

User freedom to attach devices

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Abstract

Much of the research on an *Internet of Things* assumes that users will be able to connect devices without consent by or interference from their service providers. However, in cable and satellite television networks, cellular networks, and some broadband Internet networks, the service provider often only allows use of set-top boxes, smart phones, and residential gateways obtained directly from the provider. The ability of a provider to implement such restrictions is limited by communications law. We propose a set of user and service provider rights. We identify the pertinent network architectural principles, and use these to propose a new legal framework for device attachment that, combined with standardized interfaces and protocols, can ensure an open network that supports innovation in devices.

1 Introduction

The Internet is now connecting a wide variety of heterogeneous devices. Whereas once a connection to the Internet was comprised of only a cable or DSL modem attaching one computer, it is now common that user networks include a broadband modem, a wireless router, computers, printers, network attached storage, wireless adapters, set-top boxes, televisions, music systems, VoIP phones, smartphones, tablets, e-readers, and navigation devices. A wider variety of Internet-connected devices is expected, and the *Internet of Things* is the subject of many papers.

Networking researchers often assume that users should be able to connect devices without requiring prior permission of an Internet Service Provider (ISP). The implied vision is usually that of an *open network*, in which users have the ability to connect devices of their choice to the network. On this assumption, networking research is almost always focused on creating standardized interfaces and protocols. The goal of standardization is to

support interconnection and interoperability of devices, thus creating the platform that enables heterogeneous devices.

In addition, networking researchers usually assume that users and their ISPs will share control of the protocols the devices a user places in a residential network or attaches to the Internet. The decision of which protocols of which devices are controlled by the user versus the ISP is assumed to be made on the basis of efficiency and effectiveness.

However, these three assumptions by networking researchers – user ability to connect devices of their choice, standardized protocols, and shared control based on effectiveness – are violated by many devices offered by or mandated by ISPs. We briefly discuss three such devices: residential gateways, set-top boxes, and smart phones.

Residential connection to the Internet is increasingly provided through a residential gateway provided by an ISP, which allows connection of a wide variety of devices through the gateway. However, the use of a ISP-provided residential gateway is sometimes mandated by an ISP, which thus can preclude users from attaching a router or gateway of their choice. In addition, the ISP maintains control over almost all protocols used in the gateway, depriving the user of the use and control of certain protocols that the gateway may block.

Cable and satellite television are increasingly accessed through a set-top box leased by the provider to the subscriber. In some cases, the consumer has no other option, whereas in other cases the consumer may elect to purchase a set-top box offered by a consumer electronics company but will often find that it does not provide access to all video content. The set-top box supplied by the video provider often limits the devices that a consumer may connect to the network and use to access video content. The set-top box may also use proprietary protocols to access certain information streams, and thereby eliminate the ability of other user-chosen devices to provide functionality, such as video navigation. These impedi-

ments all challenge the open network model assumed by most networking researchers.

Smart phones used on cellular networks are an even greater challenge to open networks. A cellular provider often exercises almost total control over the devices used on its network through a combination of terms of service and device pricing. The provider often reserves the right to control almost all communication protocols on the device. It is not uncommon for providers to lock devices to their networks and to cripple functionality.

Such restrictions impede the development of a competitive heterogeneous market for devices, and thus impede the likelihood that networking research on this topic will lead to innovative new devices. The ability of an ISP, video provider or cellular provider to limit the devices attached to their networks, to use proprietary protocols, and to maintain control over protocols sent through their networks is determined by communications law. However, the law has been written separately for different communications technologies. Users' ability to attach devices of their choice to the telephone network is guaranteed by law, providing that the device does not *harm* the network. A users' ability to attach set-top boxes of their choice on a cable television network is guaranteed by law, but on a satellite television network it is not. Users have no legal right to use devices of their choice on cellular networks. The Federal Communications Commission (FCC) has only very recently created a regulation, called the Open Internet Order [2], that gives users the right to use non-harmful devices of their choice on fixed Internet broadband.

