logical network layer, 3) an application layer, and 4) a content layer. An examination of several specific

* Executive V.P. and Chief Strategy Officer, CableLabs. Before working at CableLabs, Dr. Reed served for three years at the Federal Communications Commission as a Telecommunications Policy Analyst in the Office of Plans and Policy. The author's views expressed in this article are not representative of CableLabs. The author extends his thanks and gratitude for the able assistance of Travis E. Litman, a CableLabs intern, University of Colorado School of Law student, and Managing Editor of the JTHTL.

1. *See* Douglas C. Sicker & Joshua L. Mindel, *Refinements of a Layered Model for Telecommunications Policy*, 1 J. ON TELECOMM. & HIGH TECH. L. 69 (2002); Adam Thierer, *Are 'Dumb Pipe' Mandates Smart Public Policy? Vertical Integration, Net Neutrality, and the Network Layers Model*, 3 J. ON TELECOMM. & HIGH TECH. L. 275 (2005); Kevin Werbach, *A Layered Model for Internet Policy*, 1 J. ON TELECOMM. & HIGH TECH. L. 37 (2002); Richard S. Whitt, *A Horizontal Leap Forward: Formulating a New Communications Public Policy Framework Based on the Network Layers Model*, 56 FED. COMM. L.J. 587 (2004).

proposals in this regard falls beyond the scope of this paper.[2] Instead, this article offers a critique of the general idea of applying a layered regulatory framework on communications services in the United States.

My critique of the layered model follows an interdisciplinary approach with concerns organized along economic, technical, and public policy grounds. Specifically, when applied to specifications developed by CableLabs for various IP-enabled offerings, the layered model presents a poor paradigm by which to pursue regulation.

This article argues that regulations which impose access requirements based upon a layered engineering framework lack market-based checks and balances, result in a loss of technical neutrality, and stifle innovation. The article begins by looking at a set of economic failings that arise in the context of layered regulation. Specifically, under close examination, the layered model is little more than a veiled attempt to unbundle the network by imposing open access requirements on facilities-based carriers. In the past, similar regulatory unbundling efforts met with uneven success due to the inherent complexity of pricing unbundled components in a public forum, the strident gaming of all participants in the regulatory process, and the lack of market pricing of unbundled elements.

Part II of the article focuses on how the current broadband cable networks are designed with regard to protocol layers associated with a layered regulatory model. This technical analysis is described in the context of the network platforms designed and developed at CableLabs. The risk presented by imposing regulation on CableLabs specifications highlights the threats to technical neutrality. In other words, implementation of a layered model will place regulators in the position of selecting technical winners and losers, instead of relying upon the market, since regulations defining the layer interfaces must publish the specific technical elements to be maintained across layers. This means a loss of technical neutrality in regulation as specific technical implementations are ratified. In turn, a lesson of warning can be gleaned from looking at CableLabs as a model for other network platforms such as those designed for telephone and mobile phone networks.

Finally, Part III describes how the application of the layered model for regulation would result in poor public policy. In reality, network systems and public policy do not intersect in the clean, simple fashion

2. For an overview, *see* Philip J. Weiser, *Toward a Next Generation Regulatory Strategy*, 35 LOY. U. CHI. L.J. 41 (2003); *see also* Douglas C. Sicker, *Misunderstanding the Layers Model*, 4 J. ON TELECOMM. & HIGH TECH. L. 299 (2006). Suffice to say that most proposals do not agree on the exact definition for the set of layers that would serve as the best regulatory model. This fact in itself – that advocates cannot immediately agree on the precise definition of the layers – provides telling commentary as to the considerable complexity of a layered regulatory model.

that advocates of the layered model portray. The layered model presupposes the current layered structure of network systems, namely those based upon the Internet, will remain relatively stable in the foreseeable future. This may or may not be true. Moreover, strong interdependencies exist today between technical layers. A layered regulatory model would require technical changes to the current network platforms to meet its new requirements, and is certain to influence the path of future development of the network platforms. As such, regulators will become key decision-makers in approving the path of network evolution as it maps to their layered model, and could stifle innovation in cross-layer network technologies through this regulatory control.

I. ECONOMIC CONCERNS

The economic concerns that arise from a layered regulatory model should underpin any dialogue between regulators, public policymakers, and industry. The layered approach may be seen as a framework for unbundling which involves questions of market access and pricing inasmuch as it is about "network layers." As a result, it is vital that both regulators and industry participants recognize the potential economic consequences which inhere in a layered system.

A major thrust behind the impulse toward a layered model is the application of a consistent regulatory framework to service providers based upon the specific layer functionalities they provide, rather than the historical regulatory precedent of their industry.[3] Once the layers are determined, regulatory rules would govern how service providers could provide both specific layer services as well as cross-layer services for multi-layer functionalities. In terms of economic regulation, the restrictions placed upon any provider in offering services to a particular layer, or across multiple layers, would be determined by its market power where established by the layered services. A service provider would thus be precluded from leveraging substantial market power in one layer to establish a dominant market position in another layer through vertical integration of services up (or down) through the layered stack.

