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Empirical Studies of Bottom-Up Internet Governance

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Empirical Studies of Bottom-up Internet Governance

Jesse H. Sowell

Abstract—The notion of bottom-up governance in the Internet is not new, but the precise underlying mechanisms have received little primary, empirical study. The majority of Internet governance literature is couched in contrasting familiar top-down modes of governance with the design of and subsequent critique of governance institutions such as ICANN or the WSIS processes that created the Internet Governance Forum (IGF). This paper reports on dissertation work collecting and analyzing empirical evidence of how bottom-up governance mechanisms operate *in situ*. Methodologically, participant-observer ethnographies are supplemented by text mining and social network analysis—the combination facilitates analysis of community-generated artifacts cross-validated against semi-structured interviews. This paper reports on ethnographic studies thus far, drawing on early interviews and private conversations.

Scoping the domain, this work evaluates organizational modes at the intersection of Internet operations and security. Three categories of non-state organizational modes contribute evidence: network operator groups (NOGs) and RIRs; Internet eXchange Points (IXPs); anti-abuse organizations and communities such as the Messaging, Malware, and Mobile Anti-Abuse Working Group (M³AAWG), Spamhaus, and the Anti-Phishing Working Group (APWG). As of this writing, the anti-abuse study is the least developed study and will be addressed comparatively. The author engages as a participant-observer in forums from each category, developing relationships and engaging in semi-structured interviews with participants and organizers.

These studies contribute to understanding how decentralized “close-knit yet loosely organized” communities coordinate localized operational capacity (direct access to private network operations and security incidents) to achieve global operational and decisional capacity sufficient to address problems as they arise, at Internet clockspeed. Ongoing fieldwork provides early insights into these processes. Many of these governance arrangements comprise actors pursuing nominally private interests, yet they produce collateral public benefits. Important to this work is that the combination of private interests and the creation of public goods is distinct from both how open these organizational modes are and how transparent the attendant processes are. Various combinations exist within these studies and will be presented. This report will provide a preliminary comparative analysis *within* and *across* the studies. These arrangements are framed as instances of private authority. One contribution of this work is a mapping of concepts and models from international relations and political economy to the domain of bottom-up Internet governance to facilitate comparison not only within and across the studies, but also with conventional governance arrangements. Using this language, comparisons will highlight, among other factors, the variety of vetting and consensus building processes at play, trade-offs between formal and informal rules and norms, mechanisms for evaluating policies, and early evidence of the density of social networks that facilitate communication within and across differentiated policy and issue communities. Taken together, these factors will contribute to an argument that bottom-up governance (of the Internet) is not simply a variant of multistakeholder-ist or multilateralist governance confounded by a functionalist and/or corporatist flavor. Rather, bottom-up governance will be presented as a broad yet densely connected, pluralistic marketplace of governance arrangements whose continuous engagement in policy *experiments* allows the community as a whole to keep pace with the development of issues in and on the global Internet.



1 INTRODUCTION

The early Internet was built around network architectures assuming a small set of hierarchical backbones supporting access networks,¹ a single entity delegating and managing Internet protocol address resources, and a small community of trusted academics and later operators. Today, there are growing arguments around the “flattening” of the Internet topology,² a more sophisticated ecosystem of organizations involved in resource

allocation, and, taken broadly, a community³ that is both global and largely untrusted. These issues have emerged as the Internet has evolved—alongside these issues an active, more narrowly scoped community largely comprising network operators, has evolved to manage these changes and contribute to sustaining an open and innovative Internet. This paper sets out arguments and early evidence that these communities are not merely ad hoc collections of actors, but are governance arrangements filling the gaps left by state governance and, increasingly, engaging in the global political landscape. Framed in concepts from political economy, this work presents evidence of the ongoing development of these governance arrangements based on early ethnographic fieldwork in these communities.

Further scoping this study of network operator communities, the larger (dissertation) work comprises three

1. In the late 1980's and early 1990's the ARPAnet, NSFnet, and regional networks were loosely connected. The former two were built around centrally managed backbones. Regional networks more resembled the modern, commercial, decentralized Internet.

2. Ager et al. (2012) is a study of a large IXP in Europe in SIG-COMM'12, building on ideas related to traffic flows around the tier 1's (Labovitz, Iekel-Johnson, McPherson, Oberheide, & Jahanian, 2010), the flattening of the Internet topology (Gill, Arlitt, Li, & Mahanti, 2008a) and earlier work on IXes (Augustin, Krishnamurthy, & Willinger, 2009; Stanojevic, Castro, & Gorinsky, 2011).

3. Community here means the *entire* community in including operators, web application designers, users, and everyone in between; this work quickly narrows the scope to operators.

studies: (1) network operator groups (NOGs) and regional Internet registries (RIRs), (2) Internet Exchanges (IXes), and (3) anti-abuse organizations. Each class of organization is argued to provide a set of services that create order in a potentially contentious Internet ecosystem.⁴ In other words, these services contribute to governance. These services can be roughly categorized as reducing information asymmetries amongst actors in interconnection markets, monitoring resource usage, enforcing community best practices, and creating policy development and evaluation processes. Each organization does not necessarily engage in each of these activities. Evidence from fieldwork thus far⁵ confirms anecdotal evidence that these services are distributed to functionally-focused organizations such as those providing DNS blocking lists, those managing resource allocation, and those managing interconnection fabrics (to name a few functions).

The notion of bottom-up governance as an institutional mode is a common, albeit not especially rigorously operationalized, theme in the Internet governance literature. Many governance studies have focused on the IETF and ICANN, with notable exceptions.⁶ In the former, the community has clearly identified what constitutes its constituency;⁷ in the latter, the claim of representing the Internet community has been challenged on both accessibility and in terms of what constitutes the Internet community writ large. Further, with some exceptions, many analyses focus on legal evaluations⁸ but do not leverage the extensive literature on institutions and regimes from the international relations (IR) and comparative political economy (CPE) literature. An exception, Mueller, Mathiason, and Klein (2007), discusses ICANN in terms of regime theory. This work agrees that ICANN was an “ill-advised attempt to shortcut regime construction” (2007, p. 237) and partially agrees with the principles and norms of a policy development regime (2007, pp. 243–250). Where this work differs, and very fundamentally so, is in the *sources* of those principles and norms, **especially the plurality of authoritative structures and processes that have produced the rule and decision-making processes that have sustained the Internet infrastructure thus far.**⁹

4. Contentious in the sense of Clark’s notion of tussle (2005). Actors have different preference sets and contend with one another to realize their goals.

5. As of this writing, the author is actively and quickly transitioning from social network building and private conversations to formal, semi-structured interviews, sanctioned by human subjects review, that may be used in the dissertation. As such, nearly all evidence here can be assumed to be from private conversations unless otherwise noted more explicitly or as anecdotal.

6. Exceptions include Mathew and Cheshire (2008), Vincent and Camp (2004), and Caral (2004)’s discussion of the IETF and W3C in the larger dissection of ICANN (re)organization(s).

7. The best articulation of this is from the IETF itself, in the Tao of the IETF.

8. Such as Froomkin

9. It will be important to distinguish the scope of these principles and norms to identify authoritative sources, especially given the distributed and functionalist character of the institutions at hand.

The organizations in these communities are comprised largely of individuals that deal with managing, maintaining, and sustaining the Internet infrastructure on a daily basis. The ongoing problem solving practices of these individuals will be argued here as one source of the principles and norms that guide operational governance of the Internet. Many of these organizations are arguably the products of institutionalizing¹⁰ best practices. In contrast to developing principles and norms in political arenas such as the UN or the IGF, this work argues principles and norms, and importantly the rules and decision processes that directly affect those that maintain the Internet infrastructure, are developed through direct operational experience. Policies are premised more on functional objectives than society-level ideological issue-areas.¹¹ In a variety of conversations, a number of actors have discussed policies as another tool in their kit, one that is increasingly necessary to sustain management norms that are coming into more and more contact with societal-level, issue-specific norms driven by political ideology rather than operations. These two ideas are not contradictory—rather, they speak to the means of establishing an interface between these two types of policy spaces. This model of policy development has implications for the scope of these governance arrangements and their relationships with conventional governance actors, including governments (to be discussed in Sections 4.3 and 4.4).

Section 2 on theory and frameworks revisits the definition of Internet governance provided by WSIS, offering an definition of governance that gets to *how* and *why* governance works rather than *what* it should be. The theory and frameworks section identifies key theories and frameworks in IR and CPE that help understand the dynamics of the institutional landscape presented at the end of Section 3, which provides a high-level description of some familiar, some less familiar, organizations in these studies. These organizations will be described in terms of their functional remit and their constituencies. Given the landscape from Section 3 and the language established in Section 2, dimensions highlighting commonalities and differences across the three studies will be presented in Section 4. Finally, conclusions and critiques of the results thus far are presented—in particular, gaps in the existing work, how remaining data collection and analyses may fill these, and how more complete analyses may (re)shape these initial conclusions.

2 THEORY AND FRAMEWORKS

The premise of this work is to understand how organizations created within the Internet community serve as

10. This does not mean bureaucratizing, but is rather more akin to Cerny’s notion of structuration.

11. This does not mean there are not ideological biases within the epistemic community, it does mean that the scope of those is limited by domain-specific functions of the policy being made by these communities. That said, they must, and are arguably learning to (Section 4) interface with institutions dealing with societal issues.

governance arrangements. A commonly cited definition of Internet governance comes from the WSIS process:

Internet governance is the development and application by Governments, the private sector and civil society, in their respective roles, of shared principles, norms, rules, decision-making procedures, and programmes that shape the evolution and use of the Internet.

This definition focuses on *what* those engaged in the WSIS consensus process concluded governance *should* do. Little is added to Krasner's fundamental definition of a regime:

Regimes can be defined as sets of implicit or explicit *principles, norms, rules, and decision-making procedures* around which actors' expectations converge in a given area of international relations. (Krasner, 1983, p. 2, emphasis added)

Relative to Krasner, the WSIS definition introduces a broad set of actors on the front end to address a broad domain on the back end. Solum argues that "[i]f the topic of Internet governance were taken as the investigation of the regulation of all these activities when they took place on (or were significantly affected by) the Internet, then 'Internet governance' would be more or less equivalent to 'law and politics'" (Solum, 2008, p. 49). While the WSIS processes certainly produced substantive and valuable dialogue amongst the participants, this widely-referenced definition provides little insight into existing factors and mechanisms at play in operational governance.

Williamson's definition provides a starting point for understanding how mechanisms relate to order:

[G]overnance is the means by which order is accomplished in a relation in which potential conflict threatens to undo or upset opportunities to realize mutual gains. (Williamson, 1996, p. 12, emphasis in original)

"[T]he means by which" maps to incentives and mechanisms. This foundation also wants for a pluralistic market of arrangements. Williamson's framing speaks to these dynamics:

Governance is also an exercise in assessing the efficacy of alternative modes (means) of organization. The objective is to effect good order through the mechanisms of governance. A governance structure is thus usefully thought of as an institutional framework in which the integrity of a transaction, or related set of transactions, is decided. (1996, p. 11)

Governance is thus a continuous evaluation of efficacy, admitting that not only the rules may change, but, perhaps necessarily, alternate modes may need be explored. Making the distinction between a notion of governance that articulates *what* versus *how* is a simple but important distinction. It also allows for the decoupling of normative ideations of fairness and equity from a mapping of which mechanisms give rise to what types

of outcomes, regardless of a normative evaluation of those outcomes. In as much, this facilitates producing a catalog of *governance patterns*, leaving reasoning about fairness and equity implications to the constituencies that animate these processes.¹²

In these studies, institutions, of varying degrees of formality and comprising permutations of mechanisms for information sharing, monitoring, and enforcement, are at play. Institution is defined as per North (1991, p. 97):

Institutions are the humanly devised constraints that structure political, economic and social interaction. They consist of both informal constraints (sanctions, taboos, customs, traditions, and codes of conduct), and formal rules (constitutions, laws, property rights). Throughout history, institutions have been devised by human beings to create order and reduce uncertainty in exchange.

Like Williamson's definition of governance, institutions serve to create order and reduce uncertainty. This definition avoids confusion with the colloquial notion of institutionalization as a formalization process that inevitably leads to bureaucratization. It also further highlights that the creation of order occurs at many levels, from the family unit, a community such as a village run by informal norms, on through the conventional modes of governance often captured by *government*. A key element of the argument here is that the Internet, as both infrastructure being ordered and a communication medium, has facilitated scaling some of the more informal norms and attendant mechanisms beyond their conventional terrestrial constraints.

The following sections briefly describe how models and frameworks from comparative political economy and international relations are applied to explain observations of bottom-up governance arrangements thus far. In some cases, the scope will be extended to better explain the phenomena in hand; this will be noted where necessary. Applying existing theories and models helps explain the politics of operational Internet governance in well understood terms and facilitates direct comparison with the organizations that have been the focus thus far (ICANN and IGF) as well as conventional forms of governance (including *governments*) in the global arena.

2.1 Baseboards: Delegation and Transaction Costs

The idea of a governance arrangement implies that the organization in question has some form of authority, legitimating the means of reducing information asymmetries, monitoring, and enforcement of norms and rules. Under conventional post-Westphalian governance

12. Governance patterns are intentionally intended to sound like design patterns. They are not merely efficient tricks, but are coupled with a discussion of where a pattern has been effective, in terms of the kinds of outcomes desired, and where it has not been effective, in terms of undesired outcomes.

models, authority is typically delegated by an existing state authority. In the political realm, the most basic principal-agent relationship is the relationship between a constituency (the principal) and an elected official (the agent). In the technical realm, authority is often delegated from those with one form of legitimate¹³ power (a state government) to those with technical capability necessary to fulfill a specialized function efficiently and efficaciously (such as a state agency like the FCC or OfCom). Principal-agent problems occur when the agent deviates from the agenda of (or contract made with) the principal. In the simple case of an elected official, the cost of deviation may be a difficult or unsuccessful re-election campaign. In the case of a state agency, the cost of deviation may be budget cuts, staff transfers, or abolishment of the agency.

Eisenhardt provides a general definition:

[A]gency theory is directed at the ubiquitous agency relationship, in which one party (the principal) delegates work to another (the agent), who performs that work. (1989, p. 58)

Eisenhardt continues to highlight that agency problems occur “when (a) the desires or goals of the principal and agent conflict and (b) it is difficult or expensive for the principal to verify what the agent is actually doing,” (1989, p. 58). The principal agent literature has thoroughly explored and characterized the variety of principal agent problems.¹⁴ In the case of states delegating to international organizations (IOs), a key question is “Why delegate?”

Hawkins, Lake, Nielson, and Tierney (2006) refine the principal-agent problem, in particular the act of delegation, in the context of international organizations (IOs). They also provide some answers, couched in conventional state-agent constructs, to the question “why delegate?”

Delegation is a conditional grant of authority from a principal to an agent that empowers the latter to act on behalf of the former. This grant of authority is limited in time or scope and must be revocable by the principal. Principals and agents are mutually constitutive ... an actor cannot be a principal without an agent, and vice versa. The actors are defined only by their relationship to one another. (Hawkins et al., 2006, p. 7)

Hawkins et al. (2006) go on to indicate what unifies under the umbrella of principal-agent is the control of opportunism by the agent.

Above, Eisenhardt indicates the problem occurs when the goals and preferences of the principal and agent differ. Hawkins et al. (2006) provide a language for describing the varieties of agency that leads to these problems.

13. Here legitimate is in the sense of Weber’s class notion of the state having legitimate right to use force. In this sense, legitimacy is tacit in the state. This will be challenged later in the discussion.

14. Eisenhardt (1989) provides both the baseline definitions above and a comparative history of agency theory.

They identify two forms of *agency slack*, “independent action by an agent that is undesired by the principal.” *Shirking* is the minimization of effort by the agent; *slippage* is when the agent shifts policy from the principal’s preferences to the agent’s. *Autonomy* is the degree of independent action at hand given the principal’s control mechanisms put in place to constrain agent behavior. Hawkins et al. (2006) point out that autonomy and slack are subtly different: autonomy can be either beneficial or detrimental while slack is usually undesirable. A key element of these problems is discretion. Discretion is “often used as a synonym for autonomy” (2006, p. 8) but is a purposeful portion of the contract where the principal’s goals are specified but the precise means to achieve these goals are not. Discretion is a critical element of the principal-agent problem—as will be discussed in the sections below, recognizing where discretion exists in these organizations’ processes and its implications for ensuring the preferences of constituencies is a key component of this analysis.

The potential pitfalls of delegation are tacit in the principal-agent problem. To begin answering why, Hawkins et al. (2006) indicate that

[a]ll delegation is premised upon the division of labor and gains from specialization. These gains interact with all other benefits from delegation. (2006, p. 13)

Hawkins et al. (2006, pp. 13–20) provide a variety of benefits of delegation: specialization, coordination and collaboration to resolve policy externalities, collective decision making, dispute resolution, credibility, and lock-in. Of these, function-specific scoping is a clear instance of specialization. Conventional IR often sees telecommunications and technical infrastructure management as simple standards coordination problems, relegated to “low politics.” While coordination problems are considered the simpler of the two problems, as is evidenced in IXes and anti-abuse communities,¹⁵ a substantial element of emergent regime building relies on resolving collaboration problems. The specialized agent is one “with the expertise, time, political ability, or resources to perform a task,” (2006, p. 13). Early on, such organizations did not exist for the rapidly evolving Internet; more recently, specialization has settled in the NOGs and RIRs, mature IXes and umbrella organizations such as Euro-IX, and anti-abuse communities and umbrella organizations such as M³AAWG and APWG.

