A Model for Emergency Service of VoIP Through Certification and Labeling

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Abstract

Voice over Internet Protocol (VoIP) will transform many aspects of traditional telephony service including technology, the business models and the regulatory constructs that govern such service. This transformation is generating a host of technical, business, social and policy problems. The Federal Communications Commission (FCC) could attempt to mandate obligations or specific solutions to the policy issues around VoIP, but is instead looking first to industry initiatives focused on key functionality that users have come to expect of telecommunications services. High among these desired functionalities is access to emergency services that allow a user to summon fire, medical or law enforcement agencies. Such services were traditionally required (and subsequently implemented) through state and federal regulations.

Reproducing emergency services in the VoIP space has proven to be a considerable task, if for no other reason then the wide and diverse variety of VoIP implementations and implementers. Regardless of this difficulty, emergency service capability is a critical social concern, making it is particularly important for the industry to propose viable solutions for promoting VoIP emergency services before regulators are compelled to mandate a solution, an outcome that often suffers compromises both through demands on expertise that may be better represented in industry and through the mechanisms of political influence and regulatory capture. While technical and business communities have, in fact, made considerable progress in this area, significant uncertainty and deployment problems still exist.

The question we ask is: can an industry based certification and labeling process credibly address social and policy expectations regarding emergency services and VoIP, thus avoiding the need for government regulation at this critical time?[1] We hypothesize that it can. To establish this, we developed just such a model for VoIP emergency service compliance through industry certification and device labeling. The intent of this model is to support a wide range of emergency service implementations while providing the user some validation that the service will operate as anticipated. To do this we first examine

[1] We would like to thank and acknowledge the NET Institute (http://www.NETinst.org) for supporting this project.

possible technical implementations for emergency services for VoIP.[2] Next, we summarize the theory of certification as self-regulation and examine several relevant examples. Finally, we synthesize a specific model for certification of VoIP emergency services. We believe that the model we describe provides both short term and long-term opportunities. In the short term, an industry driven effort to solve the important current problem of emergency services in VoIP, if properly structured and overseen as we suggest, should be both effective and efficient. In the long term, such a process can serve as a model for the application of self-regulation to social policy goals in telecommunications, an attractive tool to have as telecommunications becomes increasingly diverse and heterogeneous.[3]

1 Introduction

The transformation to VoIP will ultimately impact all sectors of the telecommunications services industry – traditional incumbent local exchange carriers, cable providers, wireless service providers, emergency service providers, etc. – and is only in its very early stages. Similar to the service providers, both hardware and software developers are struggling to understand and take advantage of the opportunities in this area, including prospects for new technologies (such as integrated messaging and mobile collaboration). Moreover, business, governmental and residential consumer users of telecommunications equipment and services are looking for guidance on when and how to upgrade to a new technological frontier. Finally, governmental agencies are struggling to ensure that social policy concerns are addressed in a very different technological environment.

The disruption of VoIP promises to upend a century old model of voice telephony by creating a more dynamic marketplace and changing the point of control from the central office switch to the end user's device. For all of the relevant stakeholders affected by VoIP (i.e., service providers, hardware and software vendors, customers, and governmental agencies), there is a great need for clear insights and analysis of the issues raised by the transition from the traditional Public Switched Telephone Network (PSTN) to a packet-switched, Internet Protocol-based architecture.

The social policy implications of VoIP present regulators and incumbent businesses with a true dilemma – i.e., choices between mutually exclusive and equally unfavorable options. Under the current PSTN-based voice telephone network, a number of critical policy goals, such as reliable Emergency Service (ES), are provided effectively and reliably. Most VoIP services, at least as they exists today, do not deliver the same quality ES service, leading some state regulators to consider legacy regulation on this service to require it to do just that (along with other requirements), regardless of the dramatic

[2] Note that we use the term *emergency services for VoIP* rather than specifying it as *E911 for VoIP*. This is to distinguish between the technology of traditional emergency services carried over the PSTN versus those carried over IP, and to emphasize that emergency services in the IP space might be very different in terms of function from traditional E911.

[3] We would first like to thank the NET Institute (http://www.netinst.org) for funding this work. We would also like to thank Professor Patrick Ryan of the Interdisciplinary Telecommunications Program (ITP) and the School of Law at the University of Colorado at Boulder for his helpful comments and assistance. Finally, we would like to thank Hary Balasubramanian and Raunaq Gahndi of the ITP at the University of Colorado at Boulder for their contributions to Sections 2.1, 2.2 and the appendix.

technical and business model differences in nascent VoIP services.[4] The FCC has only begun to develop its regulatory strategy for how to address VoIP, although Chairman Powell has made clear that it will need to differ from the legacy model used in the PSTN context.[5] Given this situation, it is unclear how such services might evolve in a meaningful and timely fashion.

Self-regulation can be a viable alternative to government regulation in a number of specific circumstances. Certification, in particular, can be provided by a self-regulatory body as evidence of conformance to required attributes, practices, or policies. Self-regulation has a number of potential advantages; for the case of VoIP emergency services we are particularly interested in exploiting information asymmetries between industry and government given the increase in complexity and heterogeneity as we move from PSTN to VoIP. But, to be successful and credible, self-regulation needs to be set in a careful institutional framework, including clear and consistent external motivation for self-regulation, a process for determining the specifications to be certified, identification of certifiers and whether there is a competitive market for certification, reference to an appropriately neutral accrediting party (a role that government can but does not have to fill), communication of certification to users, and policing of certification. The telecommunications industry has repeatedly demonstrated the ability to self-regulate in areas of interoperability where economic motivation can be relied on to incent the activity. In this case, though, we propose that the industry self-regulate to address a social policy goal. Success in this could add self-regulation as a tool to be applied in other social policy cases, either arising through the transition from PTSN to VoIP, or from new social policy goals (that would otherwise be imposed by government regulation of telecommunications, as has traditionally been the case).

The particular technical challenges around VoIP ES arise from two major drivers: variability and location. VoIP can be seen as a much more variable service than traditional PSTN-based telephony; many new business models and technical combinations are emerging in which quality, modes of creating and terminating calls, integration with other messaging technologies,[6] types of terminals – phones, PDA's, PC's, etc., have all become heterogeneous. For ES in particular, the fact that IP networks are fundamentally location independent, and VoIP services may run on IP networks over many different types of wired and wireless access,[7] challenges a fundamental

[4] Vonage Holding Corp. v. Minnesota PUC, available at http://www.puc.state.mn.us/docs/vonagemem.pdf.

[5] Statement of Michael K. Powell on V oice over Internet Protocol, available at http://hraunfoss.fcc.gov/edocs_public/attachmatch/DOC-244231A1.pdf.

[6] Indeed, we should ask to what extent social policy expectations of emergency services response to voice communications should also apply to the many other modes of communication that are now popular or may become popular, including email, instant messaging, and video telephony. We submit that given the possible breadth of regulation that would be implied by such an increase in scope, the option of effective self-regulation would be even more valuable than for telephony ES alone.

[7] For example, VoIP is increasingly carried over WiFi wireless local access networks, and "dual mode" phones which can switch between VoIP/WiFi and cellular service are now being marketed. See Corie Lok, "One Person, One Phone," Technology Review (March 2004) (available at: http:// http://www.technologyreview.com/articles/print_version/innovation10304.asp) and Marguerite Reardon,

contemporary ES expectation – that an emergency services dispatcher can identify the location of the caller even if the caller does not know or is not able to describe it. Although substantial progress is being made in technical solutions to providing ES in the various VoIP settings, users may not be able to ascertain prior to an emergency whether the particular service they are employing is ES capable. In fact, we propose to use labeling to certify to users a particular level of ES capability, acknowledging that VoIP's diversity will preclude a single common requirement for all possible VoIP services. We also propose that testing be available to the end user to ascertain the ES capability.

Our first major goal in this paper, then, is to examine the technical issues around ES in VoIP, the status of proposed technical strategies[8], and from these identify candidate criteria to be used in certification. Secondly, we will examine the theory and examples of successful certification within self-regulation regimes, including the use of certification in product safety and in particular Underwriters Laboratories as a certifying institution, ISO 9000 quality system certification, interoperability certification within the telecommunications industry through Cable Television Laboratories and Telcordia, and the Wi-Fi Alliance as a consumer oriented certification consortium. We combine both sets of insights to make a set of specific recommendations on institutional design, technical criteria and certification process as our culminating synthesis.

2 Technology Assessment

In this section, we undertake a technology assessment of VoIP ES based on a classification of fundamental trends in technology and protocol models. We begin by reviewing the basic operations and functions of today's emergency services. Next, we discuss the engineering and operations of VoIP systems. Finally, we describe how VoIP ES might be instantiated and offer a set of possible VoIP ES *straw man* requirements.

2.1 Emergency Services and the PSTN

In the context of the PSTN, emergency services in the US have long been known by the dialing convention 9-1-1.[9] Dialing this number causes the routing of an emer gency call to the appropriate public safety answering point (PSAP) and then eventually to fire, medical or law enforcement agencies. Enhanced 911 (E911) added the ability for the emergency services dispatcher to see the calling number and the location of the caller. Regulations imposed on emergency services obligations vary across service, technology and local, national and international borders.[10] In the US, carriers are required to support

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"Wi-Fi and VoIP: Is Sum Greater Than Parts," CNET.com (March 1, 2004) (available at: http://news.com.com/2102-7352_3-5167782.html).

[8] VoIP has a number of different signaling frameworks, including the Session Initiation Protocol (SIP) and H.323. For the most part, we attempt to proceed in a framework independent manner in this paper; however, where the framework is relevant we focus on the SIP framework. We fully acknowledge that development of actual certification standards will need to consider multiple frameworks. Our emphasis on SIP is motivated by technical, market, and policy issues that are outside the scope of this paper.

[9] For background on 911, see http://www.fcc.gov/911.

[10] Although common in many respects, there are some differences, for example, between ES regulation in the European Union in the United States (see http://europa.eu.int/eur-lex/pri/en/oj/dat/2003/l_189/l_18920030729en00490051.pdf), a simple but obvious difference being the emergency number itself (112 for Europe).