The attractiveness of the layered model, therefore, is that it represents a means for organizing different categories of network functionalities for the purposes of economic regulation. More specifically, it provides a model through which regulators can implement a horizontal segmentation of the markets as represented by each layer (while still preserving the vertical-layer network interoperability required for telecommunications services). In other words, this is simply a

3. *See* Werbach, *supra* note 1, at 59.

mechanism to implement *logical unbundling* of network elements by another name.[4] What is different here is that the layered model of engineers provides the construct for identifying the functional element categories and the interfaces required across each layer boundary, rather than a model developed by policy makers.

Historically, logical unbundling models such as *Computer Inquiries I – III* and *Video Dialtone* were pursued in the presence of market power as a means to ensure network access to achieve economic benefits associated with open competition.[5] Regulators are likely to encounter technical difficulties (as explained by the CableLabs case study below) in trying to cleanly separate and associate specific layers with the services of a particular service provider.

From an economic perspective, an equally notable concern of regulatory unbundling regimes is how the unbundled elements are priced, since price is the ultimate arbiter of network access. Incumbents with market power are incented to overprice unbundled elements to discourage new entry, while new entrants have incentives to discount unbundled elements that provide them a subsidy to establish themselves as a new service provider. As a result, regulators are stuck in the middle trying to somehow discern what only the invisible hand of the market can ultimately decide. Because of this basic tension, unbundled network elements have become a costly source of conflict and litigation.[6]

Implementation of a layered regulatory model would encounter just these problems. At the outset, assuming that the layer boundaries can even be defined, allegations of unfair pricing of layered services will inevitably be brought to the regulatory authorities wherever it may serve a business interest. In turn, regulators will be placed in the position of having to decide whether or not the service layer pricing is fair. This is precisely the role and type of decision-making that regulators are notoriously poor at due both to public choice pressures and the law of unintended consequences. In other words, because regulators have no divine insights into the efficient setting of market prices for complex

4. Here, the term logical applies not to the logical network layer, but to the notion of unbundling the software elements of a network from other hardware and software elements of the network.

5. Nat'l Cable Television Ass'n. v. FCC, 33 F.3d 66 (D.C. Cir. 1994) [hereinafter *Video Dialtone*]; Regulatory and Policy Problems Presented by the Interdependence of Computer and Communications Services and Facilities, *Notice of Inquiry*, 7 F.C.C.2d 11 (1966) [hereinafter *Computer Inquiry*]; Amendment of Section 64.702 of the Commission's Rules and Regulations, *Final Decision*, 77 F.C.C.2d 384 (1980) [hereinafter *Second Computer Inquiry*]; Amendment to Sections 64.702 of the Commission's Rules and Regulations, *Memorandum Opinion & Order on Reconsideration*, 3 FCC Rcd. 1150 (1988) [hereinafter *Third Computer Inquiry*].

6. *See, e.g.,* United States Telecom Ass'n v. FCC, 359 F.3d 554 (D.C. Cir. 2004); United States Telecom Ass'n v. FCC, 290 F.3d 415 (D.C. Cir. 2002).

services, they are an ineffective proxy for market-based decisions.

In short, the layered regulatory model is really just another attempt at network unbundling, and therefore suffers from the same fatal flaws of previously proposed or implemented network unbundling regulatory regimes. The key to unbundling is the pricing of the unbundled network elements. Unfortunately, mandatory unbundling to meet regulation means that regulators, not market mechanisms, are setting the prices of unbundled elements. Regulators are ill equipped to serve this role. The heavy hand of regulation in the form of the layered model represents a highly invasive regulatory model. This model places less reliance on market mechanisms than other possible regulatory models (such as the promotion and establishment of facilities-based competition) and should be disfavored.

Unbundling through the mandatory establishment of network layers can reduce network efficiency by precluding the realization of economies of scale, scope, or other material benefits across the unbundled interfaces. The embedded implementations in the PacketCable Multimedia Terminal Adapter (MTA) and CableHome Residential Gateway (RG) as described in Part II are tangible examples of how this can translate into economic concerns. Without the ability to deploy an embedded interface with cross-layered functionality, the ability to add devices to the network would require interface development for each new device, thereby increasing the deployment cost and time. Cable operators would suffer a much longer device deployment time in the market since it would take longer to specify the protocols needed to support a standalone MTA and a higher device cost since it would demand a higher level of complexity in the new protocols to support the interface. Thus, the ultimate calculus for a layered model actually promotes lost efficiency.

