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THE ECOLOGY OF STANDARDS PROCESSES: INSIGHTS FROM INTERNET STANDARD MAKING[1]

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Abstract

In order to create Internet standards, people and ideas move across many institutions. By drawing upon the new institutionalism and on organizational ecology, we develop an ecological approach to studying this movement. The approach examines the birth and death of standards bodies and the ideas they cultivate. We apply the approach to the history of Web services choreography standards, in which over 500 participants traversed nine institutions during a 12-year period. We explain critical aspects of this history by analyzing patterns of movement of standardization ideas. We show that standard-making institutions refuse to legitimate standards by utilizing bylaws which reflect the values of the institution; these values reflect the design legacy of the Internet. We formulate conjectures about the dynamics of the birth and death of working groups inside larger institutions that form a population ecology. We discuss plausible explanations for why specific Internet standard-making efforts do not resolve quickly. The theoretical implication of the study is that an ecological approach will apply well to inventions that have been incubated, such as the Internet. The pragmatic implication is that changes to institutional Internet governance, particularly to the bylaws of standards bodies, can have drastic and unintended effects that will reshape the standard-making ecology.

Keywords: Standard making, legitimacy, organizational ecology, institutionalism, Internet standards, Web services choreography

Introduction

Researchers shut out commercial interests while the initial Internet standards were born. Now, however, commerce depends on the Internet, so companies strive for control.

They have not had an easy time of it. After 12 years of trying, the shared business terms, functions, processes, and protocols needed to coordinate business activities across the Internet have not been agreed on. Standards for such *Web services choreography* would increase the efficiency of interorganizational processes mediated by the Internet and would also enable new forms of organization to emerge. Why are such obviously needed standards missing?

This paper formulates an ecological model to explain the standard-making behaviors and outcomes associated with

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Web services choreography. This perspective complements the prevalent economic explanation of standardization processes and their outcomes.

Economics explains standard making as the interplay of rational decision makers facing choices about standards (Besen and Farrell 1994; Farrell and Saloner 1985; Shapiro and Varian 1999; Stango 2004; Weiss 1993). Failures to standardize are treated as incentive structure breakdowns, market failures, problems of bounded rationality, excess inertia, penguin effects, and other network effects that are well documented in other articles of this special issue.

By itself, this approach fails to explain adequately the behaviors and the outcomes observed in the case of standard setting for Web services choreography. An alternative approach is needed to explain the seemingly chaotic standard setting efforts that involve many institutions.

The economic approaches most often used to study standard making are neoclassical. We could modify the economic model and instead use concepts from institutional, behavioral, or evolutionary economics (e.g., Schmid 2004; Camerer 2003; Foster and Metcalfe 2001, respectively). The neoclassical model, however, has worked well on many examples of standard making, and its great virtue lies in its parsimony.

Instead, we will formulate and use an ecological model. It draws upon strands of new institutionalism (Barley and Tolbert 1997; Giddens 1984) and theories of organizational ecology (Hannan and Freeman 1977, 1989). It is complementary to the economic model.

Economic and ecological approaches share a common root, the ancient Greek notion of *oikos*, or household. The Greeks saw in the household not only a model for trade, a set of functions based on profit, but also a model for community, a set of relations based on friendship (e.g., Aristotle 350 B.C.E). Both models apply to the tight-knit community of Internet standard makers.

Our argument consists of the following. At the center, we provide an illustrative case study of standard setting, which took place in an environment of changing institutions, proselytizing participants, and churning ideas. We then show what was learned through applying the economic and ecological perspectives. Following this, we propose conjectures about Internet standard making that form the basis for future theory validation, and we discuss why some standards are harder to formulate and legitimate than others. We conclude with the theoretical implications of our study to research in standard making, as well the pragmatic implications for Internet governance. In the upcoming section, in order to lay the ground for the case study, we review previous theories and explain the ecological model. We start by introducing standard making terms.

Internet Standards and Ecologies

Standards and Standard Making

A technical standard can be defined as an agreed-upon specification for a way of communicating or performing actions (David and Greenstein 1990; Fomin et al. 2003). Specifications typically progress through a series of drafts until they are ratified by the members of a standard-making group. Such anticipatory standard making usually involves industrial corporations, research laboratories, and powerful users. They interact through a set of processes defined by the standard making institutions (Graham et al. 2003; King et al. 1994; Schmidt and Werle 1998). These processes have been studied, but less well-examined is the question of how the institutions form, change, stabilize, or dissolve.

Why do companies spend money on standardization efforts? From an economic perspective, standardization helps companies grow the overall size of the market in which they compete, but this does not mean that all players win. For example, dominant companies might lose control in their markets as a result of the adoption of standards, while their competitors might benefit from lower barriers to entry. Consequently, companies decide between an individualistic strategy of fighting for a greater share of their given market, and a cooperative standards-based strategy of growing their market size (Shapiro and Varian 1999).