2.2 Transnational Engagement and Power

Traditional IR promotes the state as the unit of analysis while relegating firms and individuals to domestic

15. Both of these communities are arguably higher clockspeed organizational modes. In contrast, the NOGs and the RIRs have been around longer and arguably have longer clockspeeds. Moreover, they are more broadly scoped.

affairs.¹⁶

[T]he Vatican, the Arabian-American Oil Company, and a host of other nonstate entities are able on occasion to affect the course of international events. When this happens, these entities become actors in the international arena and competitors of the nation-state. Their ability to operate as international or transnational actors may be traced to the fact that men identify themselves and their interests with corporate bodies other than the nation-state.¹⁷

Wolfers's quote highlights two of the actors salient at the time of the writing (1962); since then the globalization literature has provided a rich body of work on the power and influence of transnational, or multinational, organizations. The quote above also illustrates the perception that these actors, by engaging in the international arena, are naturally the *competitor* of the nation-state. Some of these are either agents of governments (as per principal-agent above) exercising varying degrees of authority or are "adopted" as agents of state principals or IOs.¹⁸ Others still are agents of an epistemic community—this is the case for nearly all the organizations in this study. Although the provenance of authority differs, this work argues *against* the assumption that the organizations studied here are necessarily competitors for authority with the state. It is argued that these organizations are continually learning to *engage* with states and traditional IOs as *complementary* peers rather than either subordinates (a pure principal-agent relationship) or competitors for rule-making authority.

Nye, Jr. and Keohane (1971b) more formally define transnational relations to

include the activities of transnational organizations, except within their home states, even when some of their activities may not directly involved movements across states boundaries ... It would seem extremely artificial, for example, to exclude an arrangement made between the Standard Oil Company of New Jersey and the French government from the arena of transnational relations merely because all negotiations for the agreement may have taken place in Paris.(1971b, p .335)

This is an important foundation for these studies. If the organizations at study here are in fact considered

16. Exceptions are the notion of the second-image reversed (Gourevitch, 1978), Keohane and Nye (1974); Nye, Jr. and Keohane (1971a, 1971b)'s notions of transnationalism discussed here, and work on private order discussed in the next (2.3) section.

17. Quoted by Nye, Jr. and Keohane (1971b, p. 330), attributed to Wolfers (1962, p. 23).

18. Cowhey and Mueller (2009) argue that the IETF was acknowledged as a standards setting authority and delegated authority as such after the fact. The difference in the discussion here is, again, that it is argued that the principal is the constituency and that power delegated by the community is more instrumental in shaping both the fundamental norms and principles and sustains the IETF as an institution.

governance arrangements, the engagement of corporate actors (multinational corporations, MNCs) and their agents are engaging in a form of transnational relations. To further complicate the situation, the bottom-up organizations, in turn, engage with states and their agents such as regulatory agencies and law enforcement agencies (LEAs). While the concepts of principal-agent theory are certainly valuable for reasoning about how bottom-up organizations manage the Internet infrastructure, transnational relationships discussed in Section 3 challenge the simple principal-agent relationship that typifies much of the study of IO. Instead, there is a complex web of authority, multiple sources of authority, and, in turn, the implication of a complex ecosystem comprising multiprincipal-agent problems.¹⁹ Complicating the situation yet still is the need to revisit subordinate versus peer relationships to understand how conventional actors that, here cast as peers, have vied to be would-be principals.

Nye's notion of hard and soft power adds a valuable explanatory dimension into whether bottom-up governance arrangement complement or compete with conventional state-base authority. In particular, it helps explain the scoping of governance in these organizations as well as describing the complementary interface between bottom-up and other organizational modes. From recent discussions, the idea of hard versus soft governance, in the sense of Nye's hard and soft power (2005; 1990), has become a valuable conceptual distinction.

Soft power is the ability to get what you want through attraction rather than coercion or payments. When you can get others to want what you want, you do not have to spend as much on sticks and carrots to move them in your direction. Hard power, the ability to coerce, grows out of a country's military and economic might. Soft power arises from the attractiveness of a country's culture, political ideals, and policies. When our policies are seen as legitimate in the eyes of others, our soft power is enhanced. (Nye, 2004, p. 256)²⁰

One hypothesis is that the governance mechanisms and strategies employed by organizations in each study can be categorized along a spectrum of hard and soft governance. Hard governance mechanisms are explicit rules backed by credible enforcement mechanisms²¹ in their

19. The notion of a MPA's has been explored in the literature on global accounting standards (Mattli & Büthe, 2005; Büthe & Mattli, 2011).

20. An early articulation of hard versus soft power is (Nye, 1990), which describes the value of soft power from first principles. Nye elaborates this work in (Nye, Jr., 2005).

21. In the sense of a credible threat, typically technically implemented, that may be used as the coercive stick to dissuade violation of the rule and/or recidivism. The threat is credible not only because of the operational capacity to follow through, but also because the organization is often also the architect and maintainer of the resource in contention. A key difference is the RIRs maintenance of number registries. RIRs are the architects and maintainers of the *registries*, but not the protocols.

function-specific domain. Soft governance is applied by an increasingly politically savvy subset of the epistemic community that advises other governance (often government) actors on adjacent societal issues, often inviting actors to engage in bottom-up governance processes as a means to solve coordination problems at the intersection of the community's core issues and adjacent issues. A common instance is engagement with LEAs. The idea of a politically savvy epistemic community is being developed into a paper that updates the traditional dichotomy of epistemic and political communities (such as presented by Haas (1992)).

2.3 Private Orders and Regimes

Conventional applications of regime theory often exclude non-state actors. Notions of private order challenge the assumption that legitimacy is exclusive to state-based authority. Büthe provides some context:

[The private authority] literature is going beyond the earlier debates over *whether* non-state actors matter, shifting the analytic focus to *how* they matter ... These often collective actors are socially constructed, interact with other non-state actors as well as governments, operate for profit or provide public goods and in doing so support or undermine the state system. (Büthe, 2004, pp. 281–282)

This work clearly accepts *whether* and focuses, through the three studies, on *how* private authority matters. Complementarity argues for a supporting role, not an undermining role.

Büthe goes on to paraphrase the characterization of private authority provided by Hall and Biersteker (2003):

[P]rivate is defined as “neither states, state-based, nor state-created” and authority is defined as “institutionalized forms of expression of power” that are legitimate in the sense that “there is some form of normative, uncoerced consent or recognition of authority on the part of the regulated or governed.” (2004, pp. 281–282)

The definition of private focuses on the provenance of the organization itself but does not preclude private authority leveraging public, state-based orders and authority to achieve its goals. Cutler, Haufler, and Porter (1999) explicitly investigate that overlap and that attendant dependencies. The discussions of the studies will highlight overlaps where evident. The notion of “institutionalized” is interpreted as following North's notion of institution above and that power includes both hard and soft power. Finally, legitimacy is a critical explanatory factor for getting to *how*. Unpacking Hall's notion of legitimacy, the mechanisms by which one comes to “un-coerced consent” and “recognition of authority” is important in understanding how the bottom-up organizations emerged and evolved.

Like descriptions of cooperation from game theory, Cutler indicates that “the essence of cooperation is the acceptance of participants of some degree of obligation and some assurance concerning their future conduct.”²² A common theme in the private authority literature is that obligation is created from familiarity and repeated interaction. Cutler provides additional factors contributing to private cooperation:

the existence of complex knowledge/technology; learning processes from repeated interactions with each other and with the market; functionalist demand for order and rules; and political opportunities.

Cutler interprets private cooperation, especially the learning processes, as a product of a loose “epistemic community” in the sense of Haas.²³ Unpacking the logic of the factors, repeated interaction highlights sources of uncertainty, gaps in community/industry knowledge, and potentially highlights where the *demand* for regulation comes from (elaborated in next section). Repeated interaction serves two purposes. First, it increases the reputation costs for defection by bringing the shadow of the future a bit closer. Second, being an evolving technological ecosystem, repeated interaction with a reputable community²⁴ is a means for sharing information and learning how to resolve problems with trusted actors, not through random transactions. The argument is that repeated successful transactions²⁵ foster the development of norms that, in turn, create demand for greater guarantees about the regularity of norm/rule monitoring and enforcement. This recognition of the benefits of ordering is a factor in creating demand.

Despite the conceptual process of institutional evolution being laid out in a semi-linear fashion, it should not imply the steps are sequential and/or mutually exclusive. Private authority, manifest as a private regime, differs from the conventional articulation in that the actors are private, as per the definition above. The character of repeated transactions and the acquisition of legitimacy derives from that community, not the state. As implied above, the regulatory supply-demand metaphor

22. Quoted from (Cutler et al., 1999, p. 7), attributed to (Richardson, 1996, p. 138).

23. Cutler indicates that it is “loose” in the sense that it is not based on scientists and scientific knowledge as was in the original use by Haas (1992). Rather, it is based on knowledge shared by professionals. Foreshadowing, the network operator community is considered one of the core epistemic communities in this study and one that is, through the RIRs and IXP, becoming increasingly policy-savvy, breaking down some of Haas's original distinctions between epistemic and policy communities.

24. Engagement with a reputable epistemic community reduces, but does not completely eliminate uncertainty. The uncertainty related to trust in following the rules is reduced. The uncertainty due to the novelty of the process or technical configuration is rooted in learning and the distribution of experience with these problems. Pure learning is the degenerate case, where the community is exposed to process or technology previously unknown to the entire community. The latter case finds a distribution of existing experience and could be modeled as information contagion.

25. In the sense that the transaction was concluded, not a normative outcome.

is tacit in the discussions by Büthe (2004) and Cutler et al. (1999). In the next section, Mattli and Woods (2009b) elaborate regulatory supply-demand metaphors. The section concludes with a typology of narrow versus common interest regulation.²⁶

2.4 Supply and Demand of Regulation

Mattli and Woods (2009a) describe global regulation in terms of factors affecting the supply of institutional mechanisms, factors affecting the demand for regulation, and the structures that affect the market for these regulatory institutions. The objective of their work is “to fill some of the gap in the international relations literature by developing an analytic framework capable of assessing major regulatory changes at the global level,” (2009a, p. 3). Fundamentally, their framework attempts to map the varieties of institutions and markets for regulation that result in either capture by narrow interests versus genuine reflection of broad, common interests. The framework identifies institutional factors, focusing on openness and due process. Private authority admits modes of authority that are often framed as illegitimate (cartels) as well as those that are illegitimate with respect to some set of norms, such as studies of terrorist and crime networks as forms of private, albeit illegitimate authority. Mattli and Woods (2009b) provide a framework that complements these somewhat normative analyses with one that differentiates between common public interest and narrow interest without as much normative baggage. This framing is also consonant with the theme of painting a landscape rather than making normative judgements.

Mattli and Woods’s framework identifies process factors, in particular demand-side factors “summarized as ‘information, interests, and ideas’,” (Mattli & Woods, 2009a, p. 4). Information refers to information on the deficiencies of the current regulatory regime. Mapping this to the previous discussion, some of this information comes from repeated transactions and the observations of deficiencies.²⁷ It is argued that revealing deficiencies will create demand for regulation. Mattli and Woods argue that while information may be provided to illustrate deficiencies as instances occur, it may be difficult to sustain interest in those. The role of interests, in particular private policy entrepreneurs, is one means for sustaining interest (and by proxy regulatory demand). As it relates to this work, private policy entrepreneurs are one category of actors that “know how to capitalize on a crisis or failure” and that

may be powerful entrepreneurs for regulatory change if they are suffering from existing regulation either as corporate consumers of poorly regulated services or products; as newcomers

to an industry whose regulation has been captured by established firms; as firms at risk from the negative publicity and fallout from an industry disaster; or from the fact that other firms with whom they must compete are not on a level playing field. (Mattli & Woods, 2009a)

Private entrepreneurs are essentially those that have the immediate motivation to facilitate overcoming the collective action problem; they are argued to have “technical expertise, financial resources, and an organizational platform,” (Mattli & Woods, 2009a, p. 4). Ideas are the final factor. If the current rationalization no longer holds, new framings will be offered as the foundation of a new (here private) order, or set of regulatory rules. Mattli and Woods (2009a, p. 36) argue that the demonstration of regulatory deficiencies “not only shake public confidence in the managers, politicians, and regulators at fault, they also shake the ideas, values, or ideologies that underpin the status quo, destroying the legitimacy of the old way of framing regulation.” Mapping this to the discussion of regimes above, the shift in ideas and framing may be the process by which norms and principles change.²⁸ The mechanisms are certainly a combination of hard and soft power, leveraging soft power to demonstrate the attractiveness of a new way of framing regulation (policy).²⁹

Mattli and Wood’s framework is depicted in Figure 1.³⁰ In the context of this work, a key question is where each of the bottom-up institutions in the three studies fall in Figure 1. How does information sharing affect the demand for regulation? Do the private actors in the bottom-up institutions follow the model of private policy entrepreneurs described by Mattli and Woods? If not, is the difference a domain-specific nuance that can be corrected by rescaling the domain-issues or a more substantive difference in fundamental behavior? For instance, the level of participation and consensus models give insight into discussions of which cell these organizations fall into. These are reifications of the two conceptual dimensions. Active participation speaks to demand for regulation. The consensus processes represents a class of institutional mechanism. Evidence will be highlighted in Section 3; comparisons and mapping to Figure 1 will be provided in Section 4.

28. Yes, this mixes concepts from constructivist and admittedly institutionalist framing of regime model of reasoning about regulation. These are not necessarily mutually exclusive in this argument. The use of ideas is an effective mechanism for understanding evolving norms in a high clockspeed policy environment. There appears to be evidence of this conceptual mapping in early interviews, in particular those investigating the notion of policy experiments.

29. Mattli and Woods start with a broad definition of regulation: “control of economic, political, and social activities by means of making, implementing, monitoring, and enforcing rules,” (Mattli & Woods, 2009a). Regulation used in this work speaks to making of rules, be they formal or informal, that “control” by creating order. In this sense, policy has a regulatory function. This is quite different from a conventional notion of regulation couched in top-down construction of specific, formal rules by a “legitimate” implicitly authoritative body.

30. This is a reproduction of Fig. 1.1, (Mattli & Woods, 2009a, p. 16).

26. Check if this is semantically correct.

27. Deficiencies may be incentives to defect or the lack of well-understood norms that reduce transaction costs.

		Institutional Supply	
		Limited (Closed and exclusive forums, minimal transparency)	Extensive (Proper due process, multiple access points)
Demand	Narrow/ Limited	<i>Pure Capture Regulation</i> [A]	<i>De facto Capture Regulation</i> [B]
	Broad/ Sustained	<i>Capture but with Concessions and Compromises</i> [C]	<i>Common Interest Regulation</i> [D]

Fig. 1: Scenarios A-D are ideal types illustrating the variety of interest representations and supply of institutional mechanisms. Scenario A depicts class regulatory capture: a narrow or limited set of interests leverage closed forums to create rents. Scenario B illustrates how capture can occur despite extensive supply of institutional mechanisms. In this case, there may be information or idea failures that limit the market for regulation. Scenario C demonstrates capture (assuming the limited supply serves the incumbent firms with access to supply) despite broad, sustained interests. Scenario D is the “ideal” solution, finding broad interests supported by an extensive supply of regulatory mechanisms.

3 STUDIES

The governance studies here focus on institutions comprising network operators. Focal issues of these institutions are operational management of the Internet infrastructure. Governance here is scoped to those institutions actively contributing to operational management *in* the Internet (infrastructure) rather than governance of the web and other technologies that facilitate the varied behavior modes *on* the Internet. That said, this does not mean issues *on* the Internet are not considered. Rather, they are closely monitored for implications of those governance functions within the remit of these organizations. The scope of these institutions’ governance is the focus of Section 4.3. As more immediate background, this section lays out the high level functions and constituencies of the institutions in these studies to provide a baseline for further discussions of the observed functional remit and current comparisons of their governance contributions (Section 4).

3.1 RIRs and NOGs

Of the three classes of organizations addressed, the RIRs and NOGs those that most obviously and directly map to the network operator community. The two communities overlap to varying degrees. In some cases, such as NANOG and ARIN, the two institutions are separate. In contrast, the RIPE community and the RIPE NCC are distinct, but tightly coupled in terms of events and

membership. NOGs will be discussed first, focusing on NANOG and RIPE community as two of the oldest.

3.1.1 NOGs

Network operator groups or network operator forums³¹ generally claim three general objectives:³²

1. sharing technical knowledge and experience,
2. carrying out technical coordination within the Internet,
3. providing education services to the community.

NANOG “is an educational and operational forum for the coordination and dissemination of technical information related to backbone/enterprise networking technologies and operational practices” (NANOG, 2012). RIPE’s history states that “Réseaux IP Européens (RIPE) began in 1989 when a group of IP network operators based in Europe began a series of regular meetings to share experiences and carry out technical coordination work,” (RIPE NCC, 2010).³³ Evaluating these two top level mission statements alone hints at the differences to come. NANOG started as, and remains a forum for sharing operational knowledge. The RIPE community engages in that role, but forums are more explicitly linked to the RIPE NCC (which, among other tasks, fulfills the role of RIR for Europe, the Middle East, and Russia).

The differences provide interesting insights into the varying degrees of coupling between the NOGs and the RIRs as two conceptually different types of institutions. In terms of characteristics of institutions writ large, namely reducing uncertainty and the challenges of monitoring and enforcement of rules, the NOGs can be considered vehicles for reducing uncertainty. The common three objectives speak to information sharing, namely reducing the information asymmetries that drive uncertainty in transactions, and ultimately, increase overall transaction costs. In contrast, the next section will highlight the RIRs role in the administrative institution for manifesting the communities’ will into policies that are monitored and enforced.