If few economies of scale and scope exist across the network and application layers, then a layered approach can be an efficient technical solution. Again, however, to the extent that market mechanisms are left in place, such a regime would better promote a successful implementation. The PacketCable Multimedia specification described in Part II is an example of an approach that more easily conforms to a layered description. The important point here is that cable operators – unsure of what the ultimate economic equation will be – have developed both the PacketCable VoIP specification, a more fully specified architecture with cross-layer functionalities, and PacketCable Multimedia, a more generic layered architecture. Cable operators will use their experiences in the market to determine their ultimate path of service deployment, and the technical platform that best fits each of their own individual deployment strategies. However, the introduction of regulation here gives cause for concern because a layered regulatory model presupposes one specific architectural approach. Indeed, any time that regulators can or should decide a specific technical architecture for the market yields cause for concern for the reasons outlined above.

A further concern is that innovation may be stifled by any assertion of regulatory control. Regulatory oversight and approval processes will hinder deployment and development of new capabilities and services based on cross-layer technologies. Once any particular interface is adopted and approved, the combination of regulatory inertia and the interest of industry incumbents will make it difficult for new technologies or techniques to be introduced. Additionally, regulatory precedent will direct investment in technologies, again influencing the direction and pace of innovation. All these actions will increase development costs, and introduce potentially inefficient market dynamics into the process of innovation.

A final economic concern is the simple observation that the economic interests of service providers along each layer, and across different layers, often will not be aligned.[7] This intrinsic element of the layered model means that controversy will be endemic to its regulatory application if firms are restricted to offering services in specific layers, or access to a particular layer must be provided to firms offering different layer services. In turn, logical outflows like protocol wars and regulatory gaming may become commonplace.

One way to change the impact of regulation in a layered model will be to change the protocols capabilities. Protocols are dynamic specifications that change over time to refine or include new capabilities. With the intense scrutiny on the technical capabilities incorporated into each protocol at each layer, one can imagine "protocol wars" will erupt as functionalities are placed at different layers to ameliorate or exacerbate the impact of regulatory decisions. These protocol wars may in fact undercut the whole basis of imposing a layered model, particularly as new technologies with destructive capabilities are introduced. Finally, a layered model must account for the presence of a large number of essential, cross-layer functionalities as will be described in Part II. Clearly, the scope and implementation of such cross-layer services will be a lightning rod for regulatory controversy under this paradigm. Inevitably, cross-layer services will often have to be approved by regulators, and it will be in the economic interest for firms competing at another layer to try to use these proceedings to constrain competition in their layer by either eliminating or severely constraining the scope of permitted capabilities. Given the disparate economic interests at hand, regulators will be placed in the middle to resolve complex technical and

7. For further discussion and support of this observation, *see* ITHIEL DE SOLA POOLE, TECHNOLOGIES OF FREEDOM (1983).

pricing issues, with a heightened lobbying of all interested parties focused on policy makers.

II. TECHNICAL CONCERNS: A CABLELABS CASE STUDY

From a technical perspective, the layered approach is a useful framework for designing and building network systems. Indeed, the technical specifications created at CableLabs are no exception; yet at the same time, they offer an illustrative example into the shortcomings of the layered model. The DOCSIS®, PacketCable™, OpenCable™ and CableHome® platforms can all be described with a layered protocol stack, though as shown below, it is not necessarily a simple description.

At the outset, the right question to consider is how the technical development process for these platforms might differ under a layered regulatory model. Today, it is the business requirements of the cable companies that are members of the CableLabs consortium that drive the development process. The cable companies, in conjunction with equipment manufacturers, design the platforms to best deliver cable services to consumers as defined by these business requirements. There is no particular concern given to the specific layers into which functionalities may fall, beyond the implications of such placement on the overall need for an efficient implementation to meet consumer demands.

As a result, CableLabs platform specifications span a number of layers, which in turn raises concerns about the application of a layered regulatory model. First, regulations might limit a particular service provider to functionalities allowed in a particular layer. Second, layered regulations require clear interfaces between all layers defined by the regulatory model. This spanning occurs today due to the *interdependency of the layers* – a particular functionality requires implementation in more than one layer – or the set of business requirements dictate the need for functionalities that occur in more than one layer. In this section, we review some of the layer interdependencies and cross-layer functionalities of the existing broadband platforms (DOCSIS, PacketCable and CableHome) on the cable network.[8]

The demonstrated interdependency of the layers raises major concerns, as the layered regulatory model could limit a particular service provider to functionalities allowed in a particular layer, or require clear interfaces between all layers defined by the regulatory model.

---

8. While not included in this discussion, similar layer interdependencies exist for functionalities necessary for the OpenCable platform that provides digital video services and separable security capabilities.

A. DOCSIS

The DOCSIS specifications define the physical interfaces supported by cable modem and cable modem termination system equipment. These physical interfaces connect the individual end users with the provider service delivery environment. Figure 1 shows a simplified description of the protocol software stack of a cable modem, which in this case, provides a typical consumer with Internet access via an Ethernet port.[9] In a rough mapping to the four-layer model noted above, the physical (PHY) layer maps to the DOCSIS physical layer and Media Access Control (MAC) protocols, the network layer maps to the TCP/IP protocols, and the application layer maps to the network and security management applications. A cable modem contains no content software that maps to the content layer.