Internet Standard Making

Internet standards, as with other technical standards, specify protocols that enable institutions, individuals, and programs to interact. But each entity can choose to use them or not, as these protocols are not mandated by law or any other form of regulatory agreement. There is no coercion: the incentive to use them comes from positive network effects and economies of scale related to the Internet's underlying technologies. In formal terms, Internet standards have become institutionalized through *de facto* processes, meaning they arise from within the technical community itself and are not promulgated as *de jure* standards by government or formal standard-developing organizations such as the International Organization for Standardization (ISO) (Schoechle 2003).

The Internet has a tradition of grass-roots, bottom-up action that still permeates its standard-making institutions. These are typically made up of nonprofit groups of dues-paying corporate participants. Their meetings are sometimes face-to-face but often occur through conference calls, electronic mailing lists, and public Web sites that include repositories of standards, standard drafts, bylaws, and discussions.

The founders of the Internet consciously resisted marketplace pressures, establishing a protected niche in which they could pursue their research (King et al. 1997). In this way, the Internet is unusual. Most modern inventions occur within a commercial context. The Internet, funded by the government and sheltered in research and development labs for decades, created a broad following interested in both its technical and its social characteristics well before commercial interests sensed its importance.

Internet researchers have an ideology. Monteiro (1998) has described the culture of Internet standard making as a *design culture*. He bemoans that vendors are a growing force in Internet standard making. But the technical ideals of simplicity and elegance, rather than commercial principles of market share and profits, still exist. More generally, Granovetter (2001) describes all inventors as being part of a *nerd culture*. In particular, programmers share values, norms, and motivations (Saxenian 1994). This is especially evident in open source development, which has been strongly influenced by Internet standard making. There, a *hacker culture* has been studied and described (e.g., Lakhani and Wolf 2003; West and Dedrick 2001).

Tuomi (2002) has applied Fleck's (1979) work on thought collectives to explain this Internet ideology. Fleck argued that those inside a thought collective think a certain way and reject many alternative ideas out of hand. They seek to legitimize and perpetuate their thought style. Consequently, by following ideas that have been rejected during standardization and examining why such rejections take place, we should be able to understand what Tuomi calls the "ecology of communities."

An Ecological Perspective

Standards bodies are not companies. Companies compete in the marketplace and therefore organize themselves for efficiency. Organizations that do not face market competition, on the other hand, organize themselves according to ideologies. They define what they will strive for in lieu of money. This helps them establish their identities and build legitimacy among their members (Meyer and Scott 1983). These beliefs, which guide organizations, are put in place at their founding and may reign long after the circumstances that gave rise to them have changed (Stinchcombe 1965). Specifically, standards bodies organize around an ideology, and will act in accordance with it even as the environment shifts over time. This filial loyalty to the institution's formative values is an important concept in the ecological approach to standard making.

Another important concept comes from *natural ecology*, which is the study of living things in relation to the environment. Ideas from natural ecology have been applied to human behavior to form the field of *human ecology* (Hawley 1950). Hannan and Freeman (1977) went further, blending ideas of institutionalism and human ecology into a theory of *organizational ecology*. In this theory, organizations, not individuals, are born, merge, and die. The existence of multiple institutions of a certain type makes it easier for a new institution of the same type to emerge—a form of organizational cloning. With too much cloning, however, too many organizations end up competing for resources and legitimacy.

Competition thus factors into both economic and ecological explanations. But while economic competition is over profit, ecological competition is driven by the desire for survival of the species, a longer-term goal. When organizations try to adapt to the changing demands of their environments, they find their flexibility is limited by institutional inertia, by their organizational genetics. Thus, the important changes take place through the birth and death of organizations. In a nutshell, physics is the metaphor of economics (think equilibrium), but biology is the metaphor of ecology (think birth and death).

Organizational ecology can explain much about Internet standard making institutions. These institutions are born with ideologies. These ideologies, like a genetic endowment, persist throughout the lifetime of the institutions. The institutions differ in the way they are born and the way they die, in their criteria for who they will admit, and in the scope of the standards, the niche, they develop for themselves.

But organizational ecology does not offer an account of individuals' actions, which might be expected to have important consequences in the small world of standards making. Thus we need to augment organizational ecology explanations with concepts that connect individual and institutional action.

Barley and Tolbert (1997) offer one such concept: the idea of *agency*, as expounded in structuration theory. They call the