911 service (under the 911 Act),[11] with regulatory responsibility divided between federal, state and local authorities.[12]

In traditional E911, the initial routing of a 911 call is provided by the central office, which makes use of a routing database to associate a caller dialing 9-1-1 with the appropriate PSAP. E911 provides calling number information in the Automatic Number Identification (ANI) and location information in the Automatic Location Information (ALI), and assumes that the PSAP that receives the call is geographically related to the call origination; this routing is accomplished through a lookup of a selective router database. The PSAP accesses a Public Safety – Automatic Line Information (PS-ALI) database to associate the calling number with a physical location. The PSAP may then forward the call to an emergency call center, which then performs another database lookup (on a database maintained by the telephone company) to associate the caller's phone number with a location.

2.2 Emergency Services and Wireless

While not wholly the same, many of the problems facing VoIP ES have commonality with those of ES for commercial mobile radio service ('wireless' telephony). Although the technologies are different, some of the solution mechanisms apply and certainly lessons could be drawn from the experience. For example, the development and adoption of wireless ES solutions took a long and convoluted path.[13] While much of this had to do with technical uncertainty, a significant amount of the delays were a direct result of industry resistance. This first suggests the need to gather a better technical understanding very early in the process. It also suggests the need for regulatory agencies to establish strict timelines. Another issue to consider is whether certain policy approaches might hasten the process. In the wireless ES regulatory process, the FCC played a substantial role in specifying and assessing the technical characteristics of the location technology. This process consumed considerable time. An industry lead specification and assessment process may have hastened this process; particularly with monitoring and deadlines set by regulatory agencies. Another issue to consider is that of the implementation process. Wireless ES made use of a phased implementation process. A phased approach that considers short versus long-term solutions should help in promoting the early approach of

[11] "In the Matter of Implementation of 911 Act: The Use of N11 Codes and Other Abbreviated Dialing Arrangements", Fifth Report And Order (CC Docket No. 92-105) and First Report And Order (WT Docket No. 00-110), 2001.

[12] For example, the 911 Act requires the FCC to take a leadership and support role in implanting wireless 911, but does not give it the authority to regulate statewide plans (see http://www.fcc.gov/911/stateplans/about.html.)

[13] Dale N. Hatfield, "Challenges of Network Design in an Increasingly Deregulated, Competitive Market" Remarks at the IEEE International Symposium (March 27, 2003), available at http://www.im2003.org/presentation%20files/RemarksDH_IM2003.doc; A Report on the Technical and Operational Issues Impacting Wireless Enhanced 911 Services (2002) (http://gullfoss2.fcc.gov/prod/ecfs/retrieve.cgi?native_or_pdf=pdf&id_document=6513296239.); Dale Hatfield, Architecture As Policy in The Standards Edge: Dynamic Tension (Sherrie Bolin, ed.) (2004).

interim solutions and allow for the creation of reasonable timelines for long-term solutions.[14]

One important lesson worth considering is not to allow past regulations define future policy. Different technologies operate in different manners and these differences can provide new features and challenges not realized with the previous technology. For example, as Schulzrinne points out, there are a number of opportunities that VoIP offers, including: higher resilience, faster call setup, accessibility support, multimedia support, more cost efficient, more call data, no telephone reliance and more competition.[15] IP networks do not have the same geographic nature as traditional telephony networks. In other words, an IP phone does not need to associate with a local central office; in fact, unlike traditional telephony, there is little-to-no need for explicit voice service providers. The functions of the provider are decomposed and pushed out to the end points with minimal provider assistance. Creating policies that do not appreciate such differences could result in the loss of technical opportunities to better serve society.

2.3 VoIP Technology

In simple terms, VoIP is the carriage of a speech conversation over an Internet Protocol-based network.[16] The power and the complexity of VoIP comes largely from the ability to separate functions that were traditionally bound together, such as transport and signaling, and thereby provide many more options for each based on ubiquitous and increasingly inexpensive IP-based networking and IP compatible access technologies, processing, and storage.

2.3.1 VoIP parameters

IP networks do not generally offer the same level of performance as circuit switched network. To provide similar performance requires that we explicitly consider specifics VoIP parameters, such as encoding, delay and transport.

Transmission of voice over packet networks (e.g., VoIP) requires the conversion of analog voice to a digitized form followed by a subsequent encapsulation of the digital content into a packet technology before transmission using an access technology. The initial analog conversion process is referred to as encoding.[17] After the analog content

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[14] In an FCC news release (see http://hraunfoss.fcc.gov/edocs_public/attachmatch/DOC-241214A1.pdf) describes the obligations imposed on certain carriers in terms of providing emergency services. The regulations on carriers are imposed in two phases, first of which requires the carriers to report the wireless caller's phone number the location of the antenna that received the call. The E911 second phase requires wireless carriers to provide the precise location of a 911 caller within 50 to 100 meters. Phase 2 can be deployed over 4 years, beginning in October 2001 and to be completed by December 31, 2005.

[15] Schulzrinne, H., "9-1-1 Calls for Voice-over-IP," Ex-Parte Filing for Docket 94-102, February 2003.

[16] The difference between VoIP providers and products is worth considering. VoIP as a product can be offered much like any other software application (e.g., MS Word). Some VoIP products can be installed on a PC and made to run with little (or no) participation of a service provider. Such products make use of the network to reach other end points and rely on intelligence within the product (or information added to the product). On the other hand, a service provider can augment a product by adding such things as additional functionality, routing and database capabilities, security and more. In this model, the product may still be software or may be physical devices (and software) coupled closely to the service provider.

[17] In digital telephony over the traditional PSTN network, voice is usually encoded using PCM-u or PCM-A resulting in a bandwidth requirement of 56 - 64 Kbps. However, a variety of different compression

has been encoded into a digital format, the information is packetized (with the help of a transport layer)[18], and passed to the access technology (e.g., Ethernet) for delivery on the network. At the other end, the digital information is retrieved and converted back into analog form, which the listener can then understand. VoIP permits a wider range of choices and tradeoffs among performance parameters than in the traditional PSTN, including:

- Distortion – low bit rate compression may be bandwidth efficient but may also distort speech.
- Errors – voice traffic has some degree of error tolerance (e.g., a small amount of missing information will not impact intelligibility – by comparison even a small error in a financial transaction is intolerable). But, at a high enough error rate from lost or errored packets, intelligibility degrades.
- Delay – compression algorithms, packetization, and other stages of packet transmission induce delay. Delays in excess of 250 milliseconds can be annoying. High delays tend to induce a half duplex conversation in which each party pauses for a substantial time after each conversational turn to see if the other party wants to speak.

  Both errors and delay are affected by whether the networks involved in transmitting the voice are loaded (are subject to traffic that is a substantial fraction of their capacity) and whether they have some form of prioritization capability (i.e. quality of service, or QoS). Loaded networks without QoS typically induce long and variable delay (jitter) and can drop packets.
- Echo – echo is a traditional issue in analog telephony; it can still be an issue in VoIP depending on the design of the analog portions of the system.
- Power – analog PSTN terminals can be powered by the phone network; providing the phone network has backup power, the system (including 911 service) can remain operational even if the customer premises is without power. This is not necessarily true of VoIP systems (although, it is also not true of now ubiquitous cordless phones connected to the PSTN).

For ES, we are concerned with the potential impact of these characteristics on the intelligibility of the call and on the availability to place ES calls during power outages.

2.3.2 VoIP Signaling

The traditional functions of setting-up and tearing-down calls persist in VoIP; however, they can be augmented and extended in a number of ways by exploiting the ubiquity of IP

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algorithms can be applied in VoIP providing all participating terminals have the required capability. Various algorithms can trade-off quality, delay, computation and bandwidth. For example, G.723.1 reduces the bandwidth usage of the call to 5.3 Kbps but also introduces a computational delay of 67.5 ms.

[18] Typically, the Real-time Transport Protocol (RTP) adds important timing and other information relevant to voice and other time sensitive media traffic. Next the User Datagram Protocol (UDP) provides limited multiplexing and data detection – it does not provide error recovery as is the case in its peer protocol TCP; error management is left to the combination of RTP and the voice codec used. Finally, UDP packets are placed in Internet Protocol (IP) packets, providing delivery to a specified internet address.

networks and inexpensive processing and storage capability. Signaling protocols control these functions.

VoIP signaling protocols continue to evolve and include several variants (in some case competing and in some case complementary) of which the most important are the Session Initiation Protocol (SIP), H.323, media gateway protocols,[19] and a number of proprietary protocols. Here we focus primarily on the role of SIP based systems in supporting ES.

The Session Initiation Protocol (SIP)[20] is a protocol developed within the IETF .[21] It provides for the establishment, modification and termination of sessions (a session can be thought of as a call). A SIP network generally consists of User Agents (UAs), proxies, registrars and redirect servers, all interconnected via an IP network. These devices exchange messages with each other in a process that leads to the establishment of the call, in a manner analogous to the now widespread packet signaling system used in the PSTN, Signaling System 7 (SS7). Appendix A provides a more detailed description of how SIP operates; including an overview of its functions, the network components and the message flows.

SIP could enable enhancements in ES by providing a more rich information set than ANI and ALI. For example, I could program my VoIP device to transmit to the emergency calling center (via SIP) my medical records or to contact my wife in the case of an emergency. Such functions, if highly desirable socially and implementable at a reasonable cost could easily become subjects of future social policy, or, as we suggest in this paper, self-regulation.

2.4 ES for VoIP

As a basis for an technical model, we turn to the work of the IETF. The IETF has several Internet Drafts (together with existing RFCs) describing the potential operation of VoIP ES based on the use of SIP and associated protocols.[22] In this section we briefly describe these works-in-progress and point out areas relevant to our model. While not all of these drafts will reach maturity, based on this work we should be able to describe a reasonable VoIP ES model.

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[19] This includes the Media Gateway Control Protocol (MGCP), MEGACO and H.248. A media gateway interfaces between a VoIP network and the PSTN; a media gateway controller interacts with the signaling systems in each domain and manages the configuration of the media gateway. The separation of voice processing from management and the ability to independently distribute the functions results in an architecture called "softswitch". VoIP architectures in which softswitch and interfacing to the PSTN play a substantial role are generally less flexible in the sense of end user control over system behavior, but such constraints may aid in implementing traditional PSTN system functionality, including E911. In any case, this type of architecture will be important for a substantial period, likely measured in multiple decades, while VoIP and PSTN systems must coexist.

[20] "Session Initiation Protocol", Rosenberg, J., Schulzrinne, H., Camarillo, G., Johnston, A., Peterson, J., Sparks, R., Handley, M. and E. Schooler, RFC 3261.

[21] Two IETF working group, SIP and SIPPING, are active in the development of session related protocols. These groups have developed various standards (RFCs) and drafts within this space, of which the SIP RFC 3261 represents the core protocol.