This fragmented approach to regulation of consumer device attachment is doomed to failure as the Internet becomes the dominant network supporting communication and supporting access to electronic content. There is thus a great need to create a unified legal framework that can dictate a user's right to attach devices to the Internet in the future.

Minimal academic literature giving guidance on how to construct such a legal framework exists. Wu [8] suggested that the law ensuring a user's right to connect devices to the wired telephone network be extended to cellular networks. A number of papers have argued that communications law must be rewritten to apply to converged networks (see e.g. [1][6][7]), but none have directly addressed how this could be accomplished with respect to device attachment.

2 User and provider rights

A legal framework should be constructed to ensure a set of rights both to subscribers of communication services and to providers of communication services. Communications services should consist of network functionality

at or below the network layer or required to manage the network, and should apply to the Internet, telephone networks, cable television networks, and cellular networks. A balanced approach that guarantees rights to both types of stakeholders will maximize social welfare. Communications law has a long history of supporting such rights.

We start with rights that users should have:

- U1** Users of communications services are entitled to connect any legal device to a communications network, so long as that device does not cause harm to the network.
- U2** Users of communications services are entitled run applications of their choice on their devices.
- U3** Users of communications services are entitled to choose a communications provider in a competitive market place.

We continue with rights that communication providers should have:

- P1** Communication providers are entitled to charge for communications services provided to their subscribers.
- P2** Communication providers are entitled to the use of reasonable network management.
- P3** Communication providers are entitled to forbearance from regulations when they are not necessary to ensure user rights.

3 Device Attachment

Several architectural and legal models for interconnection exist. In the telephone network, a legally mandated *demarcation point* defines the place and method of interconnection. ISPs and cable television networks usually connect to a user's network at a similar junction box. However, there is no legal requirement to do so and the providers often own some user devices such as residential gateways and set-top boxes. Satellite television and cellular providers connect via an air interface at a satellite dish or wireless device. However, cellular providers occasionally claim that user devices are part of the service provider's network.

In order to ensure a user's rights to connect devices (U1), we must first define where the service provider's network ends and the user's network begins. In telephone networks, Part 68 regulations define a *demarcation point* as the geographical point at which the telephone company's network interconnects with customer premises wiring. In telephone networks this demarcation point often consists of a RJ11 jack within the User

Network Interface junction box. We propose that a demarcation point should be defined not only for telephone networks but for all communication services and that this point consists of a standardized interface; a law should contain the following provision:

DEMARCATIION POINT – Facilities of communications providers at, or constituting, the demarcation point shall consist of an interface conforming to the technical criteria published by a recognized national or international standards body.

The demarcation point could thus consist of a RJ11 jack, a coaxial cable junction, an optical jack, a RJ45 Ethernet jack, a USB port, or an air interface such as GSM, CDMA (e.g. TIA-EIA-95), LTE, or Wi-Fi. The standards bodies may include ACTA, ANSI/TIA/EIA, USB Implementers Forum, 3GPP, 3GPP2, and IEEE.

Establishing a demarcation point for all communication services helps to ensure a user's right to choose a communications provider (U3). If more than one provider offers service, users can physically switch from one provider to another by simply disconnecting their network at the demarcation point from the old provider and connecting it to the demarcation point of the new provider.

Now that we have legally defined the interconnection point between the service provider's and user's networks, we can focus on ensuring users' rights to connect devices of their choice (U1). While Part 68 ensures this right for telephone devices, our goal is to ensure this right for all communications services. Part 68 ensured this right by allowing subscribers to attach non-harmful devices. We believe this concept applies to all communication services. Harm is currently defined with wired telephone lines in mind, but the definition can be easily extended to apply to terminal equipment that is connected to the facilities of all communications providers. We propose the following legal definition, which combines the current Part 68 definition of *harm* with the current regulatory definition of *harmful interference*:

HARM – The term 'Harm' means electrical hazards to the personnel of providers of communications, damage to the equipment of providers of communications, malfunction of the billing equipment of providers of communications, and unreasonable degradation of service to persons other than the user of the subject terminal equipment, his calling or called party. Unreasonable degradation includes harmful interference, defined as any emission, radiation or induction that seriously degrades, obstructs, or repeatedly interrupts a radio communication service.