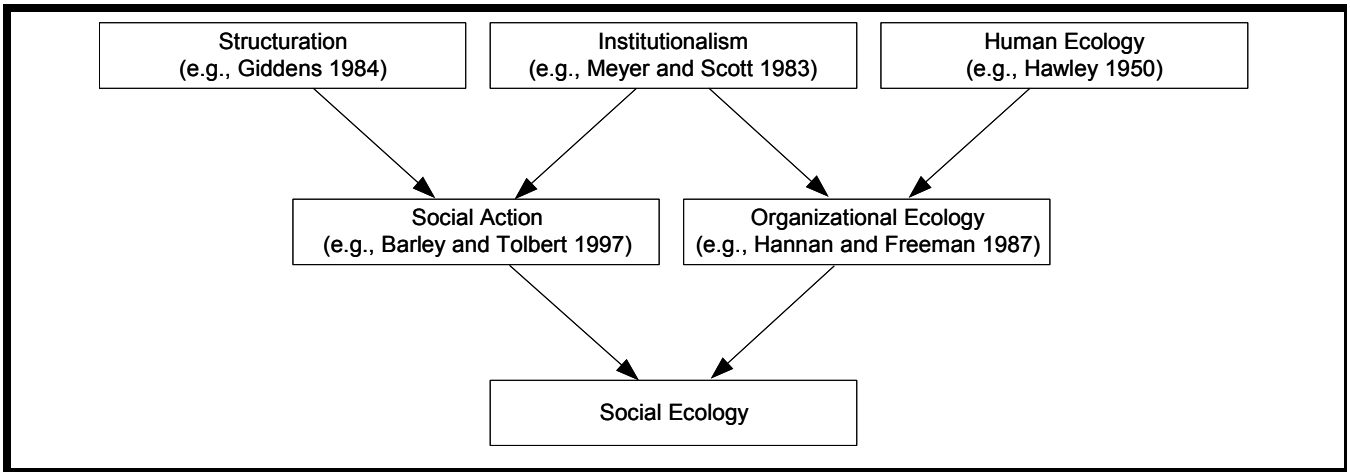


Figure 1. Inheritance of Ideas Forming an Ecological Perspective

patterns of individual behavior that constitute institutional behavior *scripts*. Thus, they make Giddens' (1984) concept of legitimacy more precise, for any institutional-level behavior should manifest itself in scripts in which individuals participate.

By blending the work of Barley and Tolbert with that of Hannan and Freeman, we arrive at what we label in Figure 1 *social ecology*. In the same way we refer to neoclassical economics in this paper as the *economic perspective*, we will refer to the theory of Figure 1 as the *ecological perspective*.

An ecological perspective suggests that individuals' actions shape and are shaped by institutions. At the same time, the institutions are subject to environmental forces: not only do they need to adapt, but they also move through entire life-cycles of birth, merger, and death, as they are culled by selection processes. What is new with respect to organizational ecology is the suggestion that individuals play an active role through their own interactions with their institutions.

Ecology suggests that the world of standards creation is made up of *habitats* that *populations* of ideas, people, and institutions literally inhabit. These habitats witness the *births* and *deaths* of institutions and ideas. If a habitat doesn't fulfill a population's needs, the population can *migrate*. Sometimes the population of a habitat will reject those trying to join it, and sometimes it will accept them. Acceptance is the ecological equivalent of *legitimation*. Populations that perform distinct functions within the overall community of populations occupy different *niches*. While populations try to adapt to new environmental pressures, their ability to change is limited by their institutional *inertia*; in biological terms, the genetic makeup of the organization is fixed at its date of formation.

From the viewpoint of ecological theory, we expect to see these phenomena:

(1) the birth, merger, and death of standards institutions

(2) the creation and survival of institutions depending largely on their legitimacy

(3) individual actions shaping and shaped by the institutions

(4) institutional inertia obstructing rapid institutional change and affecting the movement of ideas

In contrast, analyzing Web services choreography standard making from the economic perspective, we expect to see the following: participants joining standard bodies and competing or cooperating based on their perceptions of market share and market size, their technological competence, and their assets.

Our case data analysis will be driven by these expectations. We will look for examples of competitive or cooperative actions motivated by concerns related to market size. We will also examine the birth and death of standard-making institutions. We will look at how individuals shape these institutions, and how in turn the institutions enable, motivate, channel, and constrain individuals' actions. In order to understand the ecology better, we will focus on migration patterns: individuals' movements into and out of different institutions. In addition, we will look for scripts that show how institutions legitimate or block standardization ideas.

Method

The above expectations drove the details of our analysis. Because populations of institutions change slowly, our study of Web services choreography standardization was longitudinal. We examined all relevant events that occurred between 1993 and 2005 and narratives about those events, both contemporaneous and retrospective. This type of processual approach has been applied in the past in information systems and management research, as well as in sociology (Abbott 1995, 1996; Cederman 2005; Crowston 2003; Markus and Robey 1988; Mohr 1982; Pentland 1999; Shaw and Jarvenpaa 1997; Wagner 2002).

The particulars are as follows: we traced 505 participants engaged in standard-making activities across nine standard institutions. Within these institutions, we analyzed 63 meetings and 22 standards-related publications. One of us, zur Muehlen, attended 20 standards body meetings that took place during the period of our study, and his experience provided an initial motivation to examine the case data. We also asked, in person and through e-mail, several key participants in critical events to construct a chronology of the Web services choreography standard-making process. Prior to this study, we studied the battles over the underlying technologies of these standards; our explanations are reported in zur Muehlen et al. (2005).

The Internet provided a rich set of contemporaneous documents: Internet standard making has a tradition of open dialogue, which is electronically archived. Standards bodies keep meeting minutes, including transcripts of important conversations. Associated with each institution are electronic mailing lists. Attendance sheets indicated which participants attended which meetings of each standard body. We traced the participants' communications with each other by reading meeting transcripts and the log files of electronic mailing lists. Consistent with historical research methods (Mason et al. 1997), we list our sources in a separate section at the end of the paper. Most of these sources are publicly accessible over the Internet.

Now we turn to describing the case, starting with a description of the standards we studied.