[22] See the next several footnotes.

Based loosely on work within the IETF,[23] we propose the following requirements for VoIP ES: (i) the support for a reasonable QoS connection[24], (ii) an recognized ES number (the equivalent of 9-1-1) to identify an emergency call, (iii) the ability to route the call to the appropriate response group (PSAP), (iv) the means of locating the caller, (v) the means of identifying the caller and (vi) the ability to test the system.[25]

Other concerns, such as the security or network operations, are more general to VoIP, but still may warrant consideration when verifying the operation of VoIP ES. Certainly security will be highly significant and mechanisms for privacy, authentication, authorization and availability will be required.

We should note that much of the operation of a SIP-based ES would reply on well-established and commonly deployed protocols, including SIP,[26] Domain Name Service (DNS) and ENUM.[27] For the functionality not provided within this specification, we turn to various drafts. The main point of reviewing these drafts is to establish that the SIP community is resolving the problems. In a draft entitled "Emergency Services for Internet Telephony Systems," the authors describe how SIP might be used to provide ES.[28] They propose an architecture based on existing SIP features and make use of DNS mechanisms to provide location mapping. In a draft entitled "Emergency Services URI for the Session Initiation Protocol,"[29] the author defines two universal emer gency SIP URIs, which can be thought of as emergency numbers, like 9-1-1. The draft also suggests ways of increasing the likelihood of being able to contact an emergency call center. Several drafts address the problem of location through varying techniques.[30] These drafts include specifications of object formats, privacy mechanisms and the use of other protocols to assist in determining and conveying a user's location. Other drafts propose methods of conveying user agent capabilities and profiles, both of these

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[23] Schulzrinne, "Emergency Calling", presented at the 59th IETF, SIPPING working group, March 2004.

[24] We realize that this requirement is not a part of the IETF specifications and that many will question its need. Nonetheless, if the communications cannot support the intended media (or negotiate a new media type), the rest of the ES mechanisms is moot.

[25] Unlike within traditional 911, VoIP-based ES users or service providers may wish to test the operation of their service. Such testing might be motivated by; reconfigurations, new installations, power outages, changes in service or service provider, changes in location and/or simple maintenance testing.

[26] See Rosenberg, J., Schulzrinne, H., Camarillo, G., Johnston, A., Peterson, J., Sparks, R., Handley, M. and E. Schooler, "Session Initiation Protocol", RFC 3261.

[27] ENUM is a domain name service that supports the translation between internet addresses (URLs) and telephone number.

[28] See http://www1.ietf.org/internet-drafts/draft-schulzrinne-sipping-emergency-arch-01.txt

[29] See Schulzrinne, H., "Emergency Services URI for the Session Initiation Protocol", draft-ietf-sipping-sos-00 (work in progress), February 2004;

[30] See Peterson, J., "A Presence-based GEOPRIV Location Object Format", draft-ietf-geopriv-pidf-lo-02 (work in progress), June 2004; Polk, J., "Requirements for Session Initiation Protocol Location Conveyance", draft-ietf-sipping-location-requirements-00 (work in progress), February 2004; Polk, J., Schnizlein, J. and M. Linsner, "Dynamic Host Configuration Protocol Option for Coordinate-based Location Configuration Information", draft-ietf-geopriv-dhcp-lci-option-03 (work in progress), December 2003; Schulzrinne, H., "Dynamic Host Configuration Protocol (DHCPv4 and DHCPv6) Option for Civic Addresses", draft-ietf-geopriv-dhcp-civil-03 (work in progress), July 2004;

functions are useful in providing a fully functioning emergency system.[31] An important characteristic of an ES is the ability to authenticate the caller.[32] While these techniques already exist in the SIP specification, they are augmented by a number of the above and other drafts. Finally, it is worth noting that the provision of VoIP ES needs to account for interfacing between the PSTN and VoIP networks. As indicated in the following paragraph, early implementations of VoIP ES have largely been designed in the context of interfaced VoIP and PSTN networks, with PSAP's and emergency service responders on the PSTN side.[33]

To replicate ES functionality in the SIP VoIP environment, a phased approach could be employed as described by Schulzrinne and Arabshian.[34] In the simplest (and likely initial) case, the SIP elements could connect to the legacy E911 system by a gateway connecting to the PSTN. In this case, the SIP device would look much like other devices commonly attached to the PSTN (such as a PBX). In this scenario, there is little new technology to develop, but a number of existing mechanisms do need to be consider, such as security, availability and routing.[35] Nonetheless, a certification process could be useful in terms of ensuring that the location information is accurate.[36] Also a labeling procedure could indicate any additional information that the consumer might need to be aware. In the next case, the PSAP would be directly connected ("aware") of the IP network traffic. In other words, there would not be a gateway translating INVITE messages into PSTN signaling message; therefore, the SIP session would occur between the caller and the ECC. The routing, identification and location information would still reside in telephone company databases (although, not necessarily); however, the responder could now communicate with the caller with a richer media capability (because of the direct connectivity over IP and its ability to support multimedia communications). In a long-term solution, the routing, identification and location information would now reside within the Internet and the INVITE message would carry the traffic to the PSAP. There are a number of mechanisms whereby the elements within the SIP network could gather the appropriate routing and location information, such as the use of DNS to map locations

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[31] See Petrie, D., "A Framework for Session Initiation Protocol User Agent Profile Delivery", draft-ietf-sipping-config-framework-03 (work in progress), May 2004; and Rosenberg, J., "Indicating User Agent Capabilities in the Session Initiation Protocol (SIP)", draft-ietf-sip-callee-caps-03 (work in progress), January 2004;

[32] The ability to authenticate users should help prevent such problems as crank calls. However, this could be a problematic requirement, in that a failed authorization may be the result of an administrative or technical problem.

[33] See, for example, http://www1.avaya.com/enterprise/whitepapers/lb1879.pdf and http://www.nena9-1-1.org/9-1-1TechStandards/Standards_PDF/NENA_03-003.pdf

[34] Schulzrinne and Arabshian, "Providing Emergency Services in Internet Telephony", an FCC E911 Solutions Summit, March 2004.

[35] Many of the technologies already exist for the security and routing. For example, the process of authentication and authorization could be based on existing mechanisms SIP techniques and later possibly based on trait-based mechanisms currently under development.

[36] As describes by Schulzrinne (ID. at 31), location information may to manual configured, measured by the end system (GPS), conveyed to the end system or provided within the network.

to PSAPs and emergency call centers. And while the details of how this might work are outside of the scope of this paper, they might be quite relevant to the certification mechanisms that could be deployed.

As the previous paragraphs suggest, VoIP ES could be created by enhancements to existing SIP based networks. The point is that these capabilities either presently exist or soon will. What is now necessary is the implementation of these capabilities and here is where a certification process could help. To assist in defining the characteristics of this process we next examine high-level requirements for VoIP ES.

2.5 Technology Requirements

In determining what to include within the scope of a certification process, we propose that it should first support a phased implementation. While interim solutions are available immediately, some aspects of the longer-term solution will require further technical development, industry negotiations (with possible regulatory intervention) and considerable investment. Therefore, as both NENA and Schulzrinne describe, a short-term solution - attaching IP devices to the PSTN ES in much the same way as a PBX - should be available for certification now. A longer-term solution - where IP interfaces with the PSAP directly, the PSAP participate in the IP session, and the DBs are IP accessible - should be specified as soon as possible.

Together with the phased approach, we propose that the technology specifications should support a range of technologies. For example, a certification process should be developed for other IP services such as instant messaging or videophone. Further, we believe that various levels of specification should be available within a technology. For example, there might be several levels of VoIP certification available, along the lines of good, better and best.

Below we propose a *straw man* of the high level specifications that might be required of a high quality VoIP service (a 'best' service level). Note that this service could be running as software, as an IP phone or other device.[37] Also note that we focus on certifying and labeling of the VoIP end device (not the network).

- The ability of the VoIP application to access ES infrastructure
- The ability to provide reasonable quality of service (e.g., meet the performance and reliability measures discussed in 2.2).
- The ability to participate in an authentication process
- The ability to initiate an ES call; including the use of a recognized emergency number, such as 911 or SOS as well as to form the proper ES message
- The ability of the system to accurately determine and communicate the proper location of the VoIP application/caller
- The ability for the end user to test the ES
- The ability to provide information to the user through such means as device labeling or software notification

[37] While other requirements of the network do exist, these are beyond the scope of this paper.

The details of how these requirements might be assessed remains to be determined. There are likely other requirements to consider (or a disagreement with the above items); we welcome comments on this list.

3 Existing Models

In section 3, we undertake secondary research into existing certification processes. This secondary research draws on historical analysis and literature review techniques, and includes collecting and analyzing original descriptions as well as outcomes research on certification processes, how they have been embedded in overall policy systems including government regulation, and the synthesis of an overall model for successful certification tailored to the particular technical and industrial circumstances of VoIP.

3.1 Theory and Practice of Certification

Certification is well established, for example in accrediting practitioners in professions such as medicine and law, in securities markets where underwriters and auditors perform certification, and in product safety and compatibility. More recently, certification and, more broadly, self-regulation have emerged in new social policy settings, such as certifying a manufacturer's compliance with labor practice expectations in developing countries or with specific environmental practices. Substantial research has created a reasonable understanding of what certification accomplishes as well as its challenges and drawbacks.

Certification can have both economic and social policy goals. In economic terms, products or services may have attributes (such as quality or safeness) that buyers have difficulty in ascertaining prior to purchase. In the absence of consumers' abilities to rely on signals of these attributes, consumers cannot distinguish between products and there is no incentive for the production of the attributes. Although reputation (brand) and warranties may mitigate this effect, they have limitations if they are too diffuse or if it is difficult or costly for the consumer to apply them as recourse; certification can arise as an alternative method to reliably signal attribute distinctions.[38] For social policy , certification (as an aspect of self-regulation) can serve as an alternative or complement to government regulation in avoiding the overproduction of negative (social) externalities (e.g., pollution) or the underproduction of positive externalities (e.g., safety).

Certification can have important advantages over direct "command and control" regulation. It can reduce the demand on government services and consequently required levels of taxation (or, put another way, it can better accommodate reduced government capability under neo-liberalism). It can exploit information asymmetries in which industry participants have more and better information than a potential government regulator.[39] The direct use of industry information may increase the rate at which regulation can adapt as circumstances change and reduce the need to enumerate all

[38] Gian Luigi Albano and Alessandro Lizzeri, "Strategic Certification and Provision of Quality," International Economic Review, v. 42, n. 1, Feb. 2001, pp. 267-283.