The heart of the DOCSIS specification prescribes the DOCSIS PHY and MAC protocols. But one should not overlook the higher-layer functionalities which inhere in the DOCSIS specification either.[10] Most importantly, DOCSIS includes network management and security profiles.[11]

The higher-layer capabilities in network management and security are essential to the fundamental operation of the cable broadband service.[12] As such, any regulatory model that would preclude the network

---

9. The software stack diagrams were provided by Ralph Brown, CableLabs.

10. *See* CABLELABS, DATA-OVER-CABLE SERVICE INTERFACE SPECIFICATIONS DOCSIS 2.0, http://www.cablemodem.com/downloads/specs/CM-SP-RFI2.0-I10-051209.pdf.

11. As regards network management, the Operations Support System (OSS) Interface Specification defines the network management services required within DOCSIS 2.0 by using the Simple Network Management Protocol (SNMP) to perform account, configuration, fault, and performance management functions. This specification defines the subscriber account management interface that allows cable equipment vendors to develop products that address the operational requirements of cable operators' subscriber account management in a uniform and consistent manner. This includes such essential capabilities as how to provision broadband service to customers, the enforcement of the subscribed service level agreements (SLAs), and implementation of usage-based billing. From the network layers perspective, SNMP is typically associated with the higher layers (*e.g.*, application, presentation, and session layers). Meanwhile as for security, the DOCSIS 2.0 specification includes a Baseline Privacy Plus (BPI+) interface that provides cable modem users with data privacy across the cable network, in addition to providing cable operators with a strong protection from theft of service. BPI+ protects against unauthorized access to the MAC layer by enforcing encryption of the MAC layer traffic flows across the cable network. The protocol employs a client-server model running the security application. In this way the security as defined in the DOCSIS 2.0 specification is another example of an application layer functionality required to support the link layer. *See* http://www.cablemodem.com/downloads/specs/CM-SP-BPI+_I12-050812.pdf.

12. Other higher-layer protocols in the DOCSIS specification include Trivial File Transfer Protocol (TFTP) for downloading operational software and configuration information, Dynamic Host Configuration Protocol (DHCP) to allocate IP addresses, and Time of Day (ToD) protocol to obtain the time of day.

operator from higher layer functions would *literally disable* the operations systems of the network operator. In addition, the network management and security functions are multi-layer, spanning the network and application layers without open interfaces at this layer boundary. These technical characteristics of the DOCSIS platform raise important and unanswered questions of how the delivery of cross-layer functionalities could be handled in a layered regulatory model.

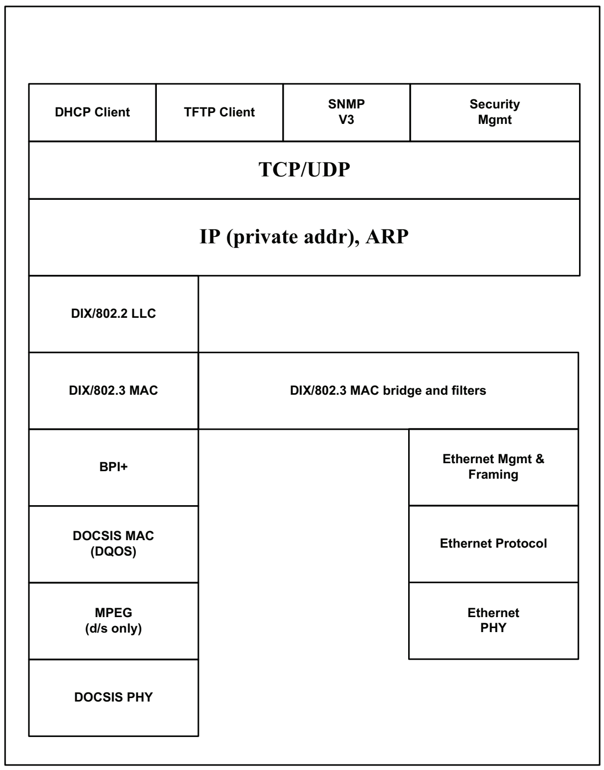

Figure 1: Software Stack of DOCSIS Cable Modem

B. PacketCable

The PacketCable specifications define the interfaces required for a cable operator to provide Voice-over-IP (VoIP) and other multimedia services. PacketCable is a set of protocols developed to deliver communications services requiring quality of service (QoS) using packet-data transmission technology to a consumer's home over the cable network.