The Development of Web Services Choreography Standards

Web Services Choreography

We will first describe the technology of *Web services choreography*. The term itself reflects the history of the Internet. The original Internet depended primarily on the communication protocol, TCP/IP, and the domain name service (DNS). Later, the hypertext transfer protocol (HTTP) and the hypertext markup language (HTML) were added to form the *World Wide Web* (WWW). In contrast to these well-established and widely used standards, *Web services* describe a set of recently designed standards that complement the existing Internet and Web protocols. The intent of these new standards, including XML, SOAP, WSDL, and UDDI, is to make the World Wide Web a platform for distributed computing.

In this context, the word *choreography* denotes the dance of data among distributed autonomous computing agents. Partners in a business process may need their information systems to interact over the Internet in a coordinated manner. Yet these interactions need to be flexible enough to allow for changing conditions. In summary, *Web services choreography* standards define how business processes can be connected over the Internet, using the previously mentioned standards as their platform (Peltz 2003).

Standards Institutions

Web services choreography is discussed in many standards institutions which try to solve overlapping aspects of the business coordination problem. For example, not only do interacting organizations need to standardize the messages that pass between them, but they need to know how to find each other and connect in the first place. This requirement has led to a wide range of related standards, including formal modeling languages for processes (e.g., OASIS BPEL4WS), software-enabled protocols for system interoperability (e.g., WfMC Wf-XML), and descriptions of trading partner behavior (e.g., OASIS ebXML CPP).

Among formal standard setters in this ecology we find institutions both large and small, regardless of whether we measure by membership size or work scope. The large institutions include the Internet Engineering Task Force (IETF), the W3C, the Object Management Group (OMG), and the Organization for the Advancement of Structured Information Standards (OASIS). The smaller institutions are the Workflow Management Coalition (WfMC) and the Business Process Management Initiative (BPMI); they happen also to be vendor-driven organizations. These institutions contain multiple working groups that work on specific parts of a given standard specification. Also, several topical working groups arose (the SWAP Consortium, the BPEL Consortium, and the AWSP working group) that were not affiliated with any particular standards institution. These groups eventually brought

their ideas to better-established institutions that had the power to legitimate standards.

In ecological terms, standards institutions often occupy distinct niches in the overall habitat. When a new standards institution forms, it often copies its bylaws from those of existing standards bodies. For example, passages in the bylaws of OASIS and BPMI were lifted verbatim from the bylaws of IETF. Nonetheless, important differences emerge. For example, procedural rules differ, and these rules can affect the movement of participants. As one standard maker observed,

> OASIS has a very liberal policy about starting a TC [technical committee]…anyone can start one. W3C, on the other hand, has a lengthy review process before you are allowed to start one. Simply put: it was easier to start an OASIS group.[2]

In the same vein, membership rules determine which bodies are viable options for those interested in switching institutions. The Appendix displays the differences between standard institutions, including their inception dates and their bylaws.

Legitimacy

Standards bodies establish and maintain their own legitimacy, which is recognized by a respectful audience steeped in the technical culture of the Internet. Consequently, even though most members of standards bodies represent the interests of corporations, the corporations themselves exert little control over the standard-making process.

IETF is the institution whose legitimacy is most secure. It is the ancestor of all other Internet standards institutions; at the same time, due to its long-term success in maintaining a hacker ideology, it is the most radical of the institutions. That radicalism can be seen in the thinking of Robert Kahn (1994), whose Corporation for National Research Initiatives provides the secretariat for the IETF, and in public IETF documents (see in particular the Tao of the IETF, 2001, and Dave Crocker's writing, 1993): Harald Alvestrand, the current chair of the IETF from March 2001 until March 2005, lists his title as *subversive*. IETF describes its core values as (1) cares for the Internet; (2) technically competent; (3) open process; (4) volunteer core. Its ideology is reflected in its slogan: "We reject kings, presidents and voting. We believe in rough consensus and running code" (Alvestrand 2002). The slogan summarizes the main criteria for the legitimacy of any Internet standard. The criterion of *rough consensus* is another mechanism for conferring as well as denying legitimacy.

The criterion of *running code* implies software that works; as a consequence, the IETF prefers ideas that have already been realized. To enforce this, IETF makes the existence of two independent implementations of a draft standard the precondition for its advancing. The rule serves as a check on vendor self-interest, preventing any one vendor from pushing for the adoption of its own technology.

All is not rosy, however. Cerf and Kahn (2005) have recently observed that the Internet is susceptible to being appropriated by corporate interests; they fear for its future, as its original pioneers retire from the volunteer positions that have kept the Internet standardization process running the way it has. Cerf and Kahn doubt whether the institutions they have established can withstand pressures from corporate interests. In other words, in a changing environment, a different population of institutions may become dominant. They suggest that younger researchers should design a radically new Internet, under the protective auspices of new government funding. Thus, when the legitimacy of the current institutions wears thin, it will be time to start over again.