[39] Hayne E. Leland, "Quacks, Lemons, and Licensing: A Theory of Minimum Quality Standards," The Journal of Political Economy, v. 87, n. 6, Dec. 1979, pp. 1328-1346.

conceivable contingencies, resulting in more flexible and lighter weight regulation.[40] And pre-emptive self-regulation may avoid subsequent investment by both industries and their opponents in political influence.[41]

There can also be a moral and cultural effect from self-regulation by inculcating an ethical component in institutional self-image that induces behavior that exceeds mere compliance with the letter of the law.[42] Conversely, imposition of rigid regulation instead of self-regulation on sectors that have a strong anti-authoritarian tradition can "destroy virtue in the business community."[43]

Certification can have undesirable side effects that should be anticipated in institutional design. If certifiers are under the control of the body being certified, certification may be deliberately structured to restrict new entrants and extract monopoly rents for already certified parties,[44] an attribute of guilds that continues in contemporary professions that require certification.[45] A parallel concern for social policy is challenged credibility if the certifier is perceived to be too tightly controlled by the certified.[46]

Similarly, if the capability of certifying is limited to a single or small number of suppliers of certifications, we might anticipate a trend towards capture of monopoly rents by the certification process itself to the detriment of suppliers or consumers. More generally,

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[40] Christodoulos Stefanadis, "Self-Regulation, Innovation, and the Financial Industry," Journal of Regulatory Economics, v. 23, n. 1, 2003, pp. 5-25.

[41] Specifically, resulting in a Pareto improvement in welfare; see John W. Maxwell, Thomas P. Lyon, and Steven C. Hackett, "Self-Regulation and Social Welfare: The Political Economy of Corporate Environmentalism," Journal of Law & Economics, vol. XLIII, October 2000, pp. 583-615.

[42] Marius Aalders and Ton Wilthagen, "Moving Beyond Command-and-Control: Reflexivity in the Regulation of Occupational Safety and Health and the Environment," Law & Policy, v. 19, n. 4, Oct. 1997, pp. 415-443 and Simon Ashby, Swee-Hoon Chuah, and Robert Hoffmann, "Industry Self-Regulation: A Game-Theoretic Typology of Strategic Voluntary Compliance," International Journal of the Economics of Business, v. 11, n. 1, Feb. 2004 pp. 91-106.

[43] Darren Sinclair, "Self-Regulation Versus Command and Control? Beyond False Dichotomies," Law & Policy, v. 19, n. 4, October 1997, pp. 529-559.

[44] Id. at 38. Leland provides a more nuanced analysis of whether licensing results in standards that are too high in order to restrict competition: "If a professional group or industry is allowed to set minimum quality standards (self-regulation), these standards may be set too high or too low. On balance, however, there is some reason to expect too-high standards will be the more likely case." (p. 1342). Schaede points out a related problem in which apparent deregulation in Japan, replaced by industry self-regulation, did little to weaken trade barriers, see Ulrike Schaede, "Industry Rules: From Deregulation to Self-Regulation," The Japanese Economy, v. 28, n. 6, Nov-Dec 2000, pp. 35-58.

[45] Bernardo Bortolotti and Gianluca Fiorentini, "Barriers to entry and the self-regulating professions: evidence from the market for Italian accountants," in Bernardo Bortolotti and Gianluca Fiorentini, eds., Organized Interests and Self-Regulation, Oxford, UK: Oxford University Press, 1999, pp. 131-157 and Roger Van Den Bergh, "Self-regulation of the medical and legal professions: remaining barriers to competition and EC law," in Bernardo Bortolotti and Gianluca Fiorentini, eds., Organized Interests and Self-Regulation, Oxford, UK: Oxford University Press, 1999, pp. 89-130.

[46] In social policy regulation, critics are quick to question the extent to which firms and industries will truly restrict themselves notwithstanding their stated intentions; to some extent this rests on questions as to whether firms optimize shareholder wealth or take a stakeholder perspective; see Javier Núñez, "A model of self-regulation," Economics Letters 74 (2001), pp 91-97 and Maxwell et al. (id at 52).

even a competitive certifier market can exhibit peculiarities depending on the level of certifier liability, regulation of the certifier market, and the amount of competition,[47] for example, equilibria in which certifiers do not provide all information or choose to provide noisy information,[48] The structure of the certifier market is consequently a non-trivial consideration.

The insurance industry plays a special role in certification. Certification can signal lower insurance risks, which may then be reflected in lower premiums; importantly, again, insurers need to be able to rely on sufficient independence of certifiers from producers. Certifiers vigorously competing for producer business may compromise the accuracy of certification; witness recent scandals in auditing.[49]

Closely related to the role of insurance in certification is the role of liability. Liability already has a role complementary to regulation in, for example, safety: neither liability nor regulation by themselves are generally adequate to produce socially desirable levels of care.[50] From a producer's perspective, self-regulation that results in an active compliance activity may provide protection against imputation of "intent" to undertake unlawful acts.[51] In product liability , for example, a showing of negligence usua lly requires that all of the following elements exist: (1) duty – did the vendor use "reasonable care", (2) breach of duty – was there unreasonable conduct (i.e., act, or a failure of act), (3) forseeability – was the problem foreseeable, (4) proximate cause – the breach must be the cause of damage, and (5) damage – usually physical injury, although sometime other loss may count. The existence of a widely accepted industry certification or a government endorsed certification and a vendor's consistent effort in securing such certification can aid a defense on both the question of duty and of breach of duty.

A critical question in self-regulation is the appropriate role of government. Pure self-regulation (that is, without any external influence) is usually rejected on the basis that

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[47] Luigi Alberto Franzoni, "Imperfect competition in certification markets," in Bernardo Bortolotti and Gianluca Fiorentini, eds., Organized Interests and Self-Regulation, Oxford, UK: Oxford University Press, 1999, pp. 158-176.

[48] Id. at 37.

[49] For another example, periodic softness in the market for maritime insurance leads to lax response of insurers to negative certification signals; see Frank Furger, "Accountability and Systems of Self-Governance: The Case of the Maritime Industry," Law & Policy, v. 19, n. 4, October 1997, pp. 445-476.

[50] Steven Shavell, "A model for the optimal use of liability and safety regulation," Rand Journal of Economics, v. 15, n. 2, Summer 1984, pp. 271-280.

[51] For example, Ruhnka and Boerstler quote from the jury instructions in a criminal anti-trust case (*U.S. v. Koppers*)

> You are instructed that the mere existence of an antitrust compliance policy does not automatically mean that a corporation did not have the necessary imputed intent. If, however, you find that the…Company acted diligently in the promulgation, dissemination, and enforcement of an antitrust compliance program in an active good faith effort to ensure that the employees would abide by the law, you may take this into account in determining whether or not to impute an agent or employees' intent to the…Company.

See John C. Ruhnka and Heidi Borestler, "Governmental Incentives for Corporate Self-Regulation," Journal of Business Ethics 17, pp. 309-326, 1998.

there is little evidence that this mode naturally arises or is effective.[52] Conversely there is a broad correlation between evidence of governmental incentives for the creation of self-regulation and self-regulatory activity,[53] so that successful and credible self-regulation seems to be consistently coupled with some form of influence or oversight, leading to a model that might be better described as co-regulation.[54] Such external influence may come from government or, as is apparent in certain contemporary social policy cases, independent non-governmental organizations with political influence or influence over consumer choice.[55] The way the government should signal its intentions when influencing the formation of self-regulatory bodies can be important: game theoretic analysis suggests that government should firmly signal an expectation of zero tolerance of undesirable behavior and the certain invocation of direct regulation if such behavior is observed.[56] On a more positive note, the government can encourage self-regulation through a variety of positive signals regarding preferential treatment for diligent self-regulators.[57]

Three processes are commonly present in social regulation and are also potentially applicable to co-regulation (by selecting whether to invoke them and, if so, how to divide responsibility between a government agency and a self-regulating body): prior approval –

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[52] Id. at 41. Id. at 42. Id. at 45.

[53] Id. at 51.

[54] The tendency in some of the literature to paint command-and-control regulation and self-regulation as stark and distinct alternatives is overly restrictive, as Sinclair (id at 54) points out (p. 532): "Those who are locked into a paradigm which incorrectly assumes that choices have to be made between artificially restrictive models of self-regulation and command and control regulation are unlikely to be capable of appreciating the more nuanced opportunities for achieving both efficiency and effectiveness, which arise from complementary combination of both types of instruments." Sinclair goes on to list four key components that can be modulated to select a policy on the spectrum between command-and-control and self-regulation:

- the nature and extent of *regulatory compulsion*;
- the extent to which *regulatory flexibility* allows firm so accommodate their individual circumstances;
- the opportunity for *industry design input* into the negotiation and development of regulation; and
- the extent which *win-win outcomes* are the focus of regulation.

(emphasis in original)

The structure of legal and regulatory incentives to influence self-regulation has traditionally been primarily "punitive" and often continue to be so, but in some more recent cases is shifting towards "positive" incentives that benefit corporations for actions that encourage or assist desirable behavior (Ruhnka).

[55] Dara O'Rourke, "Outsourcing Regulation: Analyzing Nongovernmental Systems of Labor Standards and Monitoring," The Policy Studies Journal, v. 31, n. 1, 2003, pp. 1-28, and Tim Bartley, "Certifying Forests and Factories: States, Social Movements, and the Rise of Private Regulation in the Apparel and Forest Products Fields," Politics & Society, v. 31, n. 3, Sept. 2003, pp. 433-464.

[56] Ashby.

[57] Ruhnka and Boestler, give as examples recognition of compliance with self-regulation as a mitigating factor for corporate regulatory violations by regulating agencies, state and federal prosecutors, and in jury instructions and sentencing guidelines, recognition of self-reporting as a mitigating factor by prosecutors and regulators, and substitution of internal compliance for agency monitoring.

in which firms obtain approval before engaging in an activity, mandatory standards – in which firms are required to comply and monitored, and information disclosure – in which firms are required to signal facts to buyers that they might not otherwise choose to disclose.[58] Interestingly , the framework by which self-regulation is invoked can also result in unanticipated effects; it is conceivable that a government crafted "voluntary agreement" will reduce the effort by industry to engage in its own thoughtful design of self-regulation, reducing welfare;[59] this suggests again that while government should apply credible pressure in order to motivate self-regulatory activity, it is important to do so in a manner that exploits the potential advantages of self-regulation, particularly information asymmetries.