We propose to generalize the current Part 68 right to attach non-harmful devices to all communication services using this legal provision:

ANY DEVICE – Communications equipment located on customer premises or in the possession of the user at the end of a communications link, used to permit the stations involved to accomplish the provision of communications or information services, that do not cause harm, may be directly connected to the facilities of the communications provider.

Part 68 requires certification of terminal equipment; we propose to generalize this provision by requiring that all such communications equipment either be approved by an independent body that verifies conformance with standards that prevent harm or be connected through protective circuitry. This requirement is currently met by common network devices, since they almost invariably connect through standardized interfaces.

Our legal approach thus combines the current device rights provided to telephone network users under Part 68, the new device rights of fixed broadband Internet access service users under the Open Internet Order, and current device rights of cable television users. It is thus consistent with current operation of telephone networks, Internet access using cable and DSL modems, and cable television using CableCARD set-top boxes. However, AT&T U-Verse Internet service would be in violation, since although there is a demarcation point it does not allow users to connect a residential gateway of their choice. Similarly, satellite television would be in violation if it does not allow users to attach a set-top box of their choice, and cellular service would be violation if it only allows attachment of devices obtained through the provider.

4 Device Management

We now turn to the issue of device management. We wish to address which devices and protocols a service provider controls versus which a user controls. The demarcation point defines where one network ends and the other begins. However, while we expect that a service provider will control all devices within its network, it is common practice for a service provider to control certain protocols of certain devices within a subscriber's network. We thus see a need for a further architectural and legal distinction that addresses control over user devices. We start with the architecture.

Cable modems and DSL modems are devices chosen by the user. However, this does not mean that the user has the unfettered right to control all aspects of the operation of these devices. Access to the particular broadband

Internet service purchased by the subscriber is often implemented by the ISP controlling parameters within the DSL or cable modem. For instance, the ISP may limit the maximum upload transmission rate to a rate specified by the user's subscribed plan. More specifically, we find that the ISP controls the operation of layers 1 through 3 of the ISP's side of the modem. In addition, the ISP controls certain elements of layers 4 through 7 of the ISP's side of the modem, e.g. blocking of NetBIOS traffic from the user's residential network to the ISP's network, control over DHCP, and operation of SNMP. However, the user controls all layers of the side of the modem facing the user's residential network.

Cable and satellite television set-top boxes are also partly controlled by the communications provider. At the very least, the provider controls the lower three layers of the interface facing their network. In addition, the provider often controls other elements of a set-top box, including menus and navigation guides.

Smartphones are also partly controlled by the communications provider. At the very least, the provider controls the lower three layers of the air interface. A subscriber's access to services is governed by the cellular provider, either through signaling from the provider's network or using information stored on a SIM card. However, many cellular providers limit the functionality of the device by crippling functionality or by limiting the applications that a subscriber may run.

Multiple legal models apply. The issue did not visibly arise in telephone networks since it was generally assumed that users would control all devices on their side of the demarcation point. The Open Internet Order prohibits fixed broadband Internet access service providers from blocking applications, but mobile Internet access service providers are only prohibited from blocking applications that compete with the provider's voice or video telephone services unless such blocking is deemed reasonable network management. Cellular providers can thus legally restrict devices and some applications used on their networks, providing that they disclose any third-party device and application certification procedures. Cable television service providers must allow subscribers to use a CableCARD in a set-top box of their choice, and thus they may control navigation and other higher layer services only to the extent that a subscriber chooses a set-top box from the provider. That said, CableCARD has largely failed to encourage a competitive market for set-top boxes. The FCC believes part of the reason is that CableCARDS did not allow access to two-way services such as video on demand, and that it required users to upgrade set-top boxes often to keep up with advances in the cable television providers services. In response, the FCC is considering replacing CableCARD with a new regulatory model dubbed AllVid

[3]. The AllVid approach would allow a cable television provider to require the use of a proprietary adapter capable of performing only limited functions. The allowed functions would include serving as a modem, governing access to services, content protection, and routing. However, an adapter would not be allowed to include navigation functions including programming guides and search functionality. The adapter would either be a small device that attaches to another device, or a gateway that attaches to other devices via an open standard such as Ethernet.