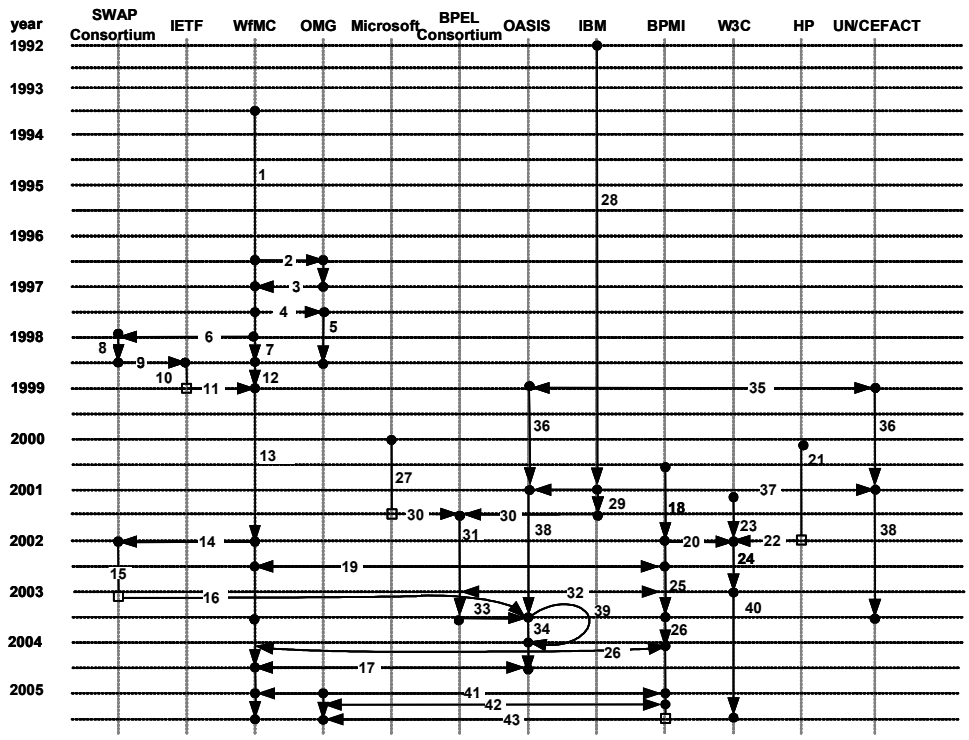
Idea Movement

Institutions legitimate standards ideas. How do these ideas move across the institutions? While these ideas arise initially in working groups of the standards institutions, they are likely to be carried to other groups by the participants in the standard-making process. We will present the interactions of the participants and the standard-making institutions at two different levels of detail. We first show at a higher level how information flows between institutions; we then show at a detailed level how individuals convey that information.

We can see from Figure 2 that standards development takes place in parallel across institutions and that ideas move, split, and recombine. Many institutions were born and many died during the 12-year period. Working groups within the larger institutions went through even more rapid cycles of birth and death as ideas came and went. Participants understood this, exhibiting an awareness of what was happening in standard institutions other than their own. Everyone who wanted to play the game was conscious of changes in the habitat.

How do individuals carry ideas between institutions? More than half (305) of the 505 participants in 63 standards meetings came to one meeting each, then dropped out. Another 105 attended 3 or more meetings; of these, 33 attended

[2]K. D. Swenson in a personal communication to M. zur Muehlen, September 2, 2003.



1. WfMC works on five standard interfaces, Reference Model and Glossary
2. WfMC members try to convince OMG to fast-track WfMC standards
3. OMG fast-track process fails and an RFP for a workflow facility is issued
4. WfMC members submit jointFlow proposal to OMG
5. OMG accepts the jointFlow proposal as the new OMG Workflow Facility
6. Netscape, HP, and Oracle informally pursue the idea of a lightweight workflow interoperability protocol (SWAP)
7. WfMC forms a SWAP working group to synchronize efforts with the SWAP consortium
8. The SWAP working group under the leadership of KS creates a first draft proposal
9. KS and group propose IETF working group
10. Two BOFs take place, where participants are asked to decide on the formation of IETF working group
11. IETF decides not to charter SWAP working group; ideas flow back to WfMC via users of the SWAP proposal
12. WfMC continues work on IF4/MIME specification
13. WfMC works on Wf-XML versions 1.0 (05/00) and 1.1 (11/01), based on a proposal by CSC and PM/JCALS (SWAP users) and influenced by a proposal submitted jointly by NEC/Fujitsu
14. KS along with JR works on AWSP independently as WfMC proposes to keep Wf-XML and AWSP separate
15. WfMC approves AWSP draft edited by KS
16. ASAP Committee in OASIS founded to further AWSP
17. Ongoing coordination between WfMC (Wf-XML2.0) and OASIS (ASAP) through member exchange
18. Intalio works on BPML, founds BPMI.org
19. WfMC and BPMI begin talks to converge XPDL and BPML
20. BPMI submits a BPML derivative (WSCI) to W3C
21. HP works on CDL
22. HP submits a CDL derivative (WSCL) to W3C
23. W3C revises its patent policy from RAND to royalty free
24. W3C accepts WSCL, WSCI as notes, starts formation of WS-CDL working group
25. BPMI continues work on BPML
26. BPMI ends BPML development; joint talks with WfMC stall
27. Microsoft works on XLANG
28. IBM works on FDL and WSFL
29. IBM releases WSFL
30. IBM and Microsoft join forces with BEA to form BPEL Consortium
31. BEA, IBM, Microsoft, SAP and Siebel work jointly on BPEL
32. Microsoft representatives attend W3C WS-CDL initial meeting but announce withdrawal on the second day
33. WS-BPEL working group is founded in OASIS
34. WS-BPEL technical committee begins to work on BPEL specification
35. UN/CEFACT and OASIS cooperate on ebXML
36. Work on the first phase of the ebXML specification
37. UN/CEFACT and OASIS work successfully for 18 months
38. Work on the second phase of the ebXML specification commences; UN/CEFACT ends collaboration with OASIS
39. ebXML technical committee is formed in OASIS
40. W3C WS-CDL working group starts regular meetings
41. BPMI and WfMC engage in formal merger talks
42. OMG invites BPMI to merge with its integration task force
43. OMG and BPMI announce merger; BPMI ceases to exist as independent organization