A necessary element for the industrial, self-regulatory component is coherent industry representation.[60] Possibilities include standards bodies, industry associations and the consortia increasingly evident in the information and communication technology industries, although care must be taken, especially in the later case, to mitigate the potential for exclusion and reduced competition.[61]

Software is an increasingly important product and component and has differences from other types of products that have traditionally been certified. Software can directly affect safety, resulting in increased scrutiny of software reliability. Certification here can serve both economic purposes of signaling quality to users and of reducing liability of producers.[62] Software often has an iterative and incremental design character; delaying certification testing until the completion of software implementation can be quite inefficient. Consequently, certification testing is better introduced as an integral part of the internal and regression-testing characteristic of software design processes.[63] Interestingly, embedding certification testing throughout the design cycle can inculcate a culture in which the criteria used for certification become implicit values of the designing organization – for example, embedding security certification testing can help foster a "security culture".[64] Broad software certification faces significant challenges, though: maintaining adequate criteria to certify may itself be infeasible if the product to be certified is complex and changes rapidly in function and capability; certification may only be practical if restricted to aspects of the system that can be reasonably isolated and slowly changing. Moreover, different types of certification come with different

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[58] A. Ogus, "Regulatory Institutions and Structures," Annals of Public and Cooperative Economics, v. 73, n. 4, 2002, pp. 627-648.

[59] Thomas P. Lyon and John W. Maxwell, "Self-regulation, taxation, and public voluntary environmental agreements," Journal of Public Economics, v. 87, 2003, pp. 1453-1486.

[60] Id. at 42.

[61] Richard Hawkins, "The rise of consortia in the information and communication technology industries: emerging implications for policy," Telecommunications Policy 23 (1999) pp. 159-173.

[62] Although it should be noted that producers of software already have a history of limiting liability through the terms of software licenses. In light of this, some advocate an insurance industry driven certification regime akin to Underwriters Laboratory style safety certification. Harold W. Lawson, "Infrastructure Risk Reduction," Communications of the ACM, v. 41, i. 6, June 1998, p. 120.

[63] Patricia Rodriguez-Dapena, "Software Safety Certification: A Multidomain Problem," IEEE Software, July/August 1999, pp. 31-38.

[64] Greg Goth, "Will the Cyber-UL Concept Take Hold?" IEEE Software, July/Aug 2002, pp. 12-15.

challenges; as Schneier points out, certifying for security – where threats are active, intelligent, and hostile – is more challenging than certifying for safety – where threats are usually passive and random.[65]

3.2 Certification Examples

Underwriters Laboratories and Product Safety Certification

Underwriters Laboratories (UL) was incorporated (as a non-profit) in 1901, funded by the National Board of Fire Underwriters to prepare lists of safe products, demonstrating the potential of linking certification to insurance[66]. In 1916, insurance industry funding ceased and UL became fully supported by testing fees. Manufacturers are motivated to seek UL certification because (i) it is required by specific customers, (ii) it is recognized as indicating product safety by consumers and (iii) it can reduce liability by supporting demonstration of reasonable care.

Co-regulation of safety by Underwriters Laboratories as an industry certifier and by government agencies is apparent in two distinct models. The Occupational Safety and Health Administration accredits Nationally Recognized Testing Laboratories through an explicit accreditation process;[67] Underwriters Laboratory was originally the only such lab but is now one of several.[68] Required evidence of certification by an accredited laboratory is present in OSHA regulation, directly motivating manufacturers to produce and buy certified products. The Consumer Product Safety Commission,[69] on the other hand, has a less formal relationship. CSPC actively contributes to the content of UL standards where it has an interest.[70] In other cases, the CSPC may use public criticism as an influence mechanism over UL practice.[71] Underwriters Laboratories, for its part, invests actively in serving government and regulators, including providing consulting service and providing information only available to regulators.[72]

Telecommunications Certification: CableLabs and Telcordia

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[65] Scott Berinato, "A UL-type seal for security? Don't bet on it." eWeek, October 16, 2000, pp. 11-12.

[66] For a brief but interesting history of UL, see Harry Chase Brearly, "A Symbol of Safety: The Origins of Underwriters' Laboratories," in Daniel B. Klein, ed., Reputation: Studies in the Voluntary Elicitation of Good Conduct, Ann Arbor, MI: The University of Michigan Press, 1997, pp. 75-84.

[67] Accreditation fees for test laboratories are on the order of $10,000.

[68] The OSHA decision in 1988 to create a competitive market for testing could not be the result of the strict profit motive on the part of UL as UL was and is a non-profit organization. However, absent the discipline of competition, even a non-profit organization may not evolve or diligently pursue efficiency. Current UL management is undertaking a major effort to modernize and increase efficiency in the organization, see http://www.ul.com/info/UL_AR_2003.pdf and Brett Nelson, "Under Fire," Forbes, v. 173, i. 13, June 21, 2004.

[69] See http://www.cpsc.gov.

[70] CPSC also participates in defining standards of other "voluntary standard" safety standard setting organizations, such as ASTM International (http://www.astm.org). CPSC also has the authority to directly regulate where it sees sufficient safety risk by "issuing and enforcing mandatory standards or banning consumer products if no feasible standard would adequately protect the public."

[71] "Underwriters Laboratories Has Been Coming Under Fire," Consumers Research, Jan. 2000, pp. 40-41.

[72] See http://www.ul.com/regulators/.

The telecommunications industry has a history of certification for interoperability purposes[73]. This form of certification most directly addresses the economic motivation for certification – interoperability is an attribute valued by buyers that is difficult for them to ascertain prior to purchase. Historically, most social policy goals have been advanced through governmental regulation rather than self or co-regulation.

Cable Television Laboratories (CableLabs) is a non-profit research consortium founded in 1988 and funded and controlled by cable operators (generally called multiple system operators, or MSOs) in the cable television industry. In addition to leading the development of standards, the firm provides certification and qualification testing for those standards.[74] The rationale for equipment vendors to design to CableLabs standards and seek CableLabs certification is that certification is a common requirement of MSO's in making equipment purchases. MSO's are motivated to seek certification against standards to increase the supply of interoperable equipment, both for the resulting commoditization of equipment (an effect observable in cable modem pricing) and for predictable equipment behavior in system design. Testing is performed at CableLabs; vendors are charged for testing, with fees ranging from $50,000 to $115,000 per product tested depending on the standard to which conformance is being certified.

Telcordia Technologies, a subsidiary of Science Applications International Corporation, is a descendant of Bell Laboratories by way of Bellcore.[75] The company has traditionally supplied services, including standards setting and certification,[76] to the Regional Bell Operating Companies, as well as other telephone companies and their equipment suppliers. Similar to the CableLabs case, equipment suppliers pay for testing and are motivated to do so in order to be able to compete for business supplying telephone operators that require the certifications. Among other standards, Telcordia inherited unique expertise in certifying interoperability of products with Bell company operations and management databases. The high cost (as much as $2M per product) and long duration of test cycles in the OSMIME process has resulted in sharp criticism of the company and the process.[77] The largest Regional Bell Operating Company, Verizon, created its own test lab accreditation program, with 10 different labs currently accredited to certify compliance against standards important to Verizon;[78] Telcordia is one of these. Partly, this can be seen as a large firm (not the government) investing to create a competitive market in interoperability oriented certification testing; the rest of the industry is free-riding on Verizon's investment. Telcordia is a viable certifier but now has to compete for certification business. Telcordia's business strategy has shifted towards emphasizing a broad array of services and technologies and away from that of a

[73] Tim McElligot, "Six Degrees of Preparation," Telephony, October 16, 2000, pp. 48-60.

[74] CableLabs standards include Data Over Cable Services Interface Specification (DOCSIS) for cable modems, and the CableHome and PacketCable specifications. See http://www.cablelabs.com/certqual/.

[75] Bellcore was established from parts of Bell Labs during the AT&T divestiture in 1984; SAIC bought the organization in late 1998. Bill Pitterman, "Telcordia Technologies: The Journey to High Maturity," IEEE Software, v. 17, n. 4, August 2000, pp. 89-96.

[76] See http://www.telcordia.com/services/testing/ntwk_integrity.html.

[77] Dan O'Shea, "A Certified Mess," Telephony, January 21, 2002, pp. 32-39.

[78] See http://www.verizonnebs.com/tcppage.html.

captive research and certification consortium of the bell operating companies (as was the case in the Bellcore era and is analogous to the current situation of CableLabs).[79]

Meta-Standard Certification: ISO 9000

The International Standards Organization ISO 9000 series of standards prescribes quality systems and their documentation and management (typically for manufacturers, although the series has been applied to service providers as well), it can be described as a management practice meta-standard.[80] A firm seeking certification creates and documents a quality system specific to its activities but in conformance with the principles documented in the ISO 9000 series. The firm is then audited by an ISO 9000 certification body (typically a commercial firm offering both auditing, certification, and consulting) to verify conformance of its documented system to the standard and of its actual practices to the documented system. Nations identify accrediting bodies that in turn accredit certification bodies.[81] Not surprisingly , the details of quality systems can vary dramatically depending on what is being manufactured or what service is provided; meta-standard certification is in effect an attempt to provide useful certification across a very diverse and heterogeneous set of circumstances by focusing on process clarity rather than specific outcomes.

Drivers for adoption of ISO 9000 by companies have come primarily from certification requirements by customers, particularly public sector customers, with secondary drivers being product liability reduction and usefulness of the standard for driving quality improvement programs in general (consistent with the theme broadly developed in the mid-80's through the mid-90's that quality improvement increases firm profitability).[82] ISO 9000 certification has grown into its own industry, with numerous consultants, trainers, auditors and registrars.

One realization that emerged in the late 90's is that the correlation between ISO 9000 certification and product quality is weaker than could be hoped. Reasons developed by task forces in the UK evaluating this phenomenon include variable quality among the broad array of certifiers and accomplices, a realization that certifying a quality system does not necessarily link strongly to certifying quality in a product, a slackening of commitment to the quality process post-certification, and a tendency to view certification

[79] The transition of Bellcore from a consortium to a supplier was partly due to increasing competition between the consortium's member Regional Bell Operating Companies; such competition undermines the viability of consortia. Pitterman.

[80] Mustafa V. Uzumeri, "ISO 9000 and other metastandards: Principles for management practice ?," Academy of Management Executive, 1997, v. 11. n. 1, p. 21-36.