Figure 2 shows a simplified protocol software stack of a PacketCable Multimedia Terminal Adapter (MTA), which includes an embedded cable modem. The term embedded means that there is no explicit interface included in the specification demarcating the boundary between the cable modem and the PacketCable software application in the MTA. In a rough mapping to the four-layer model, the PacketCable platform assumes the presence of DOCSIS for the physical and network layer protocols. PacketCable does specify a quality of service protocol at the network layer, along with the call signaling, voice codecs[13], client provisioning, billing event message collection, Public Switched Telephone Network (PSTN) interconnection, and security protocols that map to the application layer. An MTA contains no content software that maps to the content layer.

13. Coders/decoders—perform data conversions and are typically used in modems.

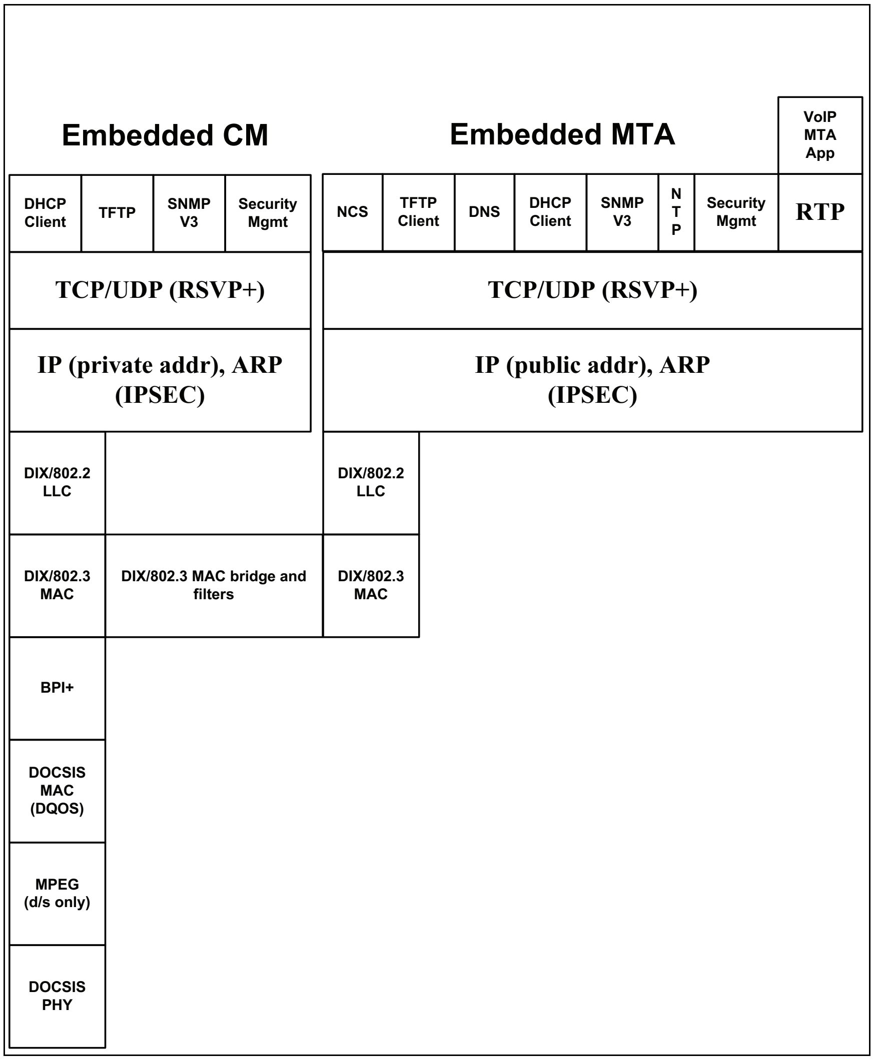

Figure 2: Software Stack of PacketCable MTA

The heart of the PacketCable specification specifies the VoIP application running in the Multimedia Terminal Adapter (MTA) in the subscribers' homes and the network elements required to support the application. For the purposes of this article concerning layered models, the PacketCable specification suite is illustrative of the problems in instituting a layered-based form of regulation. In other words, PacketCable is a poor candidate for layered regulation due to its cross-layer functionalities, its general purpose platform, and its underlying complexity.

First, an important cross-layer functionality in PacketCable is found in the dynamic QoS specification, which specifies how an MTA can request a specific quality of service from the DOCSIS network.[14] The PacketCable QoS architecture is cross layer, as it specifies the necessary interaction between protocols in the network and application layers.[15] This cross-layer specification is required even though PacketCable, as a higher-layer specification suite, is built upon the lower-layer DOCSIS 1.1 specification. The important point is that even under the best of circumstances for a layered approach (*i.e.*, PacketCable specification riding over the lower DOCSIS specifications), cross-layer functionalities such as QoS are likely to occur. From a layered model perspective, the migration of functionality in one layer will often be tied to that of another.