Figure 2. Migration of Ideas in the Development of Web Services Choreography Standards (The diagram is in the style of a space-time network [Pallottino and Scutellà 1998], with time events quantized to the nearest 6 months)

10 or more, with 1 participant attending 36 meetings. These figures follow a power-law distribution typical of social networks.

The most active standards makers fell into two groups. Of the ten individuals with the highest attendance records, six held officer positions within their institutions, while the remaining four were heads of technical working groups. The members of the first group affiliated themselves with standards institutions, where they presided over multiple standards efforts. These people tended to stay with one body for a long time, had regular patterns of attendance, and identified with their institutions' histories and collective values. These were the institution builders.

The members of the other group affiliated themselves with particular standardization ideas, which they were active in developing and promoting. These people were likely to cross institutions and were largely responsible for the proliferation of standards ideas. They saw the institutional field as a means to advance their ideas.

As is shown in Figure 3, the movement of individuals across standards institutions was significant. The horizontal swim lanes represent individual standards institutions and working groups. The vertical lines represent events, such as formal meetings or document releases. Ideas exchanged by colleagues at such events can cross institutions without any personnel realignment. In economic terms, there were no switching costs. In ecological terms, the participants were looking at the institutions as habitats that could be visited at will.

Ideas also traveled between institutions via another mechanism: criticism.[3] Critics monitored the committees' output and registered their opinions in public online discussion groups. They were not active in the institutions they critiqued, although they may have been active in others.

From an economic perspective, we expected to find that all participants in the standardization process were at the beck and call of their corporations. But we found instances of people switching jobs and continuing to work on standards in which their new employers had no vested interest. This suggests that some participants had allegiances outside the corporations for which they worked, a surmise consistent with other literature on the motivations of software developers (Lakhani and Wolf 2005; Saxenian 1994) and on professional loyalty (Abbott 1988).

From an ecological perspective, we expected to see migrations between institutions. Instead, we saw efforts to work in parallel across many institutions, with the goal of promulgating ideas. Whereas in natural ecology an organism can inhabit only one habitat at a time, in standard making, the virtual nature of interactions permits simultaneous participation in many institutions. In such an ecology, critics can play a strong role, because they don't need to commit the time and expense associated with physical meetings. Instead, they can swoop in from their remote connections, drop their ideas, and then quickly swoop in on the next institution. Consequently, the underlying Internet infrastructure changes the pattern of idea diffusion into one that is parallel rather than sequential, leading to increased public visibility and speed of dissemination.

The IETF Episode

Having explained participants' behavior in broad terms, we now turn to a specific example.

We expected to see recurring patterns of interaction between individuals and institutions—particularly legitimation scripts (Barley and Tolbert 1997). To identify these scripts, we searched for examples of ideas that had been blocked; we wanted to see the workings of the institutional machinery. One episode clearly depicts a critical event within an organizational ecology: the death of a group.

In this episode, the Internet Engineering Task Force (IETF) refused to charter a working group around a standard proposed by Workflow Management Coalition (WfMC) members (the episode is shown in Figure 2 as edges 9 through 11; it also corresponds to the crossing points between IETF and WfMC in Figure 3).

The episode began with discussions among WfMC participants about the possibility of submitting their ideas on a new interoperability protocol to IETF. The idea seemed to make sense: IETF already handled the standard for the HTTP protocol, on top of which the new protocol was proposed to run, and it exerts a great legitimating influence on standards it accepts. After preliminary contact was established at an IETF meeting in March 1998, a *birds-of-a-feather* (BOF) session was arranged for the next IETF meeting in August 1998. IETF bylaws call for BOF meetings on new topics; these meetings are used to decide if working groups should be established. If no consensus emerges, the meetings do not continue.

[3]For example, see the exchanges of messages involving W. M P. van der Aalst, "RE: Yet Another Choreography Specification," in the W3C Archives (http://lists.w3.org/Archives/Public/public-ws-chor/2003Feb/0003.html), dated February 2, 2003.