[81] In the U.S., three bodies are designated as accrediting bodies: American National Accreditation Program for Registrars of Quality Systems, American National Standards Institute, and Registrar Accreditation Board. See http://www.iso.ch/iso/en/info/ISODirectory/Country/country_US.html. National accrediting bodies may themselves be accredited by a common international organization such as the International Accreditation Forum, http://www.iaf.nu/. Note that ISO itself does not accredit any organization relative to accreditation or certification.

[82] Norman Burgess, "Lessons Learned in Quality Management – A Rational Role for Certification," IEE Symposium on Pros and Cons of ISO 9000 Accredited Certification (Digest No. 1998/421), March 31, 1999, pp. 1/1-1/3.

as a limited and temporary process rather than assimilation of a new quality approach into the operation and culture of the organization. Recommended changes to the ISO 9000 regime include calls to reduce the number of accredited registrars so that more effort can be spent on accreditation, the use product and quality system certification in combination, and recognition the higher value of Just-in-Time practices than ISO 9000; some of these are reflected in the more recent ISO 9001:2000 framework.[83]

Certification for Consumers: The Wi-Fi Alliance

The Wi-Fi Alliance is a non-profit trade association founded in 1999 and organized by equipment and component providers interested in the market for IEEE 802.11 wireless local access network equipment; the alliance had over 200 member companies by July 2004 and certified interoperability of over 1500 products between March 2000 and July 2004.[84] The alliance is typical of a number of other consortia intended to augment an otherwise established standards process (in this case IEEE wireless networking) with both interoperability certification and building of a consumer brand to assure consumers that purchased produces will interoperate. The Wi-Fi Alliance accredits independent testing labs as Wi-Fi Interoperability Certification Labs. These labs report results back to the Wi-Fi Alliance, which in turn grants certification and the right to display appropriate Wi-Fi logos. Only Wi-Fi members can request certification; however, the association's wide membership suggests that barriers to membership are low, so that the association is not substantially restricting entry in order to limit competition.

Certification Processes

Each of the examples above involves an actual certification process. From these, we can abstract a number of common and desirable elements:

- *Pre-Certification*. Certification process, expectations, and procedures are well documented. Educational and background materials are easily available to help implementers. If the certification is complex enough, a third party community of trainers, consultants, and test equipment providers should be fostered. The goal is to increase the likelihood that certification will be straightforward. Fees are documented, predictable, and reasonable.
- *Certification*. Testing and evaluation against the certification criteria takes place. For equipment that is easily transportable, this can happen at specific test facilities; preferably these facilities are convenient (perhaps regional). For equipment that is not-transportable, or in the case of facility, infrastructure, or process evaluation, certification teams go on-site. Testing is prompt, transparent, and of high quality.

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[83] Ibid. and L. Paul Dreyfus, Sanjay L. Ahire, and Maling Ebrahimpur, "The Impact of Just-in-Time Implementation and ISO 9000 Certification on Total Quality Management," IEEE Transactions on Engineering Management, v. 51, n. 2, May 2004, pp. 125-141 and E. Davies and M. Whyman, "ISO 9000:2000 – new ISO, new responsibilities for teop management," Engineering Management Journal, v. 10, i. 5, Oct. 2000, pp. 244-248, Eitan Naveh and Alfred A. Marcus, "When Does the ISO 9000 Quality Assurance Standard Lead to Performance Improvement? Assimilation and Going Beyond," *IEEE Transactions on* Engineering Management, Volume: 51, Issue: 3, Aug. 2004 Pages: 352 – 363.

[84] See http://www.wi-fi.org/OpenSection/backgrounder.asp?TID=5

- *Post-Certification*. There is a clear process, deadline, and format for reporting test results. For any failures, the reason for failure is clear and remedies are suggested. Other comments and recommendations are included. There is a clear and transparent process to question and appeal results. There is a clear process for publicizing successful certification, both by the certifier and by the certified body. A publicly accessible database of successful certification results is maintained. A follow-up regime of periodic re-inspections is documented and followed.

3.3 Implications for VoIP ES Certification

We can make several general observations about VoIP ES certification based on both theory and specific examples of certification; these observations then inform specific recommendations in Section 4.

Certification of emergency services capabilities for VoIP better fits the category of certification for social policy goals than certification for economic reasons; firms have not traditionally been able to charge consumers for 911 services.[85] The implication is that standards and related certification bodies are less likely to arise naturally driven by the industry's own economic interest (as is the case in many telecom certification examples including the Telcordia, CableLabs, and Wi-Fi Alliance examples cited above).

There is general evidence that strong external motivation is needed to motivate social policy self-regulation. In the case of VoIP ES, associations of public safety officials, such as the National Emergency Number Association and the Association of Public Safety Communications Officers, are already playing an active role in prompting self-regulatory discussions.[86] However, it seems likely that the effectiveness of this motivation derives largely from the presumption that these organizations have the ear of regulators at the local and federal levels, so that there is not a truly separate NGO playing a role by, for example, influencing consumers. Hence it appears likely that, whether directly or indirectly, government motivation is needed in this case. However, government motivation can take a number of forms along the spectrum from inspiring self-regulation through the credible threat of potential regulation to an active sharing of regulation responsibilities. Moreover, although the obvious federal agency would be the Federal Communications Commission, it is also possible that government motivation could come from the States (if they can be sufficiently coordinated to be effective) or from a combination of Federal and state agencies.

Social policy self-regulation faces a credibility challenge; there is a need to demonstrate that certification is not overly captive to certifiers and consequently subject either to use in extracting monopoly rents by restricting industry participation or by setting standards at inappropriate performance levels.[87] One option here is the use of a standard setting

[85] Firms subject to rate regulation may be relatively neutral to the imposition of 911 requirements if they are able to recover costs through a general increase in prices. However, we expect many firms involved in VoIP to be excluded from rate regulation and consequently motivated to avoid costs without offsetting revenues unless other issues, such as the threat of government regulation, arise.

[86] See http://www.nena9-1-1.org/VoIP_IP/index.htm and http://www.apcointl.org.

[87] As noted earlier, standards can be set too high – in an effort to restrict competition – or too low – in order to reduce industry costs at the expense of overall welfare.

organization that is not perceived as captive of certified companies, e.g., a broad professional organization or one that openly involves parties such as government and consumer organizations. In parallel, it would be valuable to create a "hierarchy of trust" in accrediting certifiers, where the root accrediting organization is credibly independent of the certified companies. This role can be played by government, as in the case of OSHA, or by sufficiently separated institutions, as in the case of ISO 9000 certification. It should probably not be played by a major industry firm, as in the case of Verizon's certification of testing lab, or by a tightly controlled industry consortium.[88]

Many certification processes that involve conformance testing have evolved towards creating a competitive market of certifiers; examples above include both product safety certification, telephone company product interoperability certification, and ISO 9000 quality system certification. This seems like a reasonable approach for VoIP emergency service certification as well; note though that this also motivates the need for a hierarchy of accreditation so that certifiers' capabilities can be trusted.

Much of VoIP emergency services certification is likely to consist of software certification; here it would be wise to encourage certification processes that engage with software development throughout its cycle rather than solely at the end. Also, some aspects of VoIP emergency service performance will depend on network and system characteristics that can be expected to vary widely among VoIP providers. An element of system meta-management standardization and certification, similar to ISO 9000, may be appropriate in such heterogeneous circumstances, but we need to learn from the ISO 9000 experience and not rely solely on process certification to control outcomes.

Consumers can play the key role in disciplining non-certifiers and discriminating between levels of certification through their buying choices. Examples of such consumer involvement include Underwriters' Laboratories certification and Wi-Fi Alliance certification. However, to be effective, the consumer needs to be aware of the certification's implications and confident in its legitimacy. This implies investment in consumer awareness and in policing inappropriate assertions of certification. These functions can be accomplished by some combination of government, industry trade associations (which both create a brand around certification and obtain legal rights to certification marks and prosecute infringers – the WiFi Alliance is an example) and individual firms (which are generally motivated to advertise certification and its significance once they have certified in order to differentiate from non-certifiers).

Finally, careful consideration of the role of insurance and liability mitigation could accelerate progress and industry participation beyond that naturally motivated by the threat of government regulation. Here again, government involvement can potentially help: governmental roles, for example in setting the appropriate standards and serving as the root accrediting body for certifiers can enhance the status of standards and certification as being broadly accepted and demonstrative of reasonable care. Active solicitation of insurance industry participation in standards setting and institutional design

[88] The Wi-Fi Alliance represents an ambiguous example here; while it is clearly an industry consortium and restricts membership, it appears to have been quite open in accepting membership and so might be less subject to criticism of "tight control." However, there is a risk that the potential for opaque and self-interested policies, even with broad industry membership, is sufficient to undermine credibility.

of certification is desirable if it leads to differential premiums for industry participants based on certification.

4 A Proposed Model

As they are disparate implementations of IP networks, there will also be disparate implementations of VoIP ES. To address this variation, we develop here a specific institutional framework and a set of summary technical criteria and procedure recommendations to provide a concrete model of a self-regulation and certification of ES capability. We recognize that this is not the only possible model; indeed from previous sections of this paper it is possible to induce many variations. However, the proposed model represents our best recommendation based on our current information and understanding.

4.1 Institutional Design

Here we refine the general observations of Section 3.3 into a particular, specific recommendation:

Government agencies should perform some initial coordination between federal and state levels and then publicize a consistent and credible statement of intent to regulate VoIP ES unless credible self-regulation emerges. At the same time, government agencies should move to facilitate successful self-regulation as described below.

Industry service and equipment providers should form an organization to pursue VoIP ES. While this could be a derivative of some current industry trade association or consortium, it needs to have some important properties. It should be funded by and heavily involve industry participants, but intentionally open and transparent to all industry participants and to other stakeholders, particularly regulators and consumer interest groups; such arrangements should be codified in its bylaws. This organization develops standards and updates and extends them. Traditional open standards bodies, such as the Internet Engineering Task Force, International Standards Organization, or the American National Standards Institute, can serve as models. Although the initial focus of this body would be ES, successful execution could allow it to embrace other social policy self-regulation goals.[89] This or ganization will also take on the job of creating a brand around the certification including the appropriate legal protections, co-sponsoring with government awareness of certification, maintaining the database of accreditations, and policing accreditations. The standardization activity would build on momentum such as the early agreement between the National Emergency Number Association and several VoIP industry participants.