Device management is tightly connected to a users' rights to run applications of their choice (U2). This right is fairly universally expected by users of computers with Internet access. However, whether smartphones should be entitled to such a right is an issue of intense debate. We believe this right should apply to all communications services.

In order to create a unified approach, we believe there is a need to define a control point separate from the demarcation point. The demarcation point determines who is responsible for wiring, whereas the control point will determine who is responsible for device control. Formally, we propose that the control point be legally defined as follows:

USER COMMUNICATIONS GATEWAY –
The term 'User Communications Gateway' means the customer premises equipment with network layer functionality that is closest to the demarcation point.

We then propose the following limit on a service provider's control:

CONTROL – A communications provider shall be allowed control only over communication services implemented in devices between and including the demarcation point and the communications provider's interface of the user communications gateway, unless a user gives consent otherwise.

This legal approach would allow ISPs to control layers 1 through 3 of their interface of a cable modem or DSL modem, as well as any layer 1 or 2 devices in between their network and the modem. It would not allow an ISP to control layer 4 through 7 protocols except as required for network management without the consent of the user.

There are no similar provisions in existing law that address device management. However, our proposed provision is consistent with current operation of telephone networks, Internet access using cable and DSL modems, and cable television using CableCARD set-top boxes.

Some current methods of device management by a service provider would be prohibited. AT&T governs access to services and implements network management

via control of the majority of all layers of both sides of the residential gateway. Since the gateway also implements DHCP and NAT for the residential network, and contains a firewall, users have no alternative implementation of these protocols. This would be in violation of our proposed law, since it does not allow users to control the residential gateway's use of DHCP and NAT for the residential network or to replace the built-in firewall. In contrast, Verizon's residential gateway would be consistent with our proposal, since it exercises control only of layers 1 through 3 and those protocols of layers 4 through 7 required to manage the network, and only on their side of the gateway.

In video networks, users would be able to choose their own set-top box, but it would allow video providers to control the lower layers of the interface facing their network. We believe this gracefully implements the current legal mandate to ensure competitive availability of set-top boxes without requiring the difficult delineation of allowed and prohibited functionality proscribed in the AllVid approach. In cellular networks, users would be able to choose their own devices and to download any application onto devices. The cellular provider would be allowed to control the air interface, but not to serve as an application gatekeeper.

5 Traffic Management

Having defined where a user's legal rights to connect to a service provider's network in section 3 and device management in section 4, we now consider traffic management. We start by examining the service contract between a user and a service provider, with particular attention to how the contract affects user and service provider rights.

Communication provides use two common pricing schemes. First, a provider may charge a fixed fee per unit of time for access, e.g. basic telephone service, unlimited telephone service, most residential Internet access plans through either DSL or cable, most cable and satellite television plans, and most cellular voice and data plans. Second, a provider may charge a *usage-based fee*, commonly a fee per unit of time or volume, e.g. per minute telephone service, per minute cellular voice service, and per byte charges for cellular data service. These are often combined, e.g. a cellular voice plan that charges a fixed monthly charge for a specified number of minutes and a per minute overage charge for additional minutes. In addition, service providers may charge for access to content or for higher layer services, e.g. an ISP may charge for additional mailboxes or webpage space, a cable or satellite television provider may charge for access to premium channels or pay-per-view, and a cellular provider may charge for ringtones, enhanced mailbox

service, or locator service. However, these are information services not communication services and are thus outside the scope of this paper.