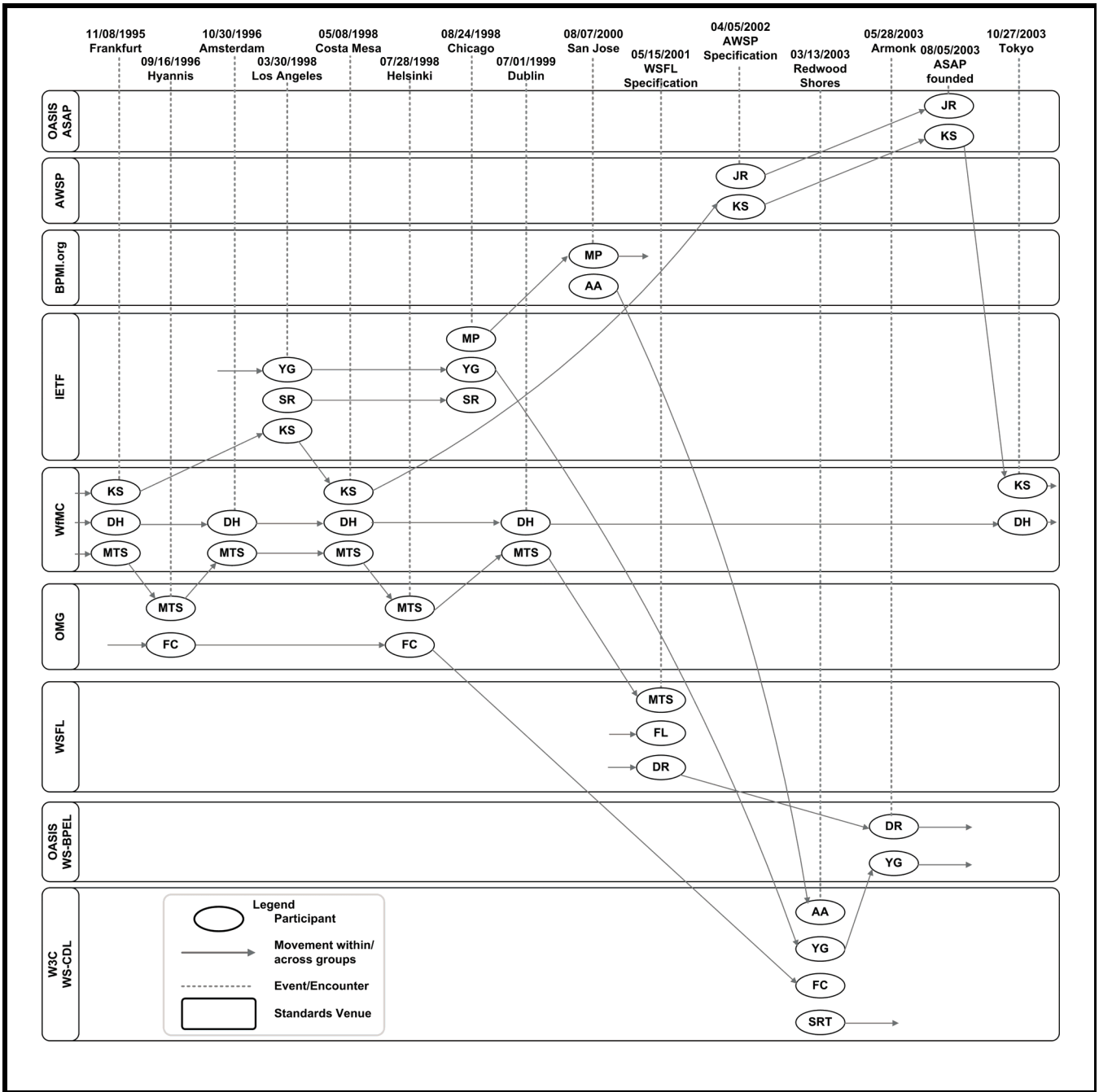


Figure 3. Link Analysis of Participant Movement

The term *birds-of-a-feather* is itself ecological. Like-minded individuals (the same "species") create the opportunity to advance a common interest. In ecological terms, the BOF sessions allow for the birth of an idea, but the containing institution builds in a rule that will automatically cull unsuccessful efforts after a trial of strength.

The IETF members instruct the WfMC on IETF's criteria for legitimation. In the notes of the second BOF meeting (IETF 1998), Dave Crocker says:

> *Technologists often don't have a market story for their gadget; the reverse in this case.*

In other words, WfMC's marketing people have walked into the meeting with a story but no gadget.

Crocker continues,

> *An exercise I do when a project remains fuzzy is to go through at least three very concrete scenarios of that nature. An Internet draft ought to be submitted illuminating what real, mechanical problems are to be solved. Try to define this in computer science stuff rather than marketing stuff.*

As noted above, IETF has a long history of anti-marketing, anti-commercial sentiment. Here, norms, rules, and belief systems are being used to fend off what are perceived as the alien values of marketing.