However, we recommend two specific "separation of power" elements to enhance the credibility of the process (in particular, to insure the process is not too much a captive of

[89] We would not expect the motivation for new social policy goals to arise naturally from the industry participants in this organization. As we have indicated elsewhere, an external motivation is needed. Most likely this would come in the form of a public debate culminating in a credible threat of government intervention. The close coordination with government that we are proposing could facilitate the efficient signaling of such events.

the certified parties to be ineffective at convincing other stakeholders that their interests are being incorporated, notwithstanding transparency and inclusiveness in the standard setting).

First, multiple independent and competitive testing organizations are enabled to actually perform accreditation. Either these organizations or third parties will provide pre-certification consulting and training.

Second, these organizations are accredited by a third party, distinct both from the standard-setting and certification branding organization and from the testing organizations. There are two major candidates for this role: a government agency and an independent institution. In the later case, a respected neutral institution such as the American National Standards Institute could play this role if willing. In that or similar cases, it would be appropriate to approve proposed standards through the processes of the accrediting institution.

Government agencies will appoint personnel to assist in the formation of the self-regulation process as follows: credibly transmit the threat of government regulation if self-regulation fails and report back to government on the success of the self-regulation process, insure agency experts provide input into certification standard and process design, champion positive inducements for self-regulation elsewhere in government in the form of recognition of self-regulatory effort as a mitigating factor in punitive proceedings, sponsor co-promotion of and education about certification to users (both industry and government should be supporting this), working with the telecommunications industry to involve the insurance industry and clarify the level of liability mitigation (beyond government liability mitigation already covered) provided to those who diligently certify products, and liasing to other interested parties in government (e.g., Congress). Although this implies significant effort, it is dramatically less than would be involved in creating and executing government command-and-control regulation. But it should be clear that we are by no means advocating a passive government role.

4.2 Technical Approach

With the transition to an IP based ES solution, it is important not to burden future models with legacy assumptions. The design and operation of the Internet provides a much more rich set of possible solutions; therefore, policy addressing future ES service should embrace this flexibility and optimize the social benefits that might be had. The policy (i) should not restrict the manner a function is provide, (ii) should support multiple methods, (iii) should encourage incorporation of ES into other technologies and (iv) should encourage developers to create cheaper, better, more feature rich technologies.

Certification will likely need to include both certification of terminals (which can potentially be transported to a test site) and certification of network characteristics (which cannot). We focus on the former in this paper. We would not expect to be able to exhaustively test all network nodes and usage combinations as a part of certification. Rather we would suggest a combination of a meta-standard style process certification focused on how the network is designed and managed to maintain ES capability, and random testing of performance of particular nodes and situations.

We expect that the diversity of possible VoIP systems will preclude the possibility of certification to a single level of performance. We also believe that this diversity is a good thing and not to be discouraged by forcing a single level of certification. Consequently, we propose that different levels of capability be certified. The number of levels needs to small enough that it is possible to efficiently educate consumers on their distinction. Within the VoIP space, this could be as simple as two levels: a carrier grade (with significant requirements) and a non-carrier grade (with less strenuous requirements). As a *straw man* a carrier grade service might include:

- The ability of the VoIP application to access ES infrastructure
- The ability to provide reasonable quality of service (e.g., meet the performance and reliability measures discussed in 2.2).
- The ability to participate in an authentication process
- The ability to initiate an ES call; including the use of a recognized emergency number, such as 911 or SOS as well as to form the proper ES message
- The ability of the system to accurately determine and communicate the proper location of the VoIP application/caller
- The ability for the end user to test the ES
- The ability to provide information to the user through such means as device labeling or software notification

To provide stages or phases of implementation, we propose to use the stages suggested in the NENA/VON Coalition initial agreement on VoIP ES.[90] Using this approach we would have:

- Phase One Certification (based on NENA/VON Coalition "interim solution"):
    - Delivery of 9-1-1 call through the existing 9-1-1 network,
    - Providing call back number to PSAP,
    - (Optional) Providing initial location information to PSAP
- Phase Two Certification (based on NENA/VON Coalition "long-term solution"):
    - Delivery of 9-1-1 call through an IP network to an IP-connected PSAP (or through existing 9-1-1 network if PSAP is not IP-connected),
    - Providing call back number/recontact information to PSAP,
    - Providing caller location information to PSAP

[90] http://www.nena9-1-1.org/VoIP_IP/VOIP-NENA%20Actual%20Agreement.pdf. Note that this agreement, reached in December of 2003, included the following industry participants: 8x8, AT&T Consumer Services, BroadSoft, Dialpad, ITXC, Level 3 Communications LLC, Level 3 Enhanced Services, PointOne, pulver.com, Voice on the Net (VON) Coalition, Vonage, and Webley.

This phased approach provides for a near immediate implementation of ES. It also encourages a move away from the traditional ES service and toward a more competitive environment.

4.3 Labeling

Throughout this paper we have mentioned that labeling could be an important aspect of this process. While the details of such a mechanism warrant a separate paper, here we briefly propose the idea, discuss its merits and suggest how it might be used.

We envision a label to include such things as (1) a sticker attached to IP phones, (2) a reminder software window that periodically informs the user of the ES specifications (possibly when the device or software detects some configuration change) or (3) an email sent to the user when the network detects a change.

By tying the operation of the label to system changes, the label becomes a more dynamic mechanism and could be very useful in situations when the network and the device cannot automate the proper operation of the ES system (in other words, when a user might need to intervene). Lastly, considering the litigious nature of our society, labeling likely provides some legal protection to the VoIP service or software provider.

Labeling could be used to provide information to the user about the (1) availability or lack of ES support, (2) ES limitations, (3) configuration requirements, (4) configuration changes or (5) alternative methods of summoning help or more.

We leave this topic for later consideration.

5 Conclusion

While the telecommunications industry has proven adept at self-regulating in areas of interoperability, historically social policy regulation has been a government role. The diversity engendered by transition to VoIP will challenge this command-and-control regulation and we believe the time has come to consider the alternative of social policy self-regulation. We recognize that there are key challenges to such a process, in particular insuring adequate motivation and credibility. But we believe with the framework we have recommended, success is possible. Success would not only be valuable in the case of VoIP emergency services, but would also be very timely in adding a new regulatory approach to the telecommunications world as it continues to evolve rapidly.

VoIP technology enables a much broader range of technical and business approaches than were feasible in the PSTN world. On the one hand this opens an exciting world of innovation and flexibility for users; on the other it makes difficult or, more likely, impossible the task of a straightforward mapping of traditional social policy goals and constructs from the PSTN to the VoIP world. We will want to preserve many of current social policy goals in one form or another, and likely consider different ones over time, but we would be well served by a more flexible, rapid, and innovative method of mapping such goals onto the increasingly heterogeneous world of telecommunications.

Emergency services are a critically important and immediate case. Traditional ES expectations include timely connection of simply placed emergency calls with high intelligibility to the appropriate answering point and enhanced with information on where the call comes from (both as a network address and as a physical location). The variety of VoIP implementations makes this intrinsically difficult. We propose to design – by industry but with motivation and input from government and other stakeholders – a multi-tier certification scheme that can signal to users the type of ES capability that can be provided by the equipment and services they purchase. We would expect the certification regime to focus on several key technical characteristics of VoIP systems: addressing, routing, location, security, availability and the related network and application standards.

Our analysis is not complete in some important respects. From the technology perspective, we would like to further develop a broad set of technology categories; these might be based on media type, network access, user expectation or some other criteria. Within these categories, we would define a set of characteristics upon which a certification process could be applied (as we have done above for VoIP). While we have performed some basic legal analysis and analysis of the role of standardization and consortia in institutional design, we believe that more progress would be useful. We have not considered how social policy funding will be affected by the transition to VoIP; for example, to the extent telecommunications industry taxation helps fund public safety, will these obligations be transferred to VoIP ore covered in some other way? Finally, we briefly discussed the usefulness of developing different categories of VoIP implementations against which different certification standards might be developed. We belief further investigation into this area would be beneficial and that this approach could expand to include other types of media over IP (e.g., IM and video).

Our proposed model needs both refinement and assessment. During the immediate scope of the project, we assessed the model by critical and documented analysis of internal integrity and credibility with respect to successful precedents and through an analysis that included dissemination to policy oriented audiences for critique and debate (such as through the submission of this paper to the TPRC). This is a process that we are familiar with through professional experience in policy formulation. We use the analysis from sections 2 and 3 to demonstrate that validity of the approach. For the longer term, this analysis was not only motivated by our particular model but also specific strategies for assessing it once used; we documented these strategies. Elements included (i) monitoring for technical and business model evolution that is out of scope of that envisaged in our model, (ii) tracking specific performance metrics of certified processes and comparing against criteria derived from consumer expectations and social policy goals, and (iii) voluntary adoption rates of certification compared against a template derived from past experience in industry sponsored certification processes. This longer-term assessment represents ongoing and future work. A critical part of this longer-term assessment is feedback from readers; and to that end we welcome comments.

6 Appendix A (Session Initiation Protocol and Gateways)

SIP

The Session Initiation Protocol[91] (SIP) is a signaling protocol supported and developed by the Internet Engineering Task Force (IETF). Its purpose is to aid in the creation of sessions between end points. A session can be thought of as a call; however, a SIP 'call' could be used to set up anything from a voice call to instant messaging to a gaming session between users. It is derived substantially from HTTP and SMTP, and as such has a decidedly 'web-like' design. The communication in SIP-based VoIP is very similar to how web browsers interact with web servers on the network.

SIP is a lightweight protocol and draws strength from the fact that most of the intelligence lies at the SIP end points. This concept is antithetical to the traditional legacy networks where the intelligence resides within the network. This gives the protocol greater flexibility, scalability and opens the network to implementation of new services. SIP does not perform the transmission of the media data, but instead uses the Realtime Transport Protocol (RTP)[92] for that purpose. Furthermore, SIP does not describe the session - this is done by the Session Description Protocol (SDP).[93]

The functionality of SIP is similar to that of other signaling protocol (such as SS7 in the PSTN) and includes: (1) locating end points, (2) initiating a session between the end points, (3) maintaining the session, which includes making any changes in the parameters of the end points if need be during the session and (4) terminating the session. A SIP session is established using messages exchanges between the end points. This includes requests and responses. Requests are known as 'methods' and include INVITE, BYE, ACK and others.