Neither fixed fees nor usage-based fees for communication services are controversial. However, the possibility that communications provider may charge also for Quality-of-Service (QoS) has been debated. Some stakeholders argue that communications providers should not be allowed to charge anyone for QoS, other stakeholders argue that communications providers should be allowed to charge end users but not application or service providers, and some argue that communications providers should be allowed to charge end users and application and service providers. We have previously argued that communication providers should be allowed to charge both residential and business users who are subscribers, but not remote application providers that do not directly connect to the communication provider's network, so long as these charges are not unreasonably discriminatory [4]. We have also argued that communication providers should be allowed to charge peering providers for QoS. These provisions ensure a communications provider's right to charge for communication services (P1).

However, service plans are sometimes used to entice or require users to select particular devices. Regardless of whether cellular providers allow subscribers to use devices obtained from other vendors, providers almost universally subsidize devices they offer directly to subscribers. In return for this subsidy, they require a minimum service contract duration and early termination fees to enforce the contract. The subsidy may approximately reflect the revenue stream earned during the contract period, but it may be more substantially based on the popularity of the device. Termination fees may approximately reflect the subsidy, but often they do not decrease over the duration of the service contract. Many providers lock devices they subsidize, thereby restricting use of the device on other cellular providers'; the locking may continue even after the service contract duration is satisfied.

In order to address such subsidies, we propose safeguards limiting the economic integration between communication devices and communications services. This could be accomplished by applying the portion of communications law that directs the FCC to ensure a competitive market in set-top boxes. We propose:

DEVICE AND SERVICE PLAN INTEGRATION – (A) Communications providers who supply a device to a subscriber shall be required to offer communications and information services without requiring this device. (B) The communications provider's charge for the device shall not be subsidized by the service. (C) Any device subsidy shall be disclosed and

any associated early termination fee shall be no greater than the device subsidy and shall decrease linearly over the life of the service contract.

We believe that these provisions would ensure a competitive marketplace not just for set-top boxes, but for all communication devices. For instance, a cellular provider would have to allow a lower monthly rate for subscribers who bring their own devices and would have to allow smart phone users to elect a voice-only plan.

We now return to the task of determining which traffic management practices are reasonable. A communications provider may implement a charge and the associated limits of a service plan either through actions taken inside their own network and/or through actions taken in a subscriber's devices. As an example, ISPs often offer multiple broadband Internet access plans, which differ by the maximum upload and download transmission rates and by price. They usually limit the download rate inside ISP equipment but limit the upload rate by setting parameters in layer 2 protocols inside a subscriber's cable or DSL modem. We would expect any limits on QoS to be handled in a similar manner; in particular upstream QoS would likely be dictated by parameters in layer 2 and 3 protocols in the cable or DSL modem.

Our proposed legal approach to defining user versus ISP control over user devices, discussed above, provides the proper limits to ensure this right. Communication providers can exercise control over layer 1 through 3 protocols in user devices in between the demarcation point and the communications provider's interface of the user communications gateway. This provision ensures right P1.

Our proposed legal approach to defining user versus ISP control over user devices also provides ideal limits for ensuring a communication provider's right to implement reasonable network management (P2). Communication providers can exercise control over higher layer protocols in between the demarcation point and the communications provider's interface of the user communications gateway if such control is necessary for reasonable network management. There is a long history in communications law of using the term *reasonable* as a qualifier on pricing and control over communications. The determination of reasonableness is usually made by the FCC. We have previously proposed the following:

REASONABLE NETWORK MANAGEMENT – A network management practice is reasonable if, and only if, the user has control over the use of the practice or the practice controls Quality-of-Service on the basis of reasonable payment.

This provision would accomplish the desired purpose of

simultaneously assuring user's rights to run applications of their choice (U2) and communications providers' rights to use reasonable network management (P2). Additional details can be found in [5].

6 Conclusion

We have proposed provisions of communications law that could ensure user rights to attach devices and to run applications, while simultaneously ensuring communication service provider rights to charge for communication services and to use reasonable network management. Central to our approach is the delineation between user and provider networks via a standardized demarcation point and delineation between user and provider control over user devices via a user communications gateway.

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