Second, while the PacketCable VoIP specifications are customized for the delivery of residential telephony services, the PacketCable Multimedia architecture offers a general-purpose platform for cable operators to deliver a variety of IP-based multimedia services that require QoS treatment.[16] This architecture works only on the DOCSIS 1.1 portion of the network. All application managers and clients reside within a single cable-administered network. Despite the general layered approach of the specification, the expectation is that each multimedia application will probably require a profile, which may or may not have cross-layer implications depending upon the unique requirements of the application.

Third and finally, by specifying an MTA with an embedded DOCSIS modem, the PacketCable specification suite was made simpler by not having to specify the interface between the cable modem and the MTA. It was also completed in much less time since the complexities associated with a standalone MTA specification (*e.g.*, how to handle firewalls and network address translation) were not required to be part of the specification. Despite these efficiencies, a layered model would not allow the same specification approach, since the interface to customer premises equipment likely would have to be fully specified to permit several permutations of deployment beyond only embedded implementations. In other words, while a layered regulatory model may not preclude embedded implementations, it almost certainly would

14. *See* CABLELABS, PACKETCABLE™ 1.5 SPECIFICATIONS: DYNAMIC QUALITY-OF-SERVICE, http://www.packetcable.com/downloads/specs/PKT-SP-DQOS1.5-I02-050812.pdf.

15. As an aside, the PacketCable QoS architecture is based upon CableLabs' DOCSIS 1.1 specification, IETF's Resource reservation Protocol (RSVP), and Integrated Services Guaranteed QoS.

16. *See* CABLELABS, PACKETCABLE™ MULTIMEDIA ARCHITECTURE FRAMEWORK TECHNICAL REPORT, http://www.packetcable.com/downloads/specs/PKT-TR-MM-ARCH-V01-030627.pdf.

require a fuller set of platform specifications, which translates into a longer time to market for equipment and more complexity in the specifications.

In short, despite the fact that PacketCable is a "higher-layer" specification suite, this review of the PacketCable specifications raises some of the same cross-layer functionality concerns as noted for the DOCSIS platform. In addition, specifications that are fully compliant to a layered model can be more complex, and take longer to reach the market as they can require more interfaces to be specified than might otherwise be the case.

C. CableHome

The CableHome specifications describe the IP-based architecture for managed home-networked services on the cable network through a DOCSIS cable modem.[17] Figure 3 shows a simplified protocol software stack of a CableHome Residential Gateway (RG), which includes an embedded cable modem. *Embedded* here means that there is no explicit interface included in the specification demarcating the boundary between the cable modem and the CableHome software application in the RG. In a rough mapping to the four-layer model noted above, the CableHome platform assumes the presence of DOCSIS for the physical and network layer protocols. CableHome does specify IP addressing requirements at the network layer, along with the home-networking management protocols that map to the application layer. An RG contains no content software that maps to the content layer.

A main focus of CableHome is to enable core DOCSIS and PacketCable functionality on home networks, with an additional focus on home network management capabilities. Like PacketCable, CableHome is also a multi-layer specification spanning the network and application layers (while DOCSIS spans these layers as well as the physical layer). This cross-layered functionality yields difficulty in imposing regulation based upon clear delineations between layers.

Yet CableHome represents a general layered approach in application. CableHome does not require a specific home-networking technology in the home. The expectation is that future network-layer profiles for specific home-networking technologies such as Wi-Fi or USB may be necessary to support certain services (like QoS) across the cable and home networks.

Finally, in specifying an RG with an embedded DOCSIS modem, the CableHome specification suite was made simpler by not having to

17. *See, e.g.*, CABLELABS, CABLEHOME 1.1 SPECIFICATION, http://cablelabs.com/projects/cablehome/downloads/specs/CH-SP-CH1.1-I10-051214.pdf.

specify the interface between the cable modem and the RG. It was also completed in much less time since the complexities associated with a standalone RG specification (*e.g.*, how to handle QoS) were not required to be part of the specification. While a layered regulatory model may not preclude this type of embedded implementation, it almost certainly would require a fuller set of platform specifications, which will have implications for a longer time to market and more complexity.