Consider one of the many technical (and social) topics at the NOGs: interconnection. As conferences comprised of network operators, many of whom manage peering arrangements for their employer, a substantive amount of the conference content relates to peering and routing. Conference content comprises tutorials, vetted confer-

31. Mostly referred to as NOGs, although a number of NOFs, such as UKNOF, fall into the same category. For simplicity, all will be referred to as NOGs.

32. This generalization is by the author, not a common generalization espoused explicitly by the NOGs. In other words, to the knowledge of the author there is no document akin to a IETF informational RFC representing any form of consensus on these objectives.

33. There is a subtle difference in “coordination and dissemination of technical information” and “carry[ing] out technical coordination.” One is purely information sharing, the other has an element of ordering.

ence presentations,³⁴ and perhaps most importantly, hallway conversations during the coffee breaks. For new network operators, the tutorials are often an introduction to best practices. For new operators and veterans, presentations by researchers (both academic and commercial), vendors, and experienced members of the community often help clarify complex contemporary topics in the field. Tutorials and presentations are certainly formal mechanisms that contribute to knowledge sharing.

Informal mechanisms are just as important. For instance, one longtime community participant familiar with this work frequently taps the author on the shoulder at conferences, circles their finger in the air indicating the activity in the social at hand, and says “This is what makes the Internet work” as they move on to their next conversation. Turning this to peering arrangements, sharing interconnection data within the social network is a valuable, and often lively topic. Dissemination of on-the-ground experience with network interconnection dynamics, often the topic of coffee-breaks and socials, is where uncertainty, and arguably transaction costs are substantively reduced. Sharing information about interconnection policies, the reputation of different networks and their operations centers, knowledge of the Internet topology, and the value proposition of interconnecting with one network over another is extraordinarily valuable. This information improves the bargaining position of actors in the interconnection market.

The social network also contributes to operational efficiency. The social network is manifest in face-to-face meetings as well as NOG and other operator e-mail lists, and private channels that are often vetted based on reputation. The e-mail lists are rife with instances of individuals reporting problems to the community, sharing information collected from topologically different vantage points, and leveraging that information to find the root cause of the problem. Possibly the most well-known instance was when Pakistan blocked YouTube over a video insulting to the Prophet Mohammed. Pakistan Telecom advertised YouTube’s network prefix, nominally intended only for Pakistan, but which leaked to the world.³⁵ The network operator community recognized the problem, introduced an intermediate fix, and ultimately PCCW (Pakistan’s upstream provider) stopped propagating the advertisement until Pakistan corrected the problem. According to one version of the Pakistan-YouTube narrative, PCCW had to balance its regional reputation with its obligation to Pakistan, its downstream provider—this framing implies it chose its regional reputation. At least one source in the mail archives and multiple private conversations indicate that

34. For instance, the NANOG program committee solicits and vets (peer reviews) conference presentations for technical quality, interest to the community, and timeliness.

35. There are a number of contending stories here. One implies it was simply a technical mistake not unlike others that have either misconfigured routing advertisements or dumped a complete routing table, such as the incident of 7007. Another implicates a voting scandal that was also being publicized on YouTube at the same time.

these kinds of routing mishaps have had a global impact every few years and happen on a smaller, regional basis a few times a year.

In both specific functions, sharing interconnection information and coordinating the resolution of routing mishaps, it is important to distinguish the precise role of the NOG as an institution. Both cases rely on information sharing that is arguably already present in the community. As an institution, the NOG *facilitates* that information sharing and the dissemination of norms established in the community (through informal communications and best practices). The interconnection story implies monitoring and a question of enforcement; the Pakistan-YouTube story is an instance of monitoring and enforcement. A key difference is that responsibility for monitoring and enforcement is not in the remit of the NOG. Interconnection agreements are monitored and enforced by the participants³⁶ and are often informal.³⁷ In the Pakistan-YouTube case, monitoring and enforcement are clearly at play, but are a manifestation of the norms promulgated by the NOG communities. In this case, adapting John Gilmore’s famous quote, “[network operators] see censorship as a damage and route[] around it.” More precisely, it is argued network operators see censorship as damage to the integrity of the routing table and act to correct it based on their norms regarding the accurate and legitimate provenance of routing information.³⁸ In contrast, the RIRs, described in the next section, do engage in monitoring and some degree of enforcement.³⁹

Nominal descriptions of the NOGs’ activities, mainly technical presentations, tutorials and social networking, may not distinguish them from the run-of-the-mill trade conferences. That said, the observed role of this information in day-to-day operations, the critical interdependence of the corresponding network-of-networks in the Internet, and the premium placed on quality of information sharing is evidence of significant differences between network operator communities from the conventional trade conference. In particular, the network operator norms certainly do not eschew gains by their individual organizations but multiple actors have referred

36. This is widely the case in the US and EU economies. A counterexample is ARCEP in France, proposing the regular documentation and reporting of interconnection agreements in France, with French companies, or affecting French traffic. The closure captures quite a few more actors than merely those with physical presences in France. A broader, contemporary topic is the renegotiation of the ITRs in the ITU, in particular proposals for regulation of interconnection agreements. While adjacent to this work and important in the discussion of bottom-up organizations as governance arrangements and their engagement with their global “peers,” the substance of ongoing ITR proposals will not be addressed in detail.

37. A recent study by PCH indicates that 99.51% of interconnection arrangements in the sample are informal “handshake” agreements (Woodcock & Adhikari, 2011).

38. A recently heated and ongoing policy debate in the community focuses on RPKI as a technical solution to the integrity of routing information. It is also a good illustration of the consensus process at play.

39. This does not imply perfect monitoring and enforcement. Like any institutions, these efforts meet with limited degrees of success.

to the idea of “co-opetition.”

The community dynamics seem to support the argument that these private actors engage in public forums, constructed to facilitate the pursuit of private (at the firm level) interests, yet consistently produce public good as a collateral benefit. This is not purely incidental, many justifications of this cooperation begin and end with “for the good of the Internet.” The comparisons in this work, especially the comparisons of common dimensions in Section 4 will provide an initial comparison and evaluation of institutional building blocks (governance mechanisms) that contribute to this seemingly virtuous cycle. Not to be a complete apologist, this work, as the author often reminds the community, is “warts and all.” Failure modes and tensions will be highlighted.

3.1.2 RIRs

The constituency of the RIR can be broadly described as any actor that uses resource registration services or to whom Internet number resources have been allocated or assigned. The rest of this section will be spent unpacking that statement without spiraling into a complete history of number resource management in the Internet. In terms of sources of authority, the history of the IR system provides one source and contemporary articulations of authority and legitimacy rooted in the community imply another. This narrative will provide overviews of each, providing a kernel of the argument for the RIRs authority to be made in the dissertation.⁴⁰ The historical source of authority is the RFCs on which the RIRs draw their norms and principles to this day. The more recent, and more often articulated source of authority, is the treatment of the constituency as a (collective) principal that directs RIR development.⁴¹

3.1.3 RFC Provenance of Authority

One of the first articulations of a registry system is RFC 1174 (Cerf, 1990), which suggests IANA remain the centralized authority, asserts IANA have the power to delegate portions of number resource management, and that “candidate delegated registries meet with the IANA and IR to review operational procedures and requirements and to produce documentation to be issued as RFCs describing the details of the proposed distributed mode of operation,” (1990, p. 3). RFC 1366 (Gerich, 1992) further refines the criteria for establishing distributed regional registries. A key premise for distribution is that registries “located in distinct geographic areas may be

40. This is the “kernel” because it is based on documented processes of delegation that have been alluded to in private conversations. Further formal interviews and analyses of the policy development processes are expected to fill in the dynamics and add evidence of where and how points of discretion in the processes play out.

41. It is important to note that even though, in the author’s experience, the constituency as a principal is the more frequently articulated source, those voicing this line of authority have not explicitly denied or obfuscated the RFC-based provenance of the IR, IANA, and RIRs’ authority. The discussion of scoping in Section 4.3 will provide a first pass at untangling this as an interdependent web of authority.

better able to serve the local community in terms of language and local customs,” (1992, p. 2). A subsequent assertion is “that there is just a single regional registry per geographical region at this level to provide for efficient and fair sub-allocation of the address space,” (1992, p. 2). RFC 1366 makes the following criteria explicit (1992, pp. 2–3):

- a) networking authorities within the geographic area legitimize the organization
- b) the organization is well-established and has legitimacy outside of the registry function
- c) the organization will commit appropriate resources to provide stable, timely, and reliable service to the geographic region
- d) the commitment to allocate IP numbers according to the guidelines established by the IANA and the IR
- e) the commitment to coordinate with the IR to establish qualifications and strategies for sub-allocations of the regional allocation.

In particular, criteria a and b provide links between community-based consensus and conventional delegation of authority. Taken as written, the process is not a simple beauty contest adjudicated by the IANA.⁴² Rather, would-be constituents of the registry must legitimize the organization. Points c–e set out criteria for coordinating resource allocation with the IANA and cooperation with the IANA to create a uniform and consistent application of general norms and principles

The principles and norms for RIRs were established in RFC 2050 (Hubbard, Kusters, Conrad, Karrenberg, & Postel, 1996) as best practices. Linking this to sources of authority, the principles described in RFC 2050 were established through experience in the community and codification of these experiences into a set of principles. The goals (interpreted here as principles) established are:⁴³

Conservation: Fair distribution of globally unique Internet address space according to the operational needs of the end-users and Internet Service Providers operating networks using this address space. Prevention of stockpiling in order to maximize the lifetime of the Internet address space.

Routability: Distribution of globally unique Internet addresses in a hierarchical manner, permitting the routing scalability of the addresses. This scalability is necessary to ensure proper operation of Internet routing, although it must be stressed that routability is in no way guaranteed with the allocation or assignment of IPv4 addresses.

42. There is certainly room to contest this, but this analysis is focusing on the documented lines of authority. Later work will evaluate the creation of AfriNIC and LACNIC with respect to discretion that may exist in this process.

43. The following are directly quoted from RFC 2050 (Hubbard et al., 1996), emphasis added.

Registration: Provision of a public registry documenting address space allocation and assignment. This is necessary to ensure uniqueness and to provide information for Internet trouble shooting at all levels.

RFC 2050 explicitly notes there is tension between conservation and routability. More recently, conservation has become an important issue in discussions over how IPv4 depletion relates to IPv6 take-up and the appropriate policy response to the dwindling pool of IPv4 addresses in the various regions. A number of additional principles common in RIR practices are evident. One issue is needs-based allocation. The articulation of conservation contains reference to needs of operators and users. The IANA, having “authority over all number spaces used in the Internet,” states that “IANA allocates parts of the Internet address space to regional IRs [RIRs] according to its established needs” (Hubbard et al., 1996, p. 3). Further, RFC 2050 states:

Regional IRs are established under the authority of the IANA. This requires consensus within the Internet community of the region. A consensus of Internet Service Providers in that region may be necessary to fulfill that role. (Hubbard et al., 1996, p. 4)

This statement in particular is a clear link between the authority of the IANA and the consensus based processes that govern policy development in the regional RIRs.

The needs-based criteria, as an element of procedure rooted in an established norm, has received criticism over the years, in the face of exhaustion has been the subject of renewed discussion on the policy mailing lists, and has been left out of certain some policies altogether. The latter, the initial resource transfer policy in APNIC, was an interesting test of the greater community’s support of needs-based criteria as a norm. Other criteria include the general types of information needed to assess needs such as utilization rates.

One of the most important criteria established are the size of the RIRs and the consensus-based process by which they are created. In November of 1996, when RFC 2050 was written, there were three RIRs: InterNIC in North America, RIPE NCC in Europe, and APNIC in the Asia-Pacific. RIRs were expected to be of continental dimensions; local Internet registries (LIRs) were considered to be “usually of national dimensions.” (Hubbard et al., 1996, p. 4). RIRs are currently of continental dimension. LIRs are typically listed as serving many different states (nations). An interesting structural difference amongst the RIRs are those that have a national Internet registry system in place or not. At one point the RIPE region did have an NIR system; APNIC and LACNIC currently do have NIRs.

The NIR system is an interesting instance of refining RFC 2050. As per above, RFC 2050 assumes LIRs will be nation-state size registries; in practice, LIRs may serve

multiple states within and/or across RIR boundaries. NIRs in both APNIC and LACNIC are scoped to national economies, often under the premise of providing more efficient local services. The address allocation process has evolved since the introduction of NIRs. For instance, APNIC has transitioned from a ‘confederation’ model where NIRs were allocated pools of addresses to be subsequently allocated to NIR members (APNIC, 2008, section 3.5) to one in which allocations are *approved* by the NIR but allocated from the regional pool by the RIR depending on the size of the block (2008, sections 3.2.1, 3.2.2). The change occurred because delegation to the NIRs and rapid consumption of those allocation windows created aggregation problems for rapidly growing organizations.

Under the principal-agent model, this appears to be a contraction of the discretion of the agent. In this case, the rationale provided in discussions is that inefficiency occurs because regional delegation of resources could better serve the aggregation norm. A number of conversations have stressed that the change was not a “reigning in” of authority, but rather the shift to allocation mechanisms that made supporting the aggregation norm more effective. The NIRs also exist for other reasons than merely allocation efficiency—language differences and delegation of operational responsibility to national registries have also been cited. The existence of NIRs in the APNIC region is also an artifact of regional politics, in particular the case of “me too” politics where one state wants an NIR because others in the region have one. “Me too” NIRs naturally lead to the question of the agent’s autonomy and whether the controls in place are sufficient to first manage the NIR and second to ensure autonomy, as noted by Hawkins et. al., does not undermine regional efforts. The RIR-NIR-LIR relationship provides an interesting context and source of evidence of differentiated governance scope amongst the RIRs.

3.1.4 Community Policy Development

Shifting gears to community-based provenance of authority, nearly all leadership articulate the principle that “the RIRs do what the community tells them.” The most frequently cited vehicle for engagement is the policy development processes in the RIRs. Across all five RIRs, policy development occurs via a combination of the mailing lists, varying degrees of shepherding by designated community members and RIR staff, and face-to-face discussion at membership meetings. In all cases, the policy development process is considered bottom-up: initial policies are created by one or more members of the community and distributed via an e-mail list dedicated to policy development. Each general phase of the process is described here in terms of participants and the consensus process.

This work distinguishes the general process into phases delineated by the consensus process: active consensus, passive consensus, review. The notions of active versus passive consensus have been developed from

review of the policy development process documents, RIR presentations, observation of member meetings, and interviews thus far.⁴⁴ Active consensus means that a sufficient number of individuals have shown support, via the e-mail list or in a public policy meeting depending on the specific PDP. In simple terms, this implies there is sufficient need in the community for a policy based solution. In Mattli and Woods' terms, this implies demand for "regulation." For instance, the ARIN PDP indicates need for policy may be "determined by a change in technology, a change in the operational environment of the Internet, or the result of experience of the implementation of the existing policy," (ARIN, 2009). The latter, experience with implementation, has been articulated multiple times in other contexts—it provides further evidence of a (tacit) paradigm of policy experiments.

Passive consensus is an opportunity for community members to challenge the version of the policy after that active consensus phase; passive consensus is the absence of objections.⁴⁵ It is important to note that unanimity is sufficient, but not necessary. In multiple PDPs this is described as an opportunity for the community to react to the current version of the policy, the product of the active consensus process. In the ARIN region, this occurs after the Advisory Council determines active consensus and moves the draft to Last Call. In the RIPE region, active consensus is at the end of the Review phase (consensus on the documents produced by the proposer and the WG chair and the impact analysis produced by RIPE NCC staff), passive consensus is at the end of the Last Call.

Review occurs after active and passive consensus has been reached. In the case of ARIN and RIPE, both involve evaluating whether the policy process itself was adhered to, not an evaluation of the policy itself. In the RIPE region, the collective of WG chairs makes this decision. In the ARIN region, the Board of Trustees of ARIN evaluates the draft policy in terms of "fiduciary risk, liability risk, conformity to law, development in accordance with the ARIN PDP, and adherence to the ARIN Articles of Incorporation or Bylaws," (ARIN, 2009). Both cases are intended to be final checks on the consensus decision making process and feasibility of the policy before moving to implementation.

3.1.5 Resources to Platforms

In terms of the three basic elements of institutions, reducing uncertainty, monitoring, and enforcement, NOGs and RIRs have different institutional roles. In terms of the scope of governance, the norms, principles, and policy development paradigms arguably form a private regime. Further, the scope of governance is different for

44. Here interviews includes both formal interviews and private conversation.

45. An excellent discussion of what is here referred to as active and passive can be found in (Steffan, 2012). This is also an excellent instance of community leadership addressing questions about the policy development process.

the NOGs and the RIRs. The latter is clearly identified in the hierarchical definitions of IR (IANA), RIR, NIR, and LIR, but contribution to the process is open to all. NOGs are organized around regions to varying degrees—compare NANOG with RIPE with UKNOG with SANOG (Southeast Asia). The reach of the networks NOG participants are managing may easily span multiple RIR jurisdictions. The YouTube-Pakistan story is prime instance, where discussion of the outage occurred on multiple operator lists.

3.2 IXes

Internet exchanges (IXes), or Internet exchange points (IXPs),⁴⁶ as organizations, exhibit an interesting confluence of technical management and political engagement.⁴⁷ A telling contribution of the IX study is the discipline with which these organizations manage to sustain the decoupling the two. This section couches the study of IXes in the larger trend of Internet infrastructure studies, provides baseline definitions, then focuses on how IXes exhibit the distinction between hard and soft governance.

3.2.1 Infrastructure in the Middle

Discussion of Internet infrastructure development and management tends to focus on three areas: large carriers' infrastructure economics, the economics of network access deployment, and the modified end-to-end principle.⁴⁸ These are certainly important for understanding how to sustain an open, innovative, and broadly accessible Internet. This study complements these by shifting the focus to the evolving topology *between* the large "backbone" carriers and the eyeballs. The unit of analysis is the Internet exchange (IX), focusing on the governance and operations of IXes as organizational modes that are contributing to the "flattening" of the

46. This difference is subtle but important for the ongoing evolution of these interconnection fabrics in terms of their governance and effect on the Internet industry. The notion of a point limits the geographic reach of an IX, historically to a metro-area. Other modes, such IX nodes connected over longer distances, are being explored, but at the moment are challenging existing norms, such as the non-compete norm, that will be discussed later in this paper.

47. Not all are involved in political engagement. The larger IXes often have a policy officer. The smaller may rely on an organization such as Euro-IX to provide collective policy engagement.

48. The original end-to-end principle explicitly addresses end-to-end communication in terms of where specific functionality lives in the protocol stack (Saltzer, Reed, & Clark, 1984). Modified forms of the end-to-end principle have proliferated. Solum argues the layering principle, derived from the end-to-end principle, that the law should respect the layers as a means to ensure the integrity of the layered architecture of the Internet (2003). van Schewick (2010) links Lessig's interpretation of the end-to-end principle (1999) to innovation *on* the Internet. While valuable contributions, the modified end-to-end principles tend to focus on how societal issues drive violations of the end-to-end principle. These typically do not address the operational and governance factors *in* the Internet that facilitate, and in some cases, ensure, end-to-end communication.

Internet topology.⁴⁹ IXes are argued to facilitate low-cost interconnection and transit, foster the development of local content markets,⁵⁰ provide the mechanisms for ensuring robust interconnection fabrics, and provide the local⁵¹ governance mechanisms necessary to manage and sustain these platforms as infrastructure resources.

With notable exceptions,⁵² IXes are understudied and have received little attention in the literature. Moreover, most histories of the Internet start with the statistical packet and end with the NSF transitioning its management of backbone networks to the commercial sector. Since then, the operational infrastructure of the Internet has seen substantive evolution. The IX study writ large is a comparative analysis of IXes in terms of the confluence between infrastructure operations and governance.

3.2.2 Definitions

A key to understanding the functions and roles of IXes is to distinguish between the technical requirements, economic and development outcomes of IXes, and the governance requirements of outcomes. The definition provided by Euro-IX is a concise articulation of an exchanges' technical function:

[An IX is a] physical network infrastructure operated by a single entity with the purpose to facilitate the exchange of Internet traffic between Autonomous Systems. (Euro-IX, 2012c)

In the early days, an IX was simply a switch at a location convenient for members to connect.⁵³ As IXes have grown, many are technically multiple point (node) exchanges, often having switching equipment in a variety of locations, typically in a metro-area, connected by either a connectivity provider or by dark fibre managed by the IX. While colocation facilities may be localized to a metro-region, the distribution of customers varies

49. Gill, Arlitt, Li, and Mahanti (2008b) explicitly refers to flattening in their hypotheses about content providers' deploying WANs and peering strategies that circumvent Tier 1's at the top of the conventional tiered topology. Labovitz addresses this more directly, but refers to "a topological trend towards a *more densely interconnected* Internet especially with respect to large content providers." (2010, p. 1, emphasis added)

50. A key element of the study is to understand, catalog, and provide empirical evidence of the economic and political criteria that creates fertile ground for this development.

51. Local to the IX.

52. Kende and Hurpy (2012) is a recent assessment of the impact of IXes in Kenya and Nigeria. Gerson and Ryan provides an overview of IXes for non-engineers, indicating "that a deeper policy understanding about how different IXPs operate can improve the regional Internet economy, mitigate corrosive sectoral distrust, improve Internet quality, and benefit consumers," (2012, p. 1). DeNardis (2012) will present work on the geopolitics of IXPs in developing regions at TPRC in September of 2012. Ager et al. (2012) is a study of a large IXP in Europe to appear in SIGCOMM'12, building on ideas related to traffic flows around the tier 1's (Labovitz et al., 2010), the flattening of the Internet topology (Gill et al., 2008a) and earlier work on IXes (Augustin et al., 2009; Stanojevic et al., 2011). Many studies of interdomain routing and traffic, using these behavior modes as evidence of changing topology, reference one or more of Bill Norton's white papers on industry peering strategy (Norton, 2012).

53. The location and ownership of the location is actually quite important, often required to be carrier-neutral.

significantly. For instance, three of the top four IXes have a diverse set of members from all six inhabited continents.

As an organizational mode,⁵⁴ IXes often define themselves in terms of interconnection objectives and benefits:⁵⁵

- keep (geographically) local traffic local
- decrease latency
- reduce transit costs
- improve route diversity for members
- improve local bandwidth
- more robust infrastructure
- more robust access to infrastructure services such as DNS and timeservers
- performance improvements incentivize further development of local content

Each of these will be addressed in turn.

The first reason for creating an exchange was localization of traffic. In the early days, substantive amounts of traffic had to be transported to a NAP such as MAE East. For instance, to get packets from one part of London to another, packets crossed the Atlantic and back. The Seattle Internet eXchange (SIX) was created to localize traffic that, despite originating and terminating *in the same building* took a detour to Texas and back. This phenomena is referred to as tromboning. Tromboning has a number of undesirable effects, among them it is expensive (paying for transit), has higher latency, and state governments have not been happy with what should be in-state traffic traveling across jurisdictional borders.

The second benefit of an exchange is a direct artifact of reducing tromboning. Once connectivity is localized, average latency is reduced and latency to local peers on the exchange is dramatically reduced. For instance, geographically local origins and destinations that were once multiple hops away across potentially congested upstream links are now only two hops away (one to the exchange, one from the exchange to the destination exchange member), increasing the chances of lower congestion.⁵⁶ This improves the overall experience for the end-user: local content is delivered more quickly, local clouds are more responsive, and lower local latency sets the stage for cached content.⁵⁷ In addition to improving general experience and application performance, lower

54. Here, organizational mode is used loosely in comparison to the dichotomy of hierarchy or a pure market. It will be argued this networked mode of engagement provides a platform for markets: interconnection as the original market, content a relatively newly matured market, and the emerging IPX market. This latter is currently evident at a few exchanges (AMS-IX and Equinix in Singapore) and bears additional observation for a variety of reasons.

55. This list is generated from private conversations and community presentations.

56. This *is not* meant to universally imply fewer hops guarantee lower latency. In this case, it is more *probable* that one will encounter longer latency over multiple hops given greater variance in latency and congestion outside of the centrally managed IX fabric.

57. Cached content is discussed at greater length in the next section (3.2.3) on IX constituencies.

latency also opens the door to localized latency-sensitive applications, such as gaming, video-conferencing, VoIP, and tele-medicine applications.

IXes are also argued to reduced transit costs. Reduced transit costs are realized by any customer of the IX that moves local traffic from transit to the IXP. The other mechanism that reduces cost is collective bargaining power. According to Jensen (2009, p. 5), IXP, an IXP in Nigeria, negotiated lower international connectivity rates from USD 6300 to USD 2800 per month for networks participating in the exchange. The relation between a transit market and the effect of an IXP are not unidirectional. The market and regulatory environment affect the potential for establishing an IX and its growth. In the other direction, an IX can be used as a catalyst to facilitate greater competition for transit. In the latter case, when IXes allow transit markets on the fabric⁵⁸ the (transaction) costs of changing transit provider is substantially lower than if having to disconnect from existing transit provider and establish direct connection with another transit provider.⁵⁹

The effects on transit costs assume the fee structure is sufficiently low to under-price transit for local traffic. A baseline calculation by Jensen (2009, p. 5) argues that localizing 20% of traffic the cost of an IXP can be covered in a few months; similar arguments have been made by a variety of IX proponents in private conversations.⁶⁰ The ROI argument is a low-barrier to development. The caveat is that would-be members' need to buy-in to the *idea* and benefits of an exchange. Like any rule, there are always exceptions. One is the situation where inter-state tariffs artificially inflate the costs of a network in one country connecting to an IX in another; in this case the scope of IX benefits may be national. Other markets have embraced the value of a regional Internet economy but have preserved elements of traditional telecommunications era interconnection tariff structures. Returning to ROI, given the continual decline of transit costs, the low-barrier to return may not be the case forever and has been a recent point of discussion in a number of conversations on IX fee structures.⁶¹

When purchasing transit from a single or even multiple providers, a network relies exclusively on those links for the entirety of their Internet access. This means access to both relatively local networks and "foreign"

58. Some IXes do not allow transit across the fabric, suggesting networks in transit relationships use private interconnects. Other IXes support private interconnects as a type of neutral managed service. Yet others suggest transitioning to a private interconnect provided by the colocation provider. In the case where the colocation provider is the same as organization as the exchange, this is similar to providing a private interconnect service except the facilities and service are provisioned and managed by the same organization.

59. Ongoing work is to take the synthesized list of IXes and categorize based on whether they facilitate a transit market or not.

60. It is technically possible that a member may have too little local traffic to warrant the cost of an IX. The success of IXes implies that this is currently not the average case.

61. Keeping fees below transit cost has been a common subject of discussion with IX operators and leadership.

networks. IX membership provides diverse routes to local content. Thus, if there is an outage at an upstream provider that does not affect local connectivity, the local links will remain available. This is arguably increasingly the case as IX membership grows, moving local connectivity to the IX rather than with the transit provider; this also brings the IX in closer competition with the transit provider. Diversity is a contributor to robust local Internet infrastructure and may be important for various government services and local businesses dependent on Internet access. A preliminary ranking of diversity based on Euro-IX data seems to be consonant with community perceptions, ranking major IXes such as AMS-IX, LINX, Equinix-Ashburn, and others near the top.⁶² Figure 2 shows a view of the diversity of membership connections to IXes. A number of networks have very diverse membership in the sense that their members are members of multiple other IXes. Note the mismatch between the visual prevalence of the purple and yellow ranges with the upper of the inset bar charts; this gives some insight into how substantively connected the content networks are and the value IXes. Future work will condition this data on state, region, various measures of member size, and mappings to topological data; the result of future work will be a characterization of IXes based on membership demographic.

Another factor that combines a number of the outcomes above is improved local bandwidth. Rather than having a diverse set of decentralized interconnects that make identifying overall bandwidth consumption and congestion factors difficult to measure, the centralized IX fabric can be monitored by the organization running the IX. For instance, IXes that maintain sFlow data can provide members with detailed information regarding which peers they are exchanging how much traffic with. For those actors with less experience or whose primary function is not network management, this is a value-added service that helps better manage their bandwidth usage and allows members to increase bandwidth to other members.

Common monitoring also contributes to bandwidth. In the aggregate, common monitoring by the IX itself also allows for collective adjustment of the capacity of the fabric. Infrastructure upgrades can be in part justified by usage statistics. In associational membership based IXes, members have a say in the features supported but in many cases the fee structure is justified by usage, but considered an implementation decision by IX management.⁶³ This is not to say the monitoring and

62. The raw data is from Euro-IX, the ranking is the product of the author's analysis.

63. This in itself is an interesting statement that intersects the scope of governance and the scope of consensus process. Here, implementation is a hard governance decision made at the discretion of IX leadership based on expert knowledge of the system. The threshold between those decisions that require consensus by the members (across the studies) versus those considered "implementation" decisions is an ongoing subject of discussions and interviews. In principal-agent terms, it is a demonstration of the discretion of the IX.

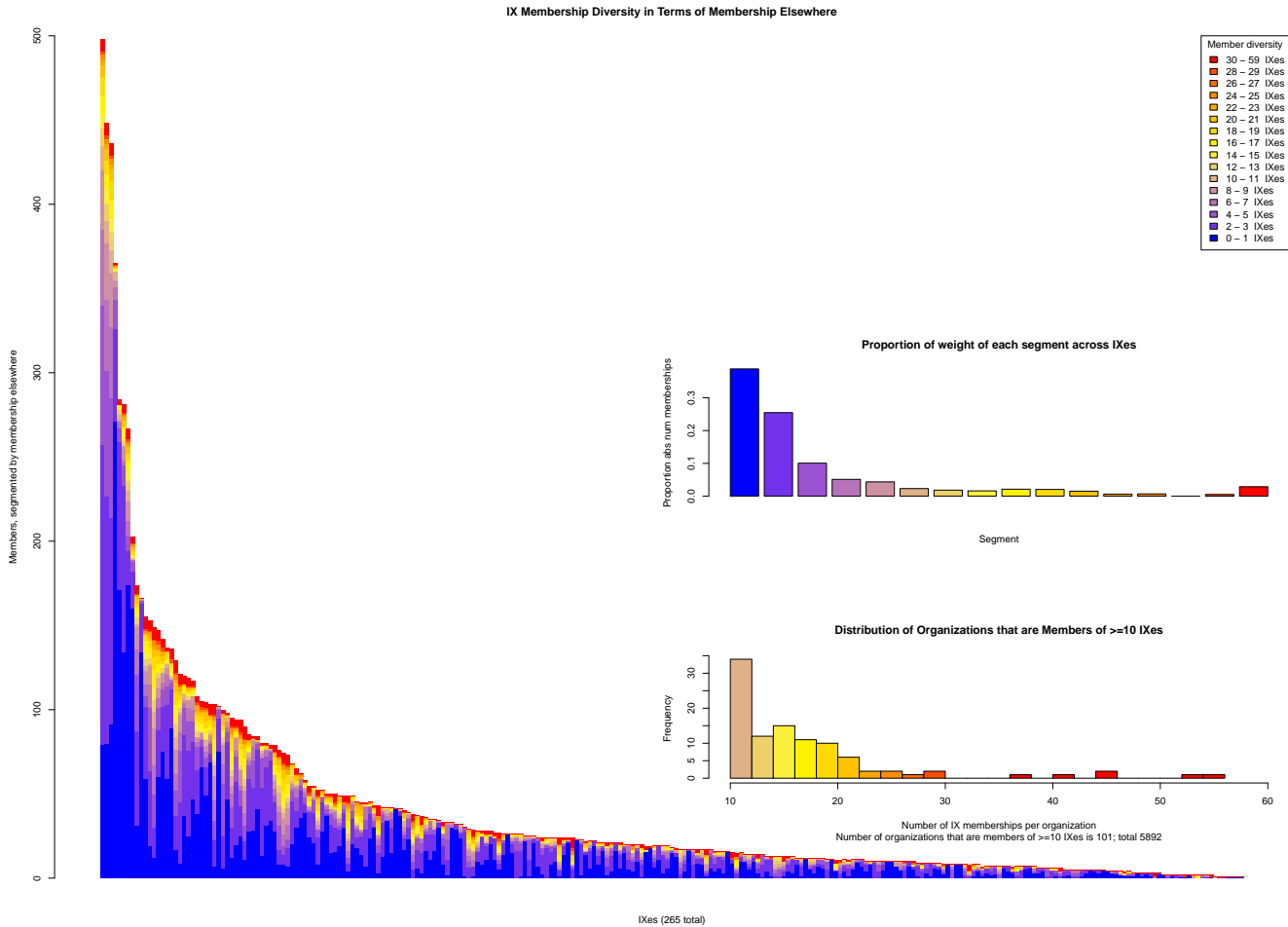


Fig. 2: The diversity of IX memberships provides interesting insight into the value of an IX to different types of networks. The bars on the x-axis are different IXes, ordered by number of members. The y-axis is the number of members. A distribution of the number of IXes a network is a member of was generate to create the segments that delineate each bar, shown in the bottom inset histogram, limited to those that are members of ≥ 10 IXes. For the bar colors, for instance, the blue bar at the bottom of each stack indicates the set of networks that peer at 0 or 1 IXes. Thus, that member is unique to that IX. The legend denotes the spectrum of colors. The distinguished case is the upper-most red. This indicates members that peer at 30 or more IXes (30-58). There are six of these in the Euro-IX data. These are, not surprisingly, a research network, a transit network, and multiple content delivery networks.

enforcement processes are simple, conflict-free transactions. Some IXes trust their members to monitor their port usage appropriately, not going over the allocated port size. Others require an upgrade at certain thresholds, such as consistent 80% capacity utilization. These technical measures contribute to ensuring the health of the fabric and that promised port capacity is available.⁶⁴

Another improvement in bandwidth may come from non-IX infrastructure investment in transport networks in the region. In conversations this boils down to a number of interpretations of how IX factors above contribute to the development of a local Internet industry sector. On the metro-scale, the demand for metro-transport for a virtual IX increases with overall IX traffic and the number of colocation sites in the metro area. A recent “trend” is the introduction of a reseller program. A reseller program allows distant networks to connect to

the IX without a direct connection; “partners” provide transport, allowing the networks to connect as if directly connected without the cost. The partner is a connectivity provider connected to the IX. The remote member contracts service that facilitates peering at the IX as if they were directly connected. Reseller programs reduces the costs of smaller networks connecting to the exchange while providing these smaller networks with the opportunities to peer with the variety of other networks at the exchange.

The reseller trend is growing and evolving, but is not embraced universally. For instance, a key question is “What is the diameter of an IXP?” One definition of diameter is the greatest geographic distance between colocation centers at which a virtual IX node resides. Some IXes have nodes in multiple metropolitan areas and serve that metropolitan market, but are not connected to one another. This means that members of that IX organization may peer with one another in the metro

64. In some cases with contractual obligation for remuneration for to the member given a certain threshold of downtime.

market, but cannot peer at the other locations unless they physically connect to the virtual IX in the other market. Instances of this are Equinix in the US; Netnod and DECIX are instances in the EU. The fundamental norm behind this behavior is that, especially for associational membership based IXes, the IX does not compete with its customers, which includes organizations providing connectivity between networks.

This norm is violated on a small scale by interconnecting colocation facilities into a virtual IX, often by leasing and lighting dark fibre. This is a subtle difference. The connectivity between IX locations does nominally compete with transport provided offered by members or potential members. That said, IXes do not seem to offer transport as a service unto itself; the transport is part of providing the primary interconnection service and provides greater flexibility (and potentially redundancy) for customers in a metropolitan area. This is arguably an improvement in the accessibility and redundancy of the mutually beneficial IX in an established market.

Another contribution to the robustness of the local Internet infrastructure is the colocation of infrastructure services such as DNS servers, root server copies, time servers and caches such as web and content caches. For instance, Netnod provides both DNS and time server services to its members. This reduces the burden on individual members to maintain these resources and is arguably an instance of the IX provisioning a semi-public good. For both classes of infrastructure, maintaining a centralized instance is also beneficial for those maintaining that service. In the case of DNS and timeservers, this is a value-added service for members. In the case of caches, there are benefits for the cache maintainer (a CDN or content provider), benefits for the members, and by proxy benefits for the IX. For the cache maintainer, one centralized cache supplying many networks reduces capital costs, maintenance costs, and connectivity costs for filling it from the nearest data center. The benefits for the members is that they have low latency, high bandwidth connections to the cache, improving the performance of “foreign” services such as Google and Netflix. It also reduces transit costs considering the popularity of the cached content such as Google searches, YouTube videos, multimedia streams, and even news servers. Member benefits improve the attractiveness of the IX by proxy because connecting to the IX typically gives access to the cache(s) available. Very coarse evidence of this can be seen in Figure 2.

Finally, as may be obvious, the presence of an IX is argued to engender industry sector development. In developed regions with mature IXes, the relationship between IXes and colocation facilities are not necessary, but are certainly mutually reinforcing. IXes benefit from high quality, professionally run colocation centers; colocations centers benefit from customers coming to access the IX. A variety of IX analyses argue that IXes are a strong contributing factor to the development of an Internet industry sector (Kende & Hurpy, 2012; Jensen,

2009; Gerson & Ryan, 2012). A number of leaders in the IX community have made it clear that, while an IX can contribute, it is not a panacea. A number of other factors must be in place. A number of IX leadership have been quick to point out that successful IX development is “20% technical, 80% social.” The 80% social includes elements of governance, discussed in the next section.

3.2.3 Constituency and Authority

Within the IX institutional ecosystem there are a number of organizational modes. Within the community, a common distinction is between the commercial model typical of the US (exemplified by Equinix) and the associational membership model, exemplified by LINX and AMS-IX. Gerson and Ryan (2012, pp. 8-17) identify four types of IXes: commercial IXes (such as Equinix) that offer a variety of infrastructure services, cooperatives (or what the community refers to as associational membership) that are run through various membership delegation mechanisms, managed non-profits (such as DE-CIX, owned by ECO, the German ISP consortium), and voluntary IXP's which Gerson indicate have no formal organization or staff. Jensen (2009) identifies four as well: nonprofit industry associations of ISPs (maps most closely to associational membership), operator-neutral commercial and for-profit companies (commercial), university and government agencies, and informal associations of networks (associational membership). While these are useful distinctions, the general distinction of associational membership and commercial seems to capture the two general ends of the spectrum: one where *members* have a role in deciding IX strategy and direction and the other where *customers* simply buy services. The categories identified above can be described as variants with different organizational roots. The commercial model has customers rather than constituents and, thus, little direct governance by those constituents; as noted by Gerson, the exchange is often one commercial service amongst many.

The constituencies of IXes have evolved since the emergence of the major IXes in the US and EU. Initially, as noted above, the objective was to reduce tromboning and transit costs. The actors mainly concerned with this at the time were local ISPs attempting to reduce their dependence on the large transit carriers. For instance, LINX was the product of two UK ISPs interconnecting with a serial link, others joined, and the group realized that the nascent fabric required greater management than a volunteer network could provide. In this case, it is also an instance of the transition from one of Gerson's modes, a voluntary IX, to another, a cooperative (associational membership) IX. As a successful case, LINX is now one of the biggest IXes in the world.

In terms of changing constituency demographics, LINX is an instance. Early on, LINX limited membership to ISPs; in 2000 it opened its membership to a wide variety of networks. IX memberships are quite diverse in terms of the types of actors. Categories include not

only traditional ISPs, but also content delivery networks, direct content providers (such as the BBC in the LINX case), hosting providers, online application providers, gaming platforms, and other specialized networks. The change in demographics yields a change in markets atop the fabric. The initial market was interconnection, either settlement free or paid. Building on the LINX case, the introduction of content providers created a content market; content markets change interconnection dynamics and thus these markets are not mutually exclusive. And, as mentioned before, some IXes allow transit across the fabric, creating a market for flexible transit relationships that do not require costly direct connection to a transit provider.⁶⁵ IXes are generally adamant that their governance processes are limited to the technical management of the fabric itself.

A key issue for constituencies across the organizational modes is the notion of a carrier-neutral exchange. In the early days of the NAPs in the US, there was substantive friction over the charging schemes and quality of service provided by carrier run NAPs like those run by Sprint and Ameritech.⁶⁶ In the EU, most IXes are associational membership organizations with one shareholder, the collective membership. In the US, the failures of the carrier based NAPs opened the door for the entry of Equinix. In the EU, early IXes avoided ties to the larger carriers. For instance, in conversations and interviews with a number of large IXes, the historical narratives often start with the rejection of hosting offers by carriers or local ISPs. Other reports on IX development have noted the efforts to balance good hosting space with carrier-neutrality. For instance, Kende indicates the Nairobi location of KIXP is in a neutral location, but the Mombosa location is hosted by an undersea cable provider, SEACOM (Kende & Hurpy, 2012)

The carrier-neutral norm gives insight into additional norms within the IX constituencies. An adjacent norm is that the IX should not compete with its constituency. This norm will be referred to as the non-compete norm. This is evident in the discussion above regarding metro and regional connectivity, but here, in terms of constituencies and authority, the role of transit carriers is interesting. In the associational membership model, the constituency votes on strategic direction. The emergence of remote IX connectivity markets is arguably a non-

65. Such markets also thrive at the colocation facilities that often host IXes. In some cases, private peering provided by the colocation facility replaces “public” peering on the fabric. There is certainly a mutually beneficial relationship between colocation facilities and IXes, even when the colocation facility provides its own IX service and hosts other IXes that operate under different organizational modes. An instance is SwissIX at Equinix-Zurich.

66. There has been much anecdotal discussion of this friction, but little documented evidence in the literature. One part of the larger work is to develop some of this history through interviews with network operators active at the time, in particular as it relates to the emergence of the norm that exchanges be carrier-neutral. It is also important to note that this was not the only factor in the failure of the carrier-based NAPs, but it is often cited as evidence supporting the carrier neutral norm.

intuitive product of this governance norm on the broader connectivity market. The non-compete norm is argued to have reduced adversarial competition and to have contributed to the development of a mutually beneficial subsector, namely regional IX connectivity contracts. As per above, a relatively uncontroversial instance is IX-Reach, focusing on providing connectivity between potential IX members and IXes.

A much more controversial instance is the relationship between AMS-IX in Amsterdam and its “connected” node in Hong Kong. AMS-IX Hong Kong is connected in the sense that members in Hong Kong *can* seamlessly peer with members at AMS-IX Amsterdam via a transport channel dedicated to this purpose. Peering between Hong Kong and Amsterdam over the fabric is not automatic; members must establish a contract with the connectivity provider. Returning to the discussion of Internet Exchange *Points*, this is a very far reaching connected exchange. Other instances of similarly connected exchanges are: LyonIX (Lyon, France) and TopIX (Turin, Italy); BalkanIX (Sofia, Bulgaria) and InterLAN (Bucharest, Romania); France-IX and SFINX, both in Paris.⁶⁷ Relative to these, the “reach” of AMS-IX is both substantively greater and the two interconnected IXes are under the same administrative umbrella.

The fact that connecting AMS-IX Amsterdam and AMS-IX Hong Kong *does* comply with the non-compete norm is subtle. Logically, the two are in fact connected. The non-compete norm is intended to avoid competition with members, in this case, carrier backhaul. Organizationally, the connection between AMS-IX and Hong Kong is a contractual relationship with a transport provider. This type of contract is available to other transport providers and thus does not preclude competition in the emerging market for connectivity to and between IXes. That said, the fact that it connects two exchange points is qualitatively different from IX transport that facilitates connecting conventional members to an IX. It also alters the scope of the interconnection and content markets, creating new market dynamics between networks that are geographically far-flung but are now topologically proximate.⁶⁸ Ultimately, the outcome is that a new transport market for connectivity to IXes, both connecting networks to IXes and potentially IXes to other IXes, is emerging. A critical question is whether that market is driven by service (feature) differentiation

67. Based on a presentation by Nipper at RIPE65.

68. This is a generalization about relatively small networks connecting to other small networks. Connectivity providers such as very large “tier-2” and tier-1 networks have geographically distributed POPs and are thus potentially topologically proximate despite their size and distance between their centers. If we assume the members of IXes are substantively smaller in geographic reach, the generalization of topological proximity holds. A working paper is currently developing categorizations of IX members to supplement the raw topological reach that can be inferred from BGP routing information.

or price.⁶⁹

Another key aspect of the constituencies is that a number of IXes that self-identify as associational membership have noted that the *constituency* is the source of innovation on member facing features, not the IX itself. The role of membership meetings is a forum for updating the membership on the state of the fabric, for voting for board members, and for members to engage the IX staff. Multiple IXes have noted that it is not the role of the IX staff to generate new services. In other words, it is not the role of the staff to innovate. Rather, it is the role of the staff to elicit the needs of the members and facilitate the discussion to understand the services that can best meet these needs. This may be framed as a continuous requirements elicitation process facilitated by a distinguished⁷⁰ subset of the epistemic community.⁷¹

The locus of innovation also speaks to the scope of governance in the IX ecosystem, where scope can be linked to the features that need be managed. For the nominal associational membership IX, hard governance is largely limited to technical management rules for the fabric and ensuring the processes prescribed in its governance documents (ByLaws, contracts) are followed when deciding on new strategy or features. For instance, some IXes are distinctly aware of the education needs of inexperienced IX members and provide help with connecting to the fabric. This is a form of reducing information asymmetries and outreach to the constituency, improving the overall quality of the Internet industry sector in that IX's market. In terms of hard governance related to monitoring and enforcement, instances are the monitoring for "rogue" routing protocols, spanning tree algorithms, using the fabric as part of the members backbone, and other activities that negatively impact the quality of the network. IXes have done substantive technical work to monitor the health of the fabric and are willing to "pull the plug" on those that break the rules. Maintaining the elements of the fabric, ie engaging in monitoring and enforcement, that ensure features are provided with the desired quality of service, is one factor that defines the scope of hard governance. It is also an instance of where the IX can, and some demonstrably have, innovated in the space of *implementation* of sanc-

tioned features.

Governance scope tied, in part, to features, is an important distinction. A number of IXes have indicated that they are *only* interested in running an interconnection fabric—moving above layer 2 or 3 is out of scope. For instance, a number of IXes have indicated that DOS attacks that may occur over the fabric are not interfered with unless they affect the fabric itself. This may seem counterintuitive, but that would require the IX to step in and privilege one member over another. This does not necessarily preclude providing information about the source of the attacks in the same way sFlow data can be used to show with whom a network exchanges the most data. In that sense, the monitoring tools used to facilitate hard governance may also be used to facilitate self-help. This type of self-help, and the organizations that have facilitated institutional modes for aggregating monitoring and distributed enforcement, are discussed in the next section.

Along the spectrum of organizational models, the sources of authority range from membership, which may be likened to a constituency, to a customer, which simply buys services. Associational membership IXes (includes cooperatives and volunteer in Gerson and Ryan's typology and Jensen's non-profit industry associations and informal associations) seems to exhibit the greatest authority delegated by, and limitations on authority, derived from the membership. A number of IX leadership have indicated that innovation is limited by the membership; some have even lamented the constraints on innovation. That said, the latter, those lamenting the constraints, go on to describe how the IX and membership engage to explore new potential features. The IX serves as an expert operator (the distinguished subset) of the fabric, providing insights into the implications and costs of new features. In terms of cost, the IX staff and leadership also provides information on how those new features will impact membership fee structure. For instance, quality of service guarantees can be controversial since one perception is that increased costs only benefit the subset that use quality of service features. In the case of failures, refunds for downtime hit the entire pool of membership fees. This is not always the case; some IXes have communities that are pooled based on choice of features, such as creating a VLAN with QoS guarantees. In this case, resources come from that community's (or market's) fee pool rather than those that do not use QoS.

Moving down the spectrum from members towards customers, actors at the customer end prefer to simply pay the fee and enjoy the service. In some cases, organizations do not want to be a member because it implies that there is an element of ownership involved. In a number of associational membership IXes, the company that manages operations is owned by a single shareholder, the membership organization. By proxy, this makes members owners. As a regional instance of this problem, many Russian networks have problems joining associational membership IXes because "ownership" of

69. This is a key differentiation in Porter's five forces model. Adversarial competition purely based in price does not create constructive competition that drives the development of new features. Competition on features moves the state of the technology and operations, and thus the industry, forward. In this vein, Porter makes an important side comment: healthy industry sectors are a public good (Porter, 2008, p. 91). This contribution to the interconnection market writ large supplements the existing public good characteristics of the neutral interconnection fabrics that facilitate local interconnection markets. It also opens the door to questions whether more traditional public regulation of the industry is necessary. See the discussion of soft governance in Section 4.

70. In the sense of a distinguished element in a set, one with unique characteristics.

71. In private conversation, this idea was been floated to a member of the leadership of one of the more mature European IXes, which confirmed this generalization. Forthcoming interviews with other IXes will further confirm this generalization.

foreign firms is complicated by Russian regulation. Some evidence of clustering to a Russian IX can be seen in Figure 2: the fourth bar from the left with a substantively higher portion of members that are exclusive to that IX, is the Moscow IX. In another example, early on American networks were wary of joining an associational membership organization because the relationship appeared to have liability implications. Other members still are simply price and policy takers.

In the case of the IXes, governance authority is derived largely from the community.⁷² There are interesting principal-agent relationships, here, though. Many associational membership IXes indicate that while strategy and the general set of features require input from the membership, implementation and operations do not. For instance, day-to-day decisions and budgeting decisions are the purview of management, not membership decisions.

Given these benefits, the fascinating aspect of associational membership IX governance is the adamant limitation of hard governance. Hard governance comprises management and maintenance of the fabric and enforcement of contracts. The IXes engaged thus far are adamant about staying out of peering relationships, the content market, and transit markets where they are supported. They make it clear they are interested in maintaining a technical platform. Like in the DOS example above, they are willing to provide, equally to all members, information that may facilitate self-help, but seem to avoid picking winners and losers in the markets and interactions that their platform supports. This is not to say they do not host forums for these relationships. Membership meetings have tracks dedicated to issues salient to the memberships' engagement on the fabric, but are described as means of demonstrating the suitability of the fabric and its services for *supporting* these activities, not directing them. In this sense, supporting forums is a form of soft governance, inviting members to engage in sharing information about what they are doing so IX engineers can better support it.

3.3 Institutional Landscape

Figure 3 attempts to locate Internet governance institutions relative to one another in terms of institutional formality and the influence of private versus public interests. Figure 3 is an intuitive view of where various institutions live—putting more rigorous empirics behind this depiction to validate and/or update this model and its implications is the objective of the dissertation. The horizontal (x) dimension labeled “Institutions: How Formal” attempts to distinguish whether the primary mechanisms animating an institution are highly formalized, such as those typical of an incorporated organization or government agency, or whether mechanisms

are informal, rooted in the norms and customs of a collective. The vertical (y) dimension attempts to capture whether the institution is dominated by public or private actors and their respective interests. A key outcome that makes this a global governance story (with implications for firm strategy) is that many of the problems addressed by private orders, such as those in the northwest and northeast quadrants of Figure 3, are motivated by private interests but yield public collateral benefits.⁷³

To explain the institution space and how dimensions interact, consider each corner of the diagram. Proceeding clockwise, the northwest-most corner comprises private, informal collectives. These collectives are dominated by private actors, often individuals. In terms of institutions, the “rules” are norms, customs, and best practices. The collectives in the northwest-most corner are “loosely organized, yet close-knit.”⁷⁴ Guided by well-understood community norms, operational and decisional capacity is tightly coupled and hypothesized to derive from the close-knit character, allowing actors to immediately contact those necessary to resolve problems.⁷⁵ The network operator groups, represented in the figure by one instance, NANOG, is a collective that facilitates the information sharing characteristic of collectives in the northwest quadrant.

The northeast quadrant comprises highly structured organizations such as corporations. These comprise actors pursuing their own private interests (for instance gainful employment) but also serving the interest of the organization (production of goods or services either for-profit or not-for-profit). The ideal type in the northeast corner is a highly bureaucratized organization partitioned into function-specific units. These partitions may be hierarchical (horizontal layer typically representing amount of power, authority, or responsibility) and/or vertical siloing of coarse-grain functions such as accounting, human resources, research and development, etc. The essential element along the horizontal axis is the level of formality embedded in this organizational structure. Moving from the far east, the formal organizational structure becomes less influential as one moves closer to the east-west mid-point—order is created and maintained by a *combination* of formal rules and informal norms. When crossing the mid-way point into the northwest quadrant, order within the institution is attributed more to informal norms and customs than formal rules and structure. This is not to say there is no longer a mix, but rather that the guiding principles are derived more from the former than the latter. **The IETF is arguably based on informal norms but has well-defined structures and lives just to the west of the**

73. This can be turned around. It may be constructed as a firm strategy story with implications for global governance.

74. This terminology is taken from Ellickson (1991).

75. Refining this a bit, what are the configurations of those with information necessary to contribute to efficacious operational decisions and those with sufficient localized decisional capacity such that, taken together, the capability is a credible relative to the problem at hand.

72. This does not mean all means of enforcing order is derived from the community. For instance, most IXes rely on the public regulation of a state to enforce contracts.

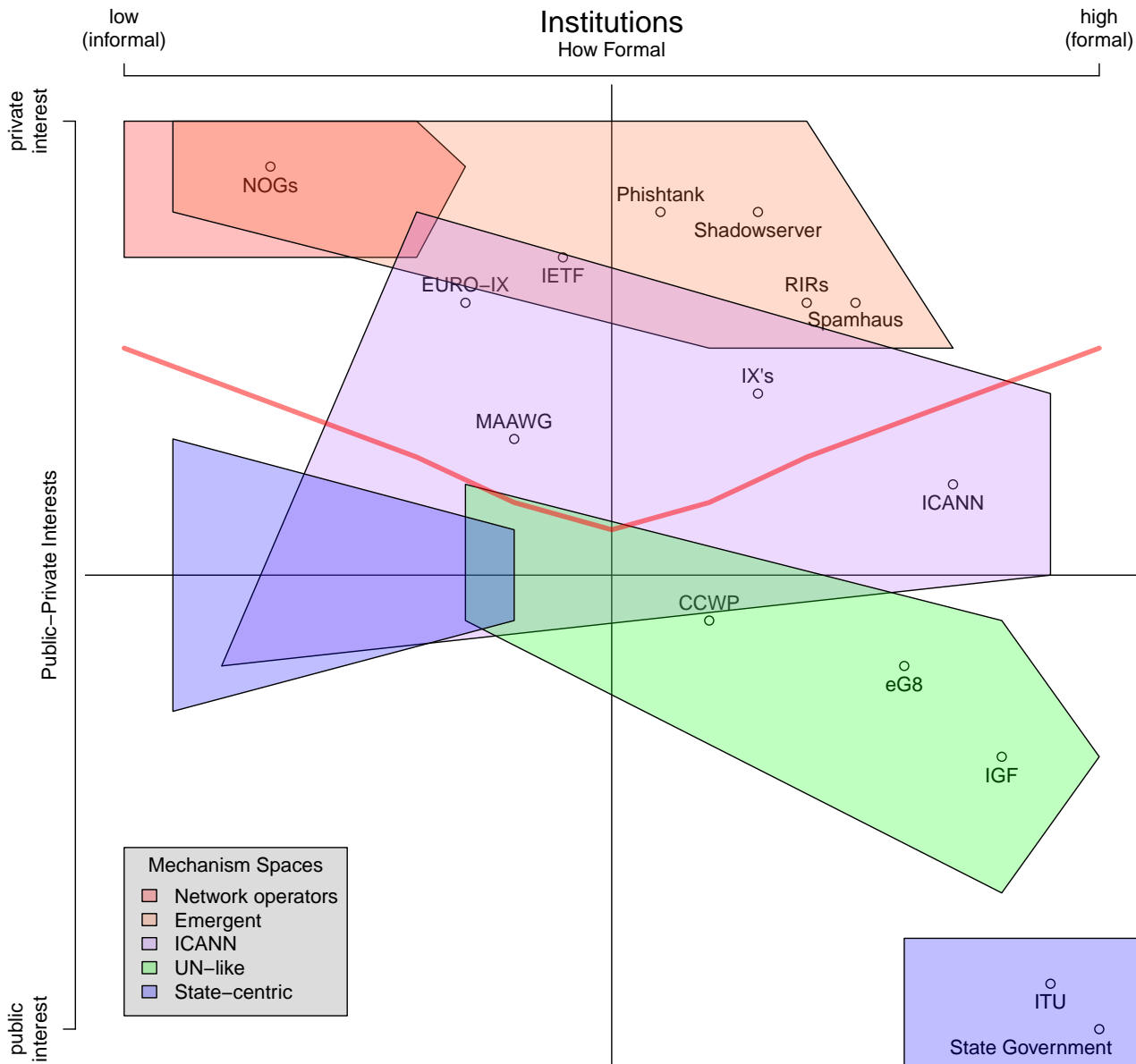


Fig. 3

mid-way point on the horizontal.

The southeast corner is the most familiar to political scientists: this is the realm of formal bureaucracies acting in the public interest. The ideal type, state governments, are present in Figure 3. The key difference between the northeast ideal type and the southeast ideal type is that the organizations in the southeast are concerned with the *public* interest, not profit or a not-for-profit

private (or semi-public) interests.⁷⁶ As a servant of the public interest writ large, institutions in the southeast are responsible for a wider variety of rights (not merely domain-specific rights, but civil and human rights) than their counterparts in the northwest. The Internet governance actors in the northwest are largely issue-specific: network operator groups are “designed” to share information about issues related to network operations and

76. This does not mean that the private interests in the northeast and/or northwest do not provide collateral public benefits (positive externalities), but the scope of “public” is the community, not society as a whole. Public is akin to common interest scoped to the domain, as per Section 2.4.

security.⁷⁷ While the decisions made in these groups may have implications for broader issues, the nominal objective of the groups and the rights of members within the group are operator-specific. Similarly, the northeast corner is also function-specific, but reifies the rights of its members relative to its own narrow, private interests. The notion of an organization's interest, a private interest, is also the other major distinction. While the individual members of a government are private actors, the organization itself is obligated to maintain the public interest of the society writ large, not merely the narrow interests of stakeholders in the organization.⁷⁸

The southwest corner of the figure is a literal and figurative ideal type. This ideal type comprises actors pursuing the public interest of a society, but with little to no structure or formally documented rules. The most immediate social group that fits this category is a primitive tribe that has developed well-defined norms and is in fact, by virtue of size and proximity, close-knit. Tribal norms ensure the public interest, but are sufficiently simple to be easily understood and transmitted by experience and observation.⁷⁹ Thus, these norms do not require formalization into rules or rules of recognition to identify the legitimate source of authority.⁸⁰ That said, this work has not identified anything akin to a "tribal" Internet governance institution. This quadrant is not salient to the discussion and is described for completeness.

4 COMMONALITIES AND INTERACTION WITH OTHER ORGANIZATIONS

4.1 Community Building and Sustainability

In all three studies, various epistemic communities within and immediately adjacent to the broader network operator community support the institutions that create order in the Internet. The histories and dynamics discussed above provide some insight into how these communities were built and how they are being sustained. The following compares origins, implications for growth, and vetting processes. These give comparative insights into how communities were built and how community norms are sustained.

77. The breadth of rights is different from issue density. Issue density within operations and security is quite high despite the relatively narrow domain of rights relative to the breadth of civil and human rights states contend with. This is a key difference when considering how actors concerned with broader societal issues engage with bottom-up organizations through soft governance mechanisms. Discussed in Section 4.

78. Recall these are *ideal* types.

79. This is an oversimplification, there are certain tribes that do have very elaborate rituals. These rituals are part of the society writ large, and, in contrast to formalization into a state constitution or company charter, these remain informally handed down by word of mouth and training. The take-away is that these are no less elaborate or sophisticated, but the processes by which they are enacted and maintained are very informal.

80. Rules of recognition are defined by Hart (1994) as those that recognize a particular source of rules as authoritative.

4.1.1 Origins

In both the NOGs and RIRs and the IX environment, the origins of community development is solving problems faced by network engineers. In the case of the NOGs, peering, routing, and developing a greater understanding of the interconnection environment were, and still are, frequent topics. In the case of the RIRs, management of IP address allocation can also be argued as a learning process. While the NOGs seemed to have emerged purely from community effort, the RIRs have an elements of authority derived from informational RFCs that serve as community agreements on how resources should be allocated. In terms of formality, NOGs are much less formal. Arguably, the variety of information sharing practices in the NOGs do not require more formality than a steering committee to manage the conference itself and ensure sufficient funds for subsequent meetings. In contrast, RIRs have much more formal structures, varying degrees of scope in terms of generating information for the community, monitoring address policy, and the infrequent application of enforcement mechanisms.⁸¹ RIRs' norms and authority are derived from the RFCs but, as per earlier, the most commonly cited authority is the community. This mix implies the norms and principles originated in the articulations of the community through the informational RFC process and are operationalized regionally by RIR policy development processes.

IXes also rely on mixed sources of authority. The origins, as per the instances discussed earlier, are again engineers attempting to solve problems. In conversations, many cite the first commercial, carrier-neutral IX to be, aptly named, the Commercial Internet Exchange. LINX and AMS-IX are also among early exchanges. In the case of LINX, as noted above, it moved from a volunteer effort (designed on the back of an envelope in a pub according to one source) to an associational membership organization. In this sense, the origin is similar to the NOGs: a group of engineers get together, identify a problem and a solution, then formalize the necessary organizational components of the solution.

IXes also rely on public ordering. In a number of European cases the IX has two organizational components: the membership association and the corporate entity that maintains the fabric itself. The membership association is the only shareholder, making the membership collective the only means of strategic direction. Key to this study is the contracting mechanisms. Many large and medium IXes (in terms of membership) establish contracts as the means to enforce rules on the fabric. The typical enforcement mechanism is disconnection or relegation to a "quarantine" area where members sort technical problems. While these are in the technical realm of the

81. The latter is a point explored in formal interviews. There is a very distinct negative cultural reaction to the notion of the RIRs as the "address police." On the other hand, as will be discussed in later in terms of the scope of governance, policing is possibly a necessary step to be considered an effective authority.

IX, contracts establish the “hard” criteria for hard governance. Soft governance is at play in IXes engagement with regulatory bodies and LEAs; this will be discussed in Section 4.4.

Both rely on community direction. Both also seem to leverage the problem solving mentality to design features for the community. This largely falls in the realm of hard governance. When engaging either external actors or actors outside the network operator community, these institutions are engaging in soft governance. This is a relatively new role for these institutions (as unitary actors) as they learn to engage more formally outside the technical arena.

4.1.2 *Size of the Community*

Given the mechanisms at play and the balance between formal and informal, the size of the community is a simple but interesting factor in operational governance. A fundamental tenet of informal institutions is that they operate effectively for a small, close-knit communities. As per the introduction, this was the case of the early Internet, comprised of a community of trusted designers, architects, and operators. As these communities have scaled up, they seem to have preserved some of the trust relations that characterized the early Internet, but have had to re-operationalize the mechanisms. The NOGs, and in particular BOFs are an interesting instance. A number of the BOFs invoke Chatham House rules to ensure operators can speak freely on problems and issues they are facing in the wild. A number of backchannels with varying degrees of access (vetting processes discussed in the next section) from outside the community also exist.

Across the studies, size has a number of implications. The immediate implication is that reputation, as per the general institutions literature, may not be sufficient for the enforcement of norms. Transactions between actors are less frequent and may be amongst those that have not met each other. For instance, the number of autonomous system numbers (ASNs) has grown substantially since the early 1990's.⁸² Organizations have created a number of mechanisms for dealing with size. For instance, at the Global Peering Forum (GPF)⁸³ uses a meeting tool to facilitate meet-up sessions between individuals that may not know each other, but want to establish an interconnection relationship. This does not mean all actors can engage with one another, but it does facilitate active peering managers in the community to get to know one another and share information. A number of sources have independently indicated that there are between 1000 to 1500 people that “keep the Internet running.”

82. CAIDA and Huston data.

83. GPF is most akin to a specialized NOG with Chatham House rules, inviting peering managers to share information and develop interconnection relationships. The relatively closed nature of GPF compared to NOGs is arguably due to the types of information shared amongst participants and the desire to facilitate more fluid and free flowing dialogue.

The IX community has also seen growth, but not on the scale implied by ASN growth. Early on, the communities of IX operators had regular conversations on the design, implementation, and regulatory challenges of IXes. Within Euro-IX, a number of facilities are available for helping new IXes get off the ground and for helping new potential IX members join IXes. For instance, the Euro-IX Twin Program intends to pair new or potentially struggling IXes with more mature, successful IXes, targeting regions in need such as Central and West Africa, North Africa, the Caribbean, Central Asia, and Southeast Asia (Euro-IX, 2012a). The number of global IXes listed by Euro-IX is 302.⁸⁴ As shown by Figure 2 there is a long tail of small IXes and a variety of IX membership diversity. In addition to Euro-IX, there are other regional IX associations such as APIX in the Asia Pacific region and LAC-IX serving the Latin America and Caribbean region. There are ongoing efforts amongst these organizations to develop a global umbrella institution to facilitate coordination and cooperation.

In both cases, regime norms have been preserved, although the precise mechanisms have evolved. RIR norms are largely the same, although IPv4 depletion has brought challenges to the needs based criteria articulated in early RFCs. In the IX world, Euro-IX and others serve to propagate existing IX norms such as the non-compete norm and the carrier-neutral norm. As evidenced by changes in constituencies and the reach of IXes (beyond IX points), the norms have been adapted to suit the changing environment and needs of the members. Section 4.2 will touch on the consensus processes that members use to promote this adaptive process.

4.1.3 *Vetting Processes*

The notion of private order does not imply closed and opaque. Private orders may live in a variety of locations in the spectrum of (1) transparent to opaque and (2) open and closed. The vetting processes immediately capture the range of open and closed, but also speak to levels of transparency and the measures taken to limit the access to information sharing services to a particular community or subcommunity. Within each study there are certainly norms for vetting new members and establishing trust. Some are simply experiential and exposure. Others are formalized into membership agreements. Others still are very distinct norms around the domain, such as within the anti-abuse subcommunities. Selected instances are described briefly for comparison.

The NOGs provide an illustrative instance. Figure 3 has also provided useful discussion fodder.⁸⁵ A number of community members immediately reacted to NOGs being placed in the upper left, comprising largely private actors engaging in an informal institution. The

84. Euro-IX (2012b) notes that the North American list is incomplete and there may be more.

85. Noting all models are wrong, the discussions around this depiction of the institutional landscape has been very useful for correcting assumptions and identifying conflicting views of the roles of various organizations.

assumption that invoked the reaction was that private implies closed. This is quite the opposite case. Private is defined by the *types* of actors, as per Hall and Biersteker (2003) described in Section 2.3, not the accessibility of the community. The degree of openness is a function of one's ability to access the community itself, access the information created by that community, and overcome the barriers to entry. Access to the NOGs are largely open to anyone and many are actively soliciting participation from non-technical actors. Access to presentations and recordings of open sessions are generally open. BOFs and informal interaction are where vetting processes kick in. Some BOFs have norms requiring attendees not repeat information discussed outside the BOF, often invoking something akin to Chatham House rules. Informal interactions often require some element of reputation based on repeated interaction to access shared community information such as the reputations of networks. In both cases, vetting is done on grounds of knowing the individual, their reputation in the community, the perception they can productively contribute to the conversation or dialogue at hand, and whether they have violated community norms. There are a number of individuals in the community that exemplify community norms; there are also individuals that have violated a subset and experience some degree of shunning.⁸⁶

RIRs are similar, but, as formal organizations that provide resource management services, they provide some services to the public but restrict other services to members. Participation in the policy development process is often open to all, but membership requires fees typically tied to the size of resource allocation. Like the NOGs, presentations at member meetings are largely available, some with transcripts. Services such as access to community data such as the WHOIS service is limited to those that respect rules such as intelligently limiting the load placed on RIR servers (through caching or bulk downloads). Other services specifically designed for members may be limited to members. Experimental services may be limited to those that demonstrate a legitimate⁸⁷ use and/or agree to limit the load placed on servers.

Vetting for RIR membership typically involves demonstrating the applicant is a recognized organization in their respective jurisdiction. That said, there is a general tension between the RIRs and the anti-abuse community related to this level of vetting: anti-abuse actors have cited this limited vetting process as allowing known resource abusers to acquire resources. There are also specific tensions between actors in the RIR community and anti-abuse community.⁸⁸ This is a tension between the norms of the two communities and is well-known by both.

86. Some of these are obvious, others are not. At this point in the study I will not be providing additional information beyond general forms of shunning and limiting access observed in the community.

87. According to the norms of those providing the service.

88. I will not go into the specifics because these are rather sensitive.

IX accessibility varies. Some IXes have membership meetings limited to the membership and invited guests. Others are open to all comers, serving as a kind of open house for existing and potential members and customers. Another dimension of openness is sharing information about the state of the fabric and the relationships on that fabric. Interconnection relationships are not shared with others beyond what can be observed by participation on the fabric. In the most basic sense, traffic information is usually considered sensitive and is not shared outside the IX. For instance, for those IXes that collect sFlow data, that data is typically only shared with the owners of the ports involved, as described earlier. More aggregate information, such as traffic levels, typically sampled at 5 minute intervals,⁸⁹ is sometimes shared on a per member basis (such as by Netnod) and almost always shared in aggregate for the IX. Along with membership, load is a primary comparative measure but many claim both are increasingly misleading. A key to understanding these measures is to understand the incentives and strategies of those actors that comprise the IX membership. Ongoing work is categorizing the 101 IX members depicted in the lower histogram of Figure 2 to identify patterns amongst "the most diversified" IX members.