SIP Network Elements

A SIP network is primarily composed of user agents (UAs), proxy and redirect servers, registrars and gateways (while gateways are not part of the SIP specifications, they play an important role in internetworking, such as between the Internet and PSTN.). The UAs and proxy servers connect in what is referred to as the SIP trapezoid, as depicted below. SIP elements (UAs and servers alike) exist as endpoints on a network (e.g., the Internet) and use the network to provide interconnection (we omit the details of the network, such as routers, switches, access and transport technology).

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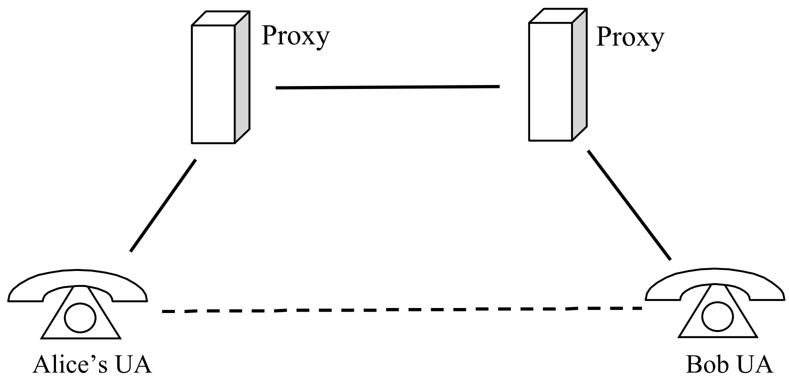
[91] Rosenberg, H. Schulzrinne, G. Camarillo, A. Johnston, J. Peterson, R. Sparks, M. Handley, E. Schooler, "SIP: Session Initiation Protocol", Network Working Group, RFC 3261, June 2002.

[92] Schulzrinne, H., Casner, S., Frederick, R. and V. Jacobson,"RTP: A Transport Protocol for Real-Time Applications", RFC1889, January 1996.

[93] Handley, M. and V. Jacobson, "SDP: Session Description Protocol", RFC 2327, April 1998.



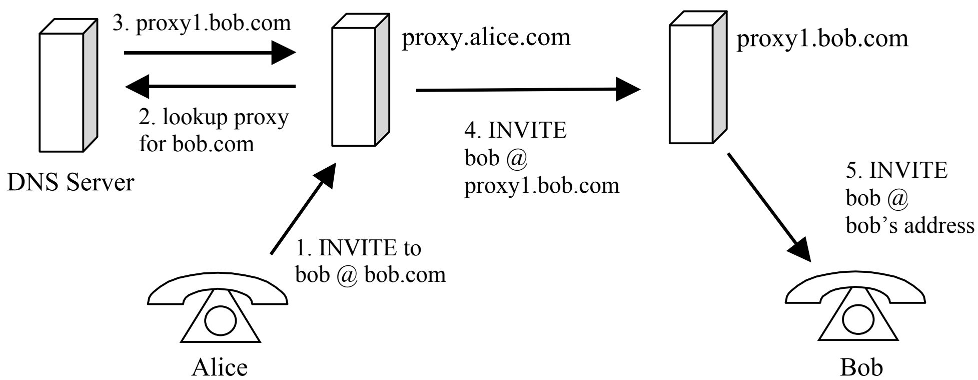
SIP User Agent
SIP User Agents (UAs) can be thought of as the signaling software (an internet application) running on a VoIP device (this device might be an IP phone, software running on a PC, software/firmware running on a specialized devise). UAs assume the role of either a User Agent Client (UAC) or User Agent Server (UAS) depending on their function during the establishment of a SIP session. For example, a UA acts as a UAC when it generates a request and as a UAS when it is the recipient of the request.

SIP Proxy Server
While UAs can communicate directly, proxies help by providing name resolution, routing and user location. Proxies generally represent a particular domain and engage in the routing of requests between different domains as to assists the UAs in establishing a session. They serve as the ingress and egress points for a domain when INVITE messages are received or sent respectively (an INVITE message is the method used to initiate a session).

Registrar
The Registrar is the network element that helps associate users with IP addresses on the network. For successful communication, SIP clients are generally configured to send a REGISTER request to the Registrar in order for their SIP to IP mapping to be stored. This request might be done at regular intervals, to allow the Registrar to refresh its mapping tables. The registrar can also provide password security at the initiation of the session.

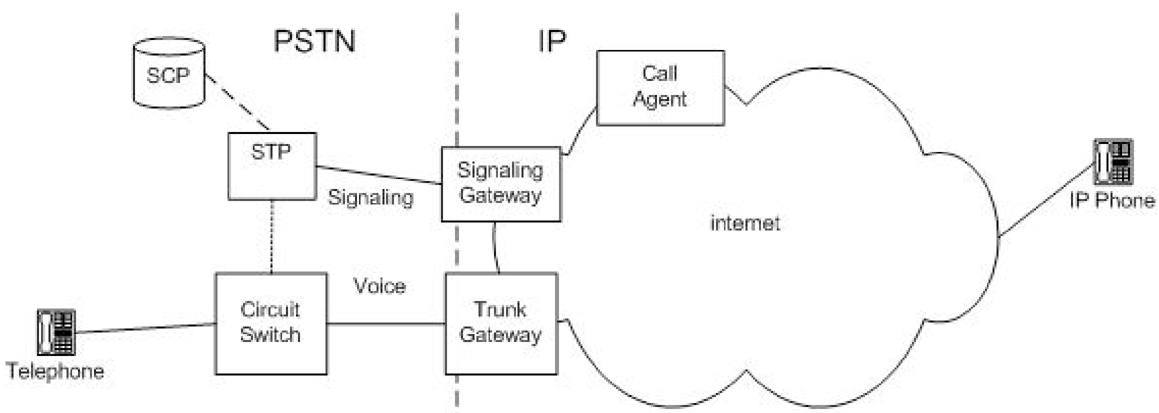
Interaction between SIP network elements
As depicted in the diagram below, the UA (Alice) at the origin sends an INVITE addressed to Bob to the origin proxy server (proxy.alice.com). This proxy resolves the address of the destination proxy by sending a request to a DNS server, which responds with the actual address of the proxy associated with Bob. The destination proxy maps the Bob's address to an IP address (not shown) and then forwards the INVITE to Bob's UA.

This is followed by other message exchanges between the endpoints to complete the session establishment.



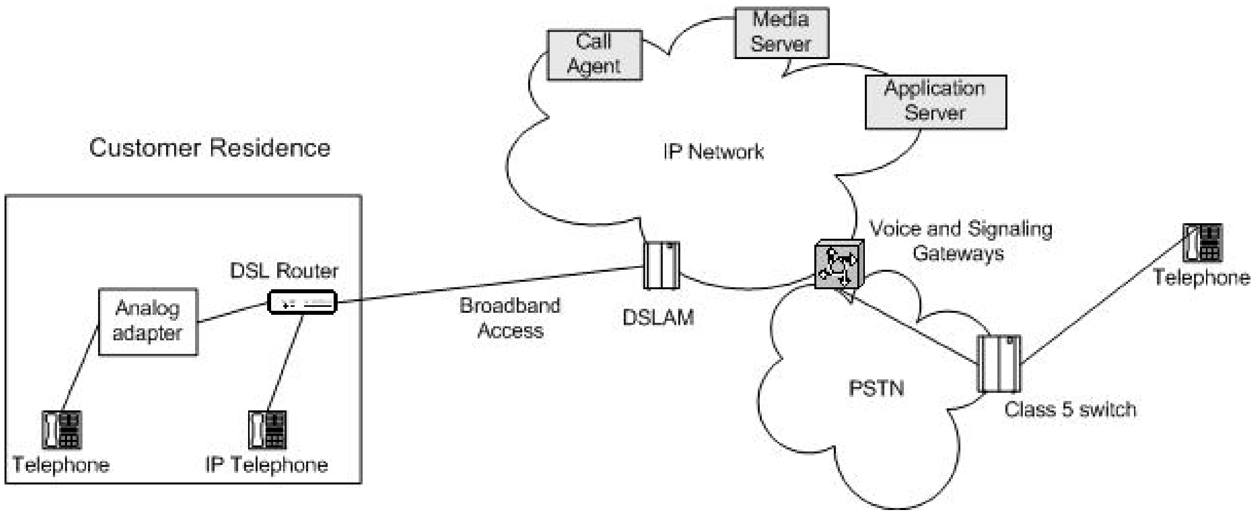
Gateways

Gateways stand at the boundary of different networks and are necessary for interoperability across different technologies. They act as an interface between different signaling networks using translation protocols. The signaling and the media transverse the networks through the gateways as depicted below.



These boundaries between the PSTN and an IP network are often instantiated by a device (or collection of devices) called a Softswitch. A protocol (a media gateway control protocol, such as MEGACO or H.248)[94] controls the operation of signaling and media gateways that operate between the SIP and PSTN network.

[94] Cuervo, F., Greene, N., Rayhan, A., Huitema, C., Rosen, B. and J. Segers, "Megaco Protocol Version 1.0", RFC 3015, November 2000.



Note that the model above does not require an IP-enabled telephone, rather the consumer could use either a traditional telephone or an "IP telephone". As depicted above, the phone would plug into an analog telephone adaptor, which allows the telephone voice and signaling to be translated into formats appropriate for IP-based networks. The communications from the telephone pass through the DSL modem/router and onto the broadband access segment of the network. However, rather than terminating at the central office on a switch for call processing, the call passes through the DSLAM into the IP network, where the actual voice service is provided by a number of elements including the Call Agent, Media Server and Application Server. These various servers (and the associated service) could be provided by a variety of providers. The point is simply that the voice service now exists in a highly distributed manner with functionality throughout the network.[95]

[95] The description above is a gross simplification of the operations of such a network and is only intended to demonstrate the delocalized nature of future voice services. In more detailed terms, the call continues through the network to an access gateway (AGW). This gateway provides a variety of functions, the first of which may be to ensure that the call is authorized to be on this network. It also can connect calls to other customers on that network. The AGW connects to the media server, which provides such functions as dial tone and message announcements. Again, these gateways may reside anywhere on the network. Another element to consider is the Signaling Gateway (SG), which might translate between IP-based signaling and SS7 messages. The call agent (CA), also called a Media Gateway Controller (MGC), provides the call logic and control of the GW(s). It provides the intelligence that would typically reside in the switch. The CA actually controls the GWs that would interconnect the IP network with the PSTN. Finally, the application server provides service logic for specific applications such as voicemail. The application server provides the VoIP network with the ability to quickly add new services to the network.