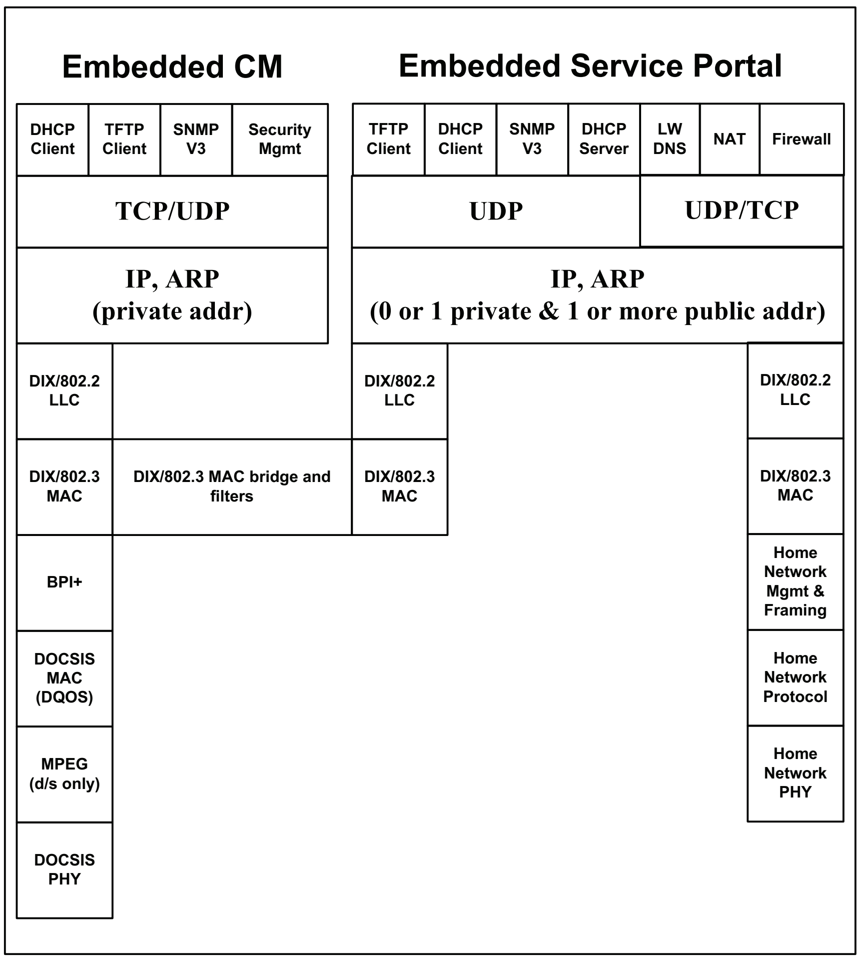

Figure 3: Software Stack of CableHome Residential Gateway

D. Technical Concerns Summary

The above examination of the protocol stacks associated with the technical platforms on cable should give the reader pause for four reasons.

First, software stacks are complex. The layered regulatory model sets a very high bar of technical competence for regulators. While the theory of layered networks provides a simple conceptual construct of how network systems work, actual implementations are much more complex to meet the business needs of the service providers.

Second, CableLabs platforms are not isolated in a single layer. The software stacks demonstrate how the DOCSIS, PacketCable, and CableHome platforms are all multi-layer by incorporating more than one layer into the specification suite. In other words, the functionalities required by cable operators to offer their services span multiple layers. Even though each layer is an important part of these cable platforms, a layered regulatory model that tries to organize services along exclusive horizontal layers will likely be problematic due to the significant amount of cross-layer functionalities.

Third, network design challenges will be presented by the erection of barriers across layers. One consequence of layer interdependence is that the technical evolution of the network is highly linked across layers. Changes in one layer need to be closely coordinated across all the other layers. A regulatory model that injects more players into the process of network evolution will make the task of planning network evolution very difficult. Moreover, a requirement for open interfaces at every layer boundary will make the specification more complex, and take longer to complete.

Finally, in a layered paradigm, regulators will be placed in the key role of designing the layered network systems through their frequent regulatory decisions. Consequently, regulators will have a primary role in controlling the rate of innovation on the layered networks. For example, bandwidth management on broadband networks has emerged as a key application for broadband network operators who must manage network usage to comply with consumer usage agreements. Bandwidth management tools have been developed with a wide range of capabilities, ranging from simple system that measure the traffic through a specific network point of control to sophisticated tools that will measure the traffic, decompose the traffic by flows, measure each flow, and restrict the passage of flows of specific types. Given the cross-layer, "traffic cop" nature of bandwidth management tools (*i.e.*, the interests of the layers are not aligned), it seems safe to predict this application, and others that are similar, would be highly controversial under a layered regulatory model and require a lot of attention from regulators. The delay caused by regulatory deliberations in this regard would serve to stifle innovation of cross-layer services.

Thus, because communications technology evolution will continue to span layers any regulatory intervention will have definite consequences. Most noticeably, by allowing regulators to select open access requirements at various points across the layers, technical neutrality is actually sacrificed in as much as technical winners and losers are no longer determined at the market. Further, by putting regulators at the vanguard of network evolution, delay and market frustration are bound to occur where advancement to market may only be accomplished through a regulatory approval.

III. PUBLIC POLICY CONCERNS

The technical and economic issues presented by the layered model of regulation addressed above also equate to problems of public policy including the loss of neutrality in regulation, the imposition of a system of price regulation, and the subsumption of innovation to regulatory control.