The following excerpt from an IETF public mailing list e-mail is just as revealing. Keith Moore, speaking on behalf of IETF, is arguing against taking in WfMC's proposed standard,

> *It's been my experience that other standards organizations, especially "industry standard" organizations, often produce large amounts of garbage.*[4]

In other words, business-biased groups produce fluffy material that doesn't meet IETF's aesthetic standards. Moore continues,

> *It's fine if the work is technically sound and the WG [working group] wants to go that way, but I'm not going to impose that constraint, and I'll lobby hard to keep other IESG [Internet Engineering Steering Group] or IAB [Internet Architecture Board] folks from imposing that constraint....I'm not going to insist that an IETF working group adhere to the work of some other body.*

This is a threat. The "IESG or IAB folks" are other long-standing IETF members who sympathize with Moore. He can lobby them to attend the next BOF meeting and thereby prevent any semblance of consensus. He is using the rules of the institution to enforce its criteria of legitimacy: work should be created inside the group, not brought in from the outside.

How is the group killed? Two months later, in the second BOF meeting (IETF 1998), Moore conducts a poll. The transcript reads,

> *Informal poll: who wants to work on that (very few); something else (slightly more); Lisa Li[ppert] asked if everyone else here was to prevent a WG forming (larger still, but still a minority).*

People came to the meeting for the express purpose of preventing a work group from forming. At the meeting, they were asked if that was their reason for attending. The question implies that the strategy is not unusual.

Later in the meeting, Moore says,

> *What I need to see: a few of the people in the audience to be convinced there's a core problem that diverse people want to work on. I suspect there may be one; but there's an implicit paradigm being used to express it—there's a different expression that will resonate here.*

The IETF, that is, needs to see that its own members are interested in working on the WfMC proposal. The WfMC members, however, have failed to identify "the expression that will resonate" with—the description of their idea that will persuade—the IETF members. Moore finishes with,

> *The other problem is that this is the second BOF, and that's the limit.*

Invoking the rules, he declares the meeting over. The WfMC's attempt to legitimate its idea through IETF has effectively been stopped.

Rough consensus can thus be a more powerful control mechanism than majority voting; all it takes to break consensus is a few dissents. In an institution with adequate continuity, there will be enough long-time members to defend against any unwelcome proposal.

[4]This series of quotes is taken from an exchange of messages in the W3C archives, "RE: SWAP WG Charter–Second Iteration," in October 1998 (http://lists.w3.org/Archives/Public/ietf-swap/1998Oct/0011.html).

While we had expected to see patterns of behavior—scripts—whereby individuals shaped institutional policy, we did not expect to find such a clear example of the intentional and self-conscious use of bylaws to force out unwanted standards. This episode shows how subgroups, which can be considered a type of institution within an institution, quickly emerge and quickly die.

In ecological terms, the episode is an attempt by the marketing population to gain the acceptance of the technical population, which dominates the habitat. The technical population refuses to accept it, and the rejected population is left to look for a more hospitable habitat. In this case they found one, the aptly named OASIS.

The W3C Episode

Threats to an institution's values can come from within as well as from without. The previous episode involved one population's failed attempt to move into the habitat of another. Here we see a debate about a critical aspect of standards groups' bylaws: the intellectual property conditions which apply to all new ideas. Obviously, companies want to keep possession of ideas they originate. Software developers, however, want standard-related technologies to be donated, freely available for use, so that the developers can proceed without legal encumbrances as they build new systems.

In 2001, an internal W3C working group proposed to change the licensing terms for all intellectual property created by the W3C. It proposed an explicit RAND (reasonable and nondiscriminatory) patent policy.[5] RAND requires patent holders to allow reasonable and nondiscriminatory licensing but does not prohibit the collection of licensing fees. Such policies are common among wireless standards bodies such as ETSI or 3GPP. Many Internet developers, by contrast, prefer RF (royalty-free) licensing. W3C solicited public comments on the working group's proposal and was greeted with a storm of protests from the group we call the critics. More than 2,000 individuals wrote in to the public message boards of W3C, with an overwhelmingly negative reaction to the RAND idea. W3C counted and summarized the major objections: the policy would discriminate against the poor and fragment the market (944 messages); the policy undermines the historical values of the Web or, more specifically, "goes against the spirit of the Web" (485 messages); the policy would be self-defeating for the W3C (292 messages); and the proposal represented a conspiracy (92 messages).[6]

The committee reversed its decision and produced a more popular royalty-free patent policy, even though the membership of the W3C consists largely of representatives from the large software vendors. In a conference call with the policy working group, the W3C director, Tim Berners-Lee, pointed out that,

> *The RF way of working is important for the Web. From a historical perspective, the Web was developed in an RF mode. The ethos was that royalties were not charged, and the initial developers didn't patent anything. When companies later joined in, then those companies didn't ask for royalties either.*[7]

One can infer that the public pressure contributed to the reversal of policies that made *prima facie* sense to the software vendors. The statement of the director was also influential. Because of his past role in the design of the early WWW protocols, Berners-Lee had both the organizational power and the authority to legitimate or defeat standards. Moreover, his invocation of the Web's original ethos is consistent with Stinchcombe's (1965) observation that the ideas that govern an organization at its inception will always permeate it.

In explaining the decision publicly, Berners-Lee offered his corporate sponsors an economic argument. He stressed to the W3C's corporate membership that the royalty-free processes of the past had allowed companies to profit from the applications that run on