Vetting is, not surprisingly, a major component of the anti-abuse communities. M³AAWG has elements of its vetting process embedded in its By-Laws and application process. The application process itself is a vetting process, explicitly indicating that would-be members adhere to the norms of reducing messaging abuse. In private conversations a number of actors have indicated that vetting is necessary to ensure the reputation, legitimacy, capabilities, and commitment of an individual to the institution in question. One set of rules invokes the Fight Club theme: the first thing about *institution X* is that you don't talk about *institution X*. A second, and much more interesting norm, is that members are expected to continually contribute to the organization's activities. This serves multiple functions: individuals are current, individuals can be relied on, individuals do not hang around unnecessarily observing activities without continuous demonstrated buyin to the larger goals. This also serves to preserve the small, close-knit community of security and anti-abuse specialists.

4.2 Consensus Processes

There are a variety of consensus modes across the three studies. Existing fieldwork has seen substantive evidence in the RIRs and IXes; the author has only a single observation of the BCP development process in M³AAWG.⁹⁰ The following will revisit the phases of active consensus in the RIRs as a segue to a comparative discussion of

89. There is some contention over this interval; some use shorter intervals, which give the perception of great load.

90. Most anti-abuse work will be based on interviews with those that participate; direct observation is unlikely at the moment.

consensus and participation in the RIR and IX decision making processes.

4.2.1 *Consensus: Active, Passive, Review*

In Section 3.1.4, the RIR consensus process was abstracted to three phases: active consensus, passive consensus, and procedural review. There is some variety amongst the RIRs. In the RIPE NCC, consensus is based on contributions on the e-mail list; discussion in the meetings seems to be largely informative. In ARIN, active consensus is adjudicated during the member meeting. In APNIC, active consensus takes place in two phases: in the SIG and in the general members meeting, soliciting consensus from those in the special interest group first, then consensus from the larger membership. Despite these operational differences, the general objective is to ensure a sufficient set community members believe there is a problem that warrants a policy solution.⁹¹

The consensus process assumes participation. A key issue faced by both RIRs and IXes is the level of participation in the active consensus process. Returning to the sources of authority, this becomes problematic if a strong form of the assertion assumes that high levels of participation are needed to legitimize an institution.⁹² In many cases, the level of participation is quite low, and community members across RIR staff, IX staff, and the network operator community have speculated on the level of participation and by whom. In particular, some have asked for analyses that can give insight into who contributes to the policy development processes the most consistently and the most effectively (in terms of adopted policies).

The level of participation coupled with the consensus process provides hints regarding which point in the regulation demand-capture space (Figure 1) these organizations live in. A cynical interpretation⁹³ would imply this immediately means the narrow/limited row of Figure 1. The strong interpretation places these institutions in *A*, pure capture. This assumes some degree of coordinated capture by like-minded individuals. This is arguably not the case; observation does confirm a small set of active participants but does not indicate forms of collusion.⁹⁴

91. Recent activity around prop-103 in the APNIC community is a great example of explicit attention to the process by which a problem is presented to the community, discussed, and becomes fodder for the policy development process.

92. This is a fairly common problem with a variety of governance modes, democracies with non-compulsory voting being a prime instance. That said, the sources of authority may be based in a delegation of certain powers from the people to the governance institution, a key difference is that legitimacy in these institutions is continuously evaluated. There is no regulatory backstop or Leviathan to replace a failed institution. Rather, there appears to be a pluralistic marketplace that drives regulatory innovation.

93. Mattli and Woods (2009a) refer to this group as *X*, those that believe regulators, here policy makers, are easily captured and make policy based on their own interests in remaining in power within the community.

94. One could also argue the vetting processes is itself a form of collusion, ensuring the issue-domain remains limited to those functional issues preferred by institutional leadership.

The weaker form of the argument moves across to *B*, de facto capture. In this scenario, the processes for broader participation are in place, but only a consistent active set make policy. Observation and evaluation of the policy development processes indicate that there are in fact multiple access points for accessing and engaging the rule and decision-making processes in the RIR and IX communities.

The anti-abuse organizations, on the surface, seem to live in the first column. The anti-abuse organizations are generally more opaque and less open (strict vetting processes). There are typically more limited means for the constituency (for instance, those that use blocking lists and those affected by blocking lists) to engage with the actors creating “regulation” or influence the means of engagement. Instead, anti-abuse organizations are, as implied by the Demand dimension in Figure 1, more affected by the market demand for their services, having to adapt to changes in demand. One piece of evidence is the many, many anti-abuse organizations that have failed along the way. Another is the willingness to participate in forums like M³AAWG and APWG, providing a limited degree of access to those that have passed various levels of vetting.

4.2.2 *Silent Majority*

The consensus problem is not necessarily so stark as to place these institutions in the northwest of Figure 1. A key piece of evidence comes from surveys asking about the level of participation. One such outcome related in private conversation was that roughly 20% valued active participation, another 20% simply wanted to be customers, and 60% valued the option to participate, but did not feel the need to unless something went seriously off the rails.⁹⁵ This implies that rather than *B*, de facto capture, these institutions may occupy be something akin to *C*, where there is capture with the option to force concessions and compromises. There are two immediate interpretations: the one in which the silent majority is “aggressively watching” or the one in which transaction costs of participation as an active member are too high and they are simply policy takers.

The aggressively watching scenario is *C* with the option described above. The silent majority pays attention to the dialogue, but does not necessarily actively participate. The silent majority may force concessions or compromises if the active set moves away from the larger group’s norms. A key question is whether the relative shepherds in each institution actively recognize this situation when it occurs. This is an active question in those interviews, especially for situations where there is a split in the opinions of the shepherds on policy.⁹⁶

95. The percentages are roughly proportional to those quoted in private conversation but are not reported exactly.

96. Especially considering members are encouraged to engage with shepherds in person to voice concerns if they do not wish to voice them on the list.

Another interpretation is that information sharing in these communities is not as effective as may be implied by those cheerleading the formal processes such as the PDPs. For the silent majority, the transaction costs to understanding the process or keeping up with the process itself may simply be too high. A number of actors, some of whom are in leadership positions, have indicated they do not follow certain policy lists because there is too much noise;⁹⁷ these actors rely more on other information channels to keep tabs on the community. Such noise obviously lowers the signal-to-noise ratio and, subsequently, raises the transaction costs of extracting the signal for those not so closely tied to the community or its leadership, or those new to the community that do not have the “filter” others may have developed with experience. This increase in transaction costs is in part due to the size and variance in the community, acceptance of norms related to keeping on topic, etc. While the implications for monitoring mechanisms given increase in size of a community is not novel, the implications for the consensus process as representative of the community is important. In this interpretation, the silent majority, due to higher transaction costs, a differentiated preference structure from the active minority, or both, is now just a policy taker. As such, this is an interesting case of the space between *B* and *C* in Figure 1: mechanisms are in place, but have not been adapted to the new community demographic. In such a case, the silent majority may want for a policy entrepreneur that can provide a more efficacious set of tools that reduce transaction costs, moving the scenario to either *C* or *D*.

The final cell in Figure 1 is *D*, common interest regulation. Defining common interest is important here and has to do with scoping of governance. Scoped to the function-specific domain, it means the common interest of the network operators that comprise these institutions. Scoped more broadly, common interest brings these institutions into contact with broader societal issues that may be affected by infrastructure decisions, broadening the scope beyond function-specific common interest. How far this can be broadened is an interesting question. In the case of the institutions here, this touches on scoping in terms of issue-area and the type of governance, hard or soft, that is applied. The following sections elaborates the latter, how *engagement with* issues adjacent to those subjected to hard governance are within the scope of soft governance (the interface implied in the introduction) and how engagement with external actors provides evidence.

4.3 Scoping Governance

All three studies exhibit what has been described as hard and soft governance. Hard governance refers to the power conferred by management of a resource the

97. It goes without saying this is the subjective opinion of a subset, not a universal statement of fact.

constituency depends on: the registry in the case of the RIRs; the IX fabric in the case of IXes; and blocking lists, access to reputation information, and the content of reputation data distributed by anti-abuse organizations. Each also exhibits soft governance: RIR engagement with LEAs, state governments, and IGOs such as the ITU; IX engagement with LEAs⁹⁸, regulatory agents, and development efforts; anti-abuse engagement with LEAs and the offer of BCPs. Hard and soft are nice intuitive umbrellas, but that power was developed through a learning process by each institution, figuring out how to map institutional roles in the bottom-up organizations to the variety of actors in more conventional institutions that have a stake in bottom-up organizations’ decisions. The following uses agency and delegation to describe the problems faced by these relations, transitioning to trans-organizationalism as a modified form of the themes in transnationalism to help understand the complex web of authority at play here.

4.3.1 Agency and Delegation

Yet another way to reason about the choice of hard and soft power is the reach of the source of that power, operational capacity. In each study, operational capacity is not delegated, it is intrinsic in the respective epistemic community. As such, there is an interesting distinction to be made: in each of the relationships above, the conventional institution is often a would-be principal. Despite its claims, a number of ITU proposals support subordinating the bottom-up multi-stakeholder processes to ITU authority. When required to cooperate with the wishes of an LEA, an actor becomes a type of agent. In the case of anti-abuse, some communities are will collaborators with LEAs (and some even former LEA themselves) while thumbing their noses at regulation such as the CAN-SPAM act.

Instead, it appears the bottom-up organizations invite these would-be principals to engage in that organization’s governance process(es). In that sense, the would-be principal is not a strict principal in the sense of a single actor directing another actor through a bilateral contract, but rather a member of the constituency (collective principal, the membership). As per earlier, the constituency is the principal, but no single actor⁹⁹ is dominant. This invites the would-be principles into a different relation, one in which they must engage more as peers with other constituents and argue their issue-positions in the consensus process. Bottom-up organizations must thus actively make their governance processes accessible to not only their historical constituencies (operators, vendors, analysis organizations) but also to actors from other governance modes. The recent trend of more formal governance-related working groups in

98. Or effective reasoning for lack thereof, which is an interesting element of the hard and soft governance distinction.

99. At least as per the articulations of the consensus processes are concerned.

various forums, governance-related speakers in bottom-up organizations' forums, increased staff dedicated to external relations, and discussion in recent interviews, is evidence of a broadening of the scope of soft governance. The next section describes these broadening in terms of engagement with external actors.

4.4 Engaging External Actors

External actors roughly constitute those actors outside the epistemic community but whose interests intersect those of the operator community. For instance, LEAs have an obvious interest in the forensic quality of the types of information seen by anti-abuse organizations. For the RIRs, the development of engagement with LEAs has been a learning process, developing relationships and educating LEAs on what the registry can and cannot do, especially with regard to limiting actors access to the network. For the IXes, engaging LEAs has been a process of demonstrating that even though the IX may seem a convenient place to tap into data flows, but a more effective place is where the subject accesses the network. In each case, the organization needed to demonstrate clearly the limits of the utility of the resource at hand. While this can be interpreted as a statement on the restriction of the behavior of a would-be principal, these dialogues seem to be the starting points for developing soft governance tools for resolving contention at the intersection of LEA goals and the institutional norms in the governance of Internet operations.

The RIPE LEA Roundtables are an excellent instance. A number of actors have indicated this was about educating LEAs how to get the information they need for investigations. In the case of looking for information that contributes to attribution in an investigation, the integrity of the registry is now a common norm for both the sets of actors. Further, explaining that the registry does not facilitate "removing someone from the Internet" was a major early education point. In the case of LEAs, private conversations indicate a lot of the progress is due to a small number of individuals that have made an effort to map who to contact to ensure relations go smoothly.

APNIC's work in IPv6 development in the Asia Pacific region is an interesting case of engagement with external actors. According to conversations and the recent APNIC report, APNIC, in its remit to foster Internet development in the APNIC region, their "IPv6 program also participated in joint sessions with policymakers and regulators to build awareness and support the industry with IPv6 deployment," (APNIC, 2012). Two notable engagements with IGOs were Asia-Pacific Economic Cooperation (APEC-Tel) organization and the Pacific Telecommunications Council (PTC); notable engagements with states include work with various information and technology agents within the governments of Hong Kong, China, and Singapore. In the RIPE region, the NCC has been engaged with a number of governance bodies:

various OECD informational sessions; roundtables with government officials regarding IPv6, critical infrastructure considerations, public sector ICT procurement; and the confluence of cross-border law enforcement and the registry system, to name a few on the agenda from the last roundtable in February 2012. As a collective, the RIRs, through the Number Resource Organization (NRO), were founding members of and continue participate in the OECD's Internet Technology Advisory Council (ITAC).

Described as such, the actors engaging are the organizations. From observation in fieldwork, there are a number of key "network personalities" involved, those individuals that are key drivers in the engagement between non-state organizations and non-state and state-based organizations (agencies). For instance, in APNIC, government engagements above were noted as a collaboration between their IPv6 program, Liaison officers, Learning and Development, and Public Affairs (APNIC, 2012). Each division has a function-specific engagement role. This collaboration amongst roles is an excellent instance of the adaptation of transnationalism discussed in the next section.

4.4.1 Scope Revisited: "Trans-Organizationalism"

The baseline discussion of transnationalism above (Section 2.2) focuses on the role of non-state actors, MNCs in particular, are comprised of individuals that "identify themselves and their interests with corporate bodies other than the nation state," (). The organizations discussed here find actors identifying themselves with a variety of institutions of varying degrees of formality, manifesting role-specific interests in each. Moreover, the roles engaged in by a single actor may conflict with one another, requiring elements of conflict of interest resolution. A simple tactic is to avoid all conflicts of interest. This seems unrealistic given the density of social interconnection between these communities. What seems to have emerged is a web of relations between policy entrepreneurs within the epistemic community and those that shepherd policies through the various consensus processes. In some cases, these overlap.

Returning to trans-organizationalism, the observation thus far is that there is in fact a core of individuals that serve to share information across functional domains. Thus, the function-specific activities are not simplistic instances of functionalism. They are not simple manifestations of neo-corporatism either, where a central actor legitimizes and mediates amongst function- or issue-specific organizations as the exclusive representative of a constituency's interests. Instead, the multiplicity of roles across functions serves as coordination and collaboration mechanisms across functional domains. Returning to a core question of accountability in the consensus processes, what is the kind and reach of the power of vested in the core "network personalities"?

In contrast to conventional governance organizations with formal structures for coordination amongst agen-

cies, there is a variety of formality in the coordination mechanisms. For instance, the NRO and a variety of NRO supported coordination groups (Engineering Coordination Group, Communications Coordination Group) exist amongst the RIRs to coordinate common interests relative to external actors, share information, share implementation strategies, and share learnings. IX external relations and public affairs personnel engage in a variety of forums ranging from RIPE NCC Roundtable events, cooperation and government working groups, governance dialogue forums such as EuroDIG and IGF. In contrast to the NRO's activities, which are part of explicit decision making processes related to how non-state organizations engage with respect to their governance roles and larger governance objectives,¹⁰⁰ the activities of IX personnel is much more akin to soft governance. These actors serve to share information with a variety of constituencies, not exclusively those of their immediate employer. The result is soft governance activities that serve an information sharing and governance monitoring role.

A challenge for the external relations subset expressed by some in this group is maintaining relations with relevant actors, especially in regulatory agencies and other government bodies. In the case of the external relations subset, many of those in these positions are veterans of the industry and bottom-up institutions. The stability *within* this core set of actors, in terms of knowing where to find information and operational capacity within the bottom-up institutions, seems to be well-established. The process of engagement with those outside the bottom-up institutions (ie, across the red line in Figure 3) appears to be an ongoing learning process for the organizations, facilitated by these actors.

As these policy entrepreneurs engage in soft governance, they engage with policy entrepreneurs and policy makers from broader governance forums such as the OECD, ICANN, and the IGF.¹⁰¹ For instance, LEA engagement in both the RIR system and ICANN has been facilitated by a number of trans-organizational actors that are actively engaged in at least two if not three of the communities characterized by the studies here as well as engaging "entrepreneurial" members of the LEAs. As implied by the principal agent discussion of LEAs above, the experience of these actors have fed into soft governance mechanisms for demonstrating where the most efficacious engagement may occur without one subordinating to the other to the point of violating their respective norms. Similarly, IXes have engaged with regulators through soft governance mechanisms and have started to formalize their engagement with regulators through external relations and public affairs positions. Recent attention has been paid to the implications of

ITR revisions in the ITU for interconnection. IX external relations actors have followed these issues as they are pertinent to their business model and the business models of their constituency. As one set of community experts on interconnection, they are in a unique position to argue for or against the implications of ITR-based regulation of interconnection.

4.5 Factors Affecting Policy Experiments

In the discussion of the consensus processes and the feedback loops in the institutional landscape, the notion of policy experiments was offered. This is an appealing characterization because it is not only consonant with the engineering mentality of the epistemic community at hand, but is also consonant with the agility of rule making attributed to private regimes. A number of the comparisons above reaffirm the learning characteristic of the basic mechanisms at play, but also highlight potential failure modes. Are the problems presented in policy development processes, described as consensus problems, the problems faced by the community as a whole or just a subset? Arguments for both sides have been proffered by the community, ranging from narrow interest proposals to corner cases that only affect a minority but do not create adverse consequences for the majority to those proposals that affect the fundamental mechanisms of IP management or the policy making process itself.

Along with the consensus process, the confluence of increasing size and the variety of members engaging through soft governance processes also has potential implications for the efficacy of these governance arrangements. On one hand, soft governance is an effective way to limit the scope of hard governance, avoiding bending technical functionality and capability to expressly political ends. On the other hand, the fundamental premise of soft governance is to attract other actors to one's model. In the case of operational governance, institutions are attracting actors with broader set of social interests and that need education on the implications of changes.

A simple case is between the RIRs and the anti-abuse community. For instance, the fundamental norms of the RIRs focus on preserving the integrity of the registry. An instance of confluence between the two issue areas is the efforts at introducing abuse records to the various registries. This effort introduces additional complexity and requirements to registry management and members of the RIR. That said, in principal it would also provide a facility for actors external to the RIR community, anti-abuse and LEAs, to contact networks in abuse investigations. It is also arguably a compromise to the early tension over vetting registry members and where enforcement mechanisms should reside.

5 CONCLUSIONS AND ONGOING WORK

As governance arrangements, the bottom-up institutions do seem to fulfill the criteria of a private regime. These

100. For instance, the NRO in its capacity fulfilling the ASO role and continuing to provide financial support to ICANN.

101. ICANN and the IGF are listed here because both have a much broader set of constituencies and issue-areas addressed in the respective forums.

organizations are also learning to engage with existing regimes. The strength of the bottom-up institutions thus far has been function-specific focus on well-scoped issues: maintaining the registry system, maintaining a local interconnection fabric. In contrast to conventional function-specific organizations, authority to play these roles has developed bottom-up, based on the direction of the constituency rather than a set of centralized top-down actors. The previous analyses based on frameworks from political economy and international relations provide additional explanatory power to nominal descriptions of behaviors.

Despite the immediate applicability, the explanatory power of these frameworks has not necessarily provided solutions, but highlighted some of the challenging dynamics at the periphery of those frameworks. As per Section 2.1, the principal-agent language provides useful concepts, but when applied to the problem at hand, it becomes clear this is a very complex multiple-principal-agent problem. Further, as per the discussion in the previous section, not all principal-agent relations within this system are created equal: the notion of strict top-down delegation of authority is replaced with a variety of contributing roles that must contend within the consensus process. The adaptation of transnationalism is also applicable, but requires some refinement to capture governance activities amongst the bottom-up organizations, amongst bottom-up and conventional top-down, as well as between non-state and state actors. There are plenty of instances: the IX community's engagement with ARCEP, RIRs engagement with the ITU, the RIPE NCC's engagement with LEAs, APNIC's engagement with IGOs and states through the IPV6 program, and anti-abuse organizations engagement with RIRs.

Finally, Mattli and Woods' framework for understanding the demand for regulation helps frame the consensus problem. As per above, a number of interpretations are possible. Early on, when the Internet and the community were relatively small, it would be easy to say that the policy making process resembled common interest regulation, where common was scoped to the values and norms of the Internet community at the time. With the growth in size and scope of impact, the various communities within these studies exhibit varying degrees of openness and transparency. The anti-abuse organizations seem fall into cell C of Figure 1. Others, such as the RIRs and IXes, seem to have aspirations for cell D, but low levels of active participation in the consensus processes provide evidence that they may live in cell B, where an active cohort serve as the de facto capture group. The role of the silent majority is important here—if that de facto group is in fact representative, the low participation level may be a false indicator of capture and an interesting indicator of informal mechanisms for validating what is in the common interest.

The findings presented here are based on observations, private conversations, and early, initial formal interviews. A number of formal interviews remain across

the three studies. These formal interviews have been improved by the work on linking frameworks to existing observations. A number of the questions posed here will be transposed into topics for semi-structured interviews and follow-up interviews. To address one of the biggest questions, that regarding the active set of policy entrepreneurs and community participation, text mining of community artifacts will supplement observations and interviews. Simple measures such as identifying core community members based on attendee lists have been started. Comparing these with "speakers" on the policy lists and those authoring policy proposals, mapping which proposals actually became policy, and the topics these actors engage on will provide some further evidence of the scope and magnitude of participation. As a mixed methods approach, interviews will provide some insight into the causal mechanisms that animate the dynamics that emerge from text mining efforts. Taken together, better evidence will further the questions raised here.

REFERENCES

- Ager, B., Chatzis, N., Feldmann, A., Sarrar, N., Uhlig, S., & Willinger, W. (2012, 13-17 August). Anatomy of a Large European IXP. In *SIGCOMM'12*. Helsinki, Finland: ACM. Available from <http://www.eecs.qmul.ac.uk/~steve/papers/ixp-sgcm.pdf>
- APNIC. (2008, August). *Operational Policies for National Internet Registries in the APNIC Region*. Available from www.apnic.net/policy/operational-policies-nirs/text (Retrieved from www.apnic.net/policy/operational-policies-nirs/text.)
- APNIC. (2012). *APNIC Annual Report 2011*. Available from http://www.apnic.net/_data/assets/pdf_file/0005/45347/AR_2011.pdf (Retrieved from http://www.apnic.net/_data/assets/pdf_file/0005/45347/AR_2011.pdf.)
- ARIN. (2009, January). *ARIN Policy Development Process*. Available from <https://www.arin.net/policy/pdp.html> (Retrieved from <https://www.arin.net/policy/pdp.html>.)
- Augustin, B., Krishnamurthy, B., & Willinger, W. (2009). IXPs: Mapped? In *Proceedings of the 9th ACM SIGCOMM conference on internet measurement conference* (pp. 336–349). New York, NY, USA: ACM. Available from <http://doi.acm.org/10.1145/1644893.1644934>
- Büthe, T. (2004, Fall). Governance Through Private Authority: Non-State Actors in World Politics. *Journal of International Affairs*, 58(1), 281–290.
- Büthe, T., & Mattli, W. (2011). *The New Global Rulers: The Privatization of Regulation in the World Economy*. Princeton, NJ: Princeton University Press.
- Caral, J. (2004). Lessons from ICANN: Is self-regulation of the Internet fundamentally flawed? *International*

- Journal of Law and Information Technology*, 12(1), 1–31.
- Cerf, V. (1990, August). *IAB recommended policy on distributing internet identifier assignment and IAB recommended policy change to internet “connected” status* (No. 1174). RFC 1174 (Informational). IETF. Available from <http://www.ietf.org/rfc/rfc1174.txt>
- Clark, D., Wroclawski, J., Sollins, K., & Braden, R. (2005). Tussle in cyberspace: defining tomorrow’s Internet. *Networking, IEEE/ACM Transactions on*, 13(3), 462–475. Available from 10.1109/TNET.2005.850224
- Cowhey, P., & Mueller, M. (2009). Delegation, Networks, and Internet Governance. In M. Kahler (Ed.), *Networked Politics: Agency, Power, and Governance* (pp. 173–193). Ithaca, NY: Cornell University Press.
- Cutler, A. C., Haufler, V., & Porter, T. (Eds.). (1999). *Private Authority and International Affairs*. Albany, NY: State University of New York Press.
- DeNardis, L. (2012, September). Governance at the Internet’s Core: The Geopolitics of Interconnection and Internet Exchange Points (IXPs) in Emerging Markets. In *Proceedings of the 40th Research Conference on Communication, Information and Internet Policy*. Available from http://papers.ssrn.com/sol3/papers.cfm?abstract_id=2029715 (Abstract available at http://papers.ssrn.com/sol3/papers.cfm?abstract_id=2029715.)
- Eisenhardt, K. M. (1989, January). Agency Theory: An Assessment and Review. *The Academy of Management Review*, 14(1), 57–74. Available from <http://www.jstor.org/stable/258191> (ArticleType: research-article / Full publication date: Jan., 1989 / Copyright © 1989 Academy of Management)
- Ellickson, R. C. (1991). *Order Without Law: How Neighbors Settle Disputes*. Cambridge, MA: Harvard University Press.
- Euro-IX. (2012a). *Euro-IX Twin Program of IXPs in Need*. Available from <https://www.euro-ix.net/documents/673-twin-ixp-program-pdf?download=yes> (Retrieved from <https://www.euro-ix.net/documents/673-twin-ixp-program-pdf?download=yes>.)
- Euro-IX. (2012b). *List of 302 Known IXPs Around the Globe*. Available from <https://www.euro-ix.net/resources-list-of-ixps> (Retrieved from <https://www.euro-ix.net/resources-list-of-ixps>.)
- Euro-IX. (2012c). *What is an IXP?* Available from <https://www.euro-ix.net/what-is-an-ixp> (Retrieved from <https://www.euro-ix.net/what-is-an-ixp>.)
- Gerich, E. (1992, October). *Guidelines for Management of IP Address Space* (No. 1366). RFC 1366 (Informational). IETF. Available from <http://www.ietf.org/rfc/rfc1366.txt> (Obsoleted by RFC 1466)
- Gerson, J., & Ryan, P. (2012). *A PRIMER ON INTERNET EXCHANGE POINTS FOR POLICYMAKERS AND NON-ENGINEERS* (Tech. Rep.). SSRN. Available from <http://ssrn.com/abstract=2128103> (Retrieved from <http://ssrn.com/abstract=2128103>.)
- Gill, P., Arlitt, M., Li, Z., & Mahanti, A. (2008a). The Flattening Internet Topology: Natural Evolution, Unsightly Barnacles or Contrived Collapse? In M. Claypool & S. Uhlig (Eds.), *Passive and active network measurement* (Vol. 4979, pp. 1–10). Springer Berlin / Heidelberg. Available from <http://www.springerlink.com/content/1255p8g3k6766242/abstract/>
- Gill, P., Arlitt, M., Li, Z., & Mahanti, A. (2008b). The Flattening Internet Topology: Natural Evolution, Unsightly Barnacles or Contrived Collapse? In M. Claypool & S. Uhlig (Eds.), *Passive and active network measurement: 9th international conference* (pp. 1–10). Berlin: Springer. (Proceedings of PAM 2008, Cleveland, OH, USA, April 29–30, 2008.)
- Gourevitch, P. (1978). The Second Image Reversed: The International Sources of Domestic Politics. *International Organization*, 32(4), 881.
- Haas, P. M. (1992). Introduction: Epistemic Communities and International Policy Coordination. *International Organization*, 46(1), 1.
- Hall, R. B., & Biersteker, T. J. (Eds.). (2003). *The Emergence of Private Authority in Global Governance*. Cambridge, UK: Cambridge University Press.
- Hart, H. (1994). *The concept of law* (2nd ed.). Oxford University Press.
- Hawkins, D. G., Lake, D. A., Nielson, D. L., & Tierney, M. J. (2006). Delegation Under Anarchy: States, International Organizations, and Principal-Agent Theory. In D. G. Hawkins, D. A. Lake, D. L. Nielson, & M. J. Tierney (Eds.), *Delegation and Agency in International Organizations*. Cambridge University Press.
- Hubbard, K., Kusters, M., Conrad, D., Karrenberg, D., & Postel, J. (1996, November). *Internet Registry IP Allocation Guidelines* (No. 2050). RFC 2050 (Best Current Practice). IETF. Available from <http://www.ietf.org/rfc/rfc2050.txt>
- Jensen, M. (2009). *Promoting the Use of Internet Exchange Points: A Guide to Policy, Management, and Technical Issues* (Tech. Rep.). Internet Society. Available from <http://www.internetsociety.org/promoting-use-internet-exchange-points-guide-policy-management-and-technical-issues> (Retrieved from <http://www.internetsociety.org/promoting-use-internet-exchange-points-guide-policy-management-and-technical-issues>.)
- Kende, M., & Hurpy, C. (2012, April). *Assessment of the Impact of Internet Exchange Points—Empirical Study of Kenya and Nigeria* (Report for

- the Internet Society No. 20945-144). Internet Society. Available from <http://internetsociety.org/ixpimpact> (Retrieved from <http://internetsociety.org/ixpimpact>.)
- Keohane, R. O., & Nye, J. S. (1974, October). Trans-governmental Relations and International Organizations. *World Politics*, 27(1), 39–62. Available from <http://www.jstor.org/stable/2009925> (ArticleType: research-article / Full publication date: Oct., 1974 / Copyright © 1974 Trustees of Princeton University)
- Krasner, S. D. (Ed.). (1983). *International regimes*. Ithaca, NY: Cornell University Press.
- Labovitz, C., Iekel-Johnson, S., McPherson, D., Oberheide, J., & Jahanian, F. (2010, 30 August–3 September). Internet Inter-Domain Traffic. In *SIGCOMM'10*.
- Lessig, L. (1999). *Code and other laws of cyberspace*. New York, NY: Basic Books.
- Mathew, A. J., & Cheshire, C. (2008). The New Cartographers: Trust and Social Order within the Internet Infrastructure. *Proceedings of the 36th Research Conference on Communication, Information and Internet Policy*. (Double check this citation!)
- Mattli, W., & Büthe, T. (2005, July). Accountability in Accounting? The Politics of Private Rule-Making in the Public Interest. *Governance*, 18(3), 399–429.
- Mattli, W., & Woods, N. (2009a). In Whose Benefit? Explaining Regulatory Change in Global Politics. In W. Mattli & N. Woods (Eds.), *The Politics of Global Regulation* (pp. 1–43). Princeton, NJ: Princeton University Press.
- Mattli, W., & Woods, N. (Eds.). (2009b). *The Politics of Global Regulation*. Princeton, NJ: Princeton University Press.
- Mueller, M., Mathiason, J., & Klein, H. (2007, June). The Internet and Global Governance: Principles and Norms for a New Regime. *Global Governance*, 13(2), 237–254.
- NANOG. (2012, August). *About NANOG*. Available from <http://www.nanog.org/about/> (Retrieved from <http://www.nanog.org/about/>.)
- North, D. C. (1991, Winter). Institutions. *Journal of Economic Perspectives*, 5(1), 97–112.
- Norton, B. (2012). *Internet Peering White Papers*. Available from <http://drpeering.net/white-papers/An-Internet-Peering-White-Papers-Index.html> (Retrieved from <http://drpeering.net/white-papers/An-Internet-Peering-White-Papers-Index.html>.)
- Nye, J. S. (1990, July). The Changing Nature of World Power. *Political Science Quarterly*, 105(2), 177–192. Available from <http://www.jstor.org/stable/2151022> (ArticleType: research-article / Full publication date: Summer, 1990 / Copyright © 1990 The Academy of Political Science)
- Nye, J. S. (2004). Soft Power and American Foreign Policy. *Political Science Quarterly*, 119(2), 255–270.
- Nye, Jr., J. S. (2005). *Soft power: The Means to Success in World Politics*. PublicAffairs.
- Nye, Jr., J. S., & Keohane, R. O. (1971a). Transnational Relations and World Politics: A Conclusion. *International Organization*, 25(3), 721.
- Nye, Jr., J. S., & Keohane, R. O. (1971b). Transnational Relations and World Politics: An Introduction. *International Organization*, 25(3), 329–349.
- Porter, M. E. (2008, January). The Five Competitive Forces that Shape Strategy. *Harvard Business Review*, 86(1), 78–93.
- Richardson, G. B. (1996). The Organization of Industry. In L. Putterman & R. S. Krozener (Eds.), *The Economic Nature of the Firm: A Reader*. Cambridge, UK: Cambridge University Press.
- RIPE NCC. (2010, October). *The History of RIPE*. Available from <http://www.ripe.net/ripe/about/the-history-of-ripe> (Retrieved from <http://www.ripe.net/ripe/about/the-history-of-ripe>.)
- Saltzer, J. H., Reed, D. P., & Clark, D. D. (1984). End-to-end arguments in system design. *ACM Transactions on Computer Systems*, 2(4), 277–288.
- Solum, L. B. (2008). *Models of Internet Governance* (Tech. Rep. No. Law & Economics Research Paper No. LE08-027). University of Illinois Law. Available from http://papers.ssrn.com/sol3/papers.cfm?abstract_id=1136825
- Solum, L. B., & Chung, M. (2003). *The layers principle: Internet architecture and the law*.
- Stanojevic, R., Castro, I., & Gorinsky, S. (2011). CIPT: Using Tuangou to Reduce IP Transit Costs. In *Proceedings of the seventh Conference on emerging networking EXperiments and technologies* (pp. 17:1–17:12). New York, NY, USA: ACM. Available from <http://doi.acm.org/10.1145/2079296.2079313>
- Steffan, S. (2012, September). *What is Consensus?* (Archive at <https://ripe64.ripe.net/archives/#Thursday>. Video at <https://ripe64.ripe.net/archives/video/837>; transcript at <https://ripe64.ripe.net/archives/steno/18>.)
- van Schewick, B. (2010). *Internet Architecture and Innovation*. Cambridge, MA: The MIT Press.
- Vincent, C., & Camp, J. (2004). Looking to the Internet for Models of Governance. *Ethics and Information Technology*, 6(3), 161–173. Available from <http://www.springerlink.com.libproxy.mit.edu/content/1t77736h087404h1/>
- Williamson, O. E. (1996). *The Mechanisms of Governance*. New York, NY: Oxford University Press.
- Wolfers, A. (1962). The Actors in World Politics. In A. Wolfers (Ed.), *Discord and Collaboration: Essays on International Politics*. Baltimore, MD: Johns Hopkins Press.
- Woodcock, B., & Adhikari, V. (2011, May). *Survey of Characteristics of Internet Carrier Interconnection*

Agreements (Tech. Rep.). San Francisco, CA: Packet Clearing House. Available from <http://www.pch.net/docs/papers/peering-survey/PCH-Peering-Survey-2011.pdf> (Retrieved

from <http://www.pch.net/docs/papers/peering-survey/PCH-Peering-Survey-2011.pdf>.)