As noted above, the layered model threatens to result in another attempt to impose price regulation under the guise of unbundling or open access requirements. The imposition of open access requirements on facilities-based carriers ultimately perverts the true price of various elements by regulatory machination with the overall result of inefficiency. In the past, similar regulatory unbundling efforts have met uneven success due to inherent complexity of pricing unbundled components in a public forum, the strident gaming of all participants in the regulatory process, and the lack of market-based checks and balances on the viability of unbundled elements. Layering advocates may argue that there is no better solution, but as will be discussed below, there is a better alternative in the form of promoting facilities-based competition and correcting for regulatory imbalances as they occur.

A central tenet of good public policy has long been to craft regulatory frameworks that are technologically neutral so that the market, not regulators, can ultimately decide upon the best technologies for deployment. However, the implementation of a layered model will place regulators in the position of selecting technical winners and losers instead of relying upon the market. In short, this sacrifices technical neutrality.

Regulations defining the layer interfaces must publish the specific technical elements to be maintained across layers, and any layered model ultimately selected by regulators constitutes a technical architecture in its own right. In turn, a loss of technical neutrality in regulation will arise as specific technical implementations are ratified. For example, regulators agreeing to implement a four-layer model versus a six- or seven-layer model will result in different technology being built and deployed by the different service providers for reasons of regulatory compliance. For this reason, a layered regulatory model would be highly invasive, at least in terms of a managing communications markets, and would require expert application by regulators with a strong technical comprehension and strategic vision.

Finally, one of the most disturbing public policy concerns raised by the layered model is that regulators, as the ultimate decision-makers for what constitutes the layered model, will be in control of ongoing technical evolution of telecommunications networks. Even if regulators were to defer to technical standards bodies, any disputes arising from these organizations would ultimately have to be arbitrated by the regulators. Most proposed layered regulatory models presuppose the current layered structure of network systems based upon the Internet, and that such systems will remain relatively stable in the foreseeable future. This may or may not be true, but it would be the regulators' decisions directing the path of network evolution, not competitive markets featuring potentially disruptive technologies to the layers architecture.

With the regulatory intervention intrinsic to the layers regulatory model, public policy makers will need to establish a strong market failure to justify the high degree of market micromanagement associated with the implementation of the model with regard to how the networks will develop. With the steady increase in competition seen today in most telecommunications markets, imposition of a layers regulatory model would serve to provide regulatory intervention in the absence of market failure.

CONCLUSION

In short, what is good for the engineer is not easily applicable to the regulator, at least not in terms of adoption of a rigid framework required for consistent regulatory decision-making. This is not a surprising observation as these two professions are trying to accomplish very different goals. Namely, engineers *build* networks to meet their clients' business and functional requirements; policy makers *regulate* communications services for the public benefit. Historically, when the two mix (*e.g.*, engineers try to build networks to achieve public policy objectives or policy makers design and dictate technical architectures),[18] inefficient outcomes are the common result. Thus, while it is true that engineers find a layered architecture useful in designing and building their network systems, the notion of applying this model for regulatory purposes is misguided and will likely result in an overly complex and rigid model upon implementation.

18. *See, e.g.,* Nat'l Cable Television Ass'n, 33 F.3d at 66.

As a result of these difficulties in successful implementation of a layered model, alternatives should be considered. Foremost among other paradigms of regulation is a regulatory model that promotes consistent facilities-based competition among service providers. In essence, this is the current policy in the United States. Competition among cable and telephone companies for broadband services is fierce, and the FCC has done a good job removing artificial entry barriers to allow more new service providers seeking to offer broadband services. Serious new broadband market entrants may emerge using broadband over power line, wireless broadband, or satellite technology. A public policy framework promoting facilities-based competition remains technologically neutral in that all technologies are given as reasonable prospects for success as is feasible by regulators. Regulators leave pricing to the competitive markets; they are not forced to intervene and make arbitrary judgments regarding how prices should be set.

The facilities-based model, however, requires some patience before the full benefits of competition can be realized. In the real world, it takes time to deploy the network infrastructure needed to support residential broadband networks, particularly on a nationwide basis. Indeed, it has taken time for digital broadband services to obtain its substantial market position, but it is now a viable competitor to traditional cable services.[19]

Thus, while the layered model may provide a useful framework for understanding the basic rudiments of telecommunications technology and network systems, it is not a useful regulatory model to tackle real-world public-policy issues. The few instances where proxies for layered regulation have occurred, such as UNEs in wireline telephony or the establishment of a video dialtone platform, have been failures despite the simplicity of this technology relative to advanced broadband networks.

Instead, it is important to turn to pause and look at the current market realities. Competition is steadily increasing in most telecommunications markets and, as such, imposing a layered regulatory model would be regulatory intervention in the absence of market failure. Such regulation would not only be unwarranted but likely to result in the unintended consequences including the loss of technological neutrality, unbundling obligations, and the stifling of future innovation.

19. Annual Assessment of the Status of Competition in the Market for the Delivery of Video Programming, *Eleventh Annual Report*, 20 FCC Rcd. 2,755, 2,766-68 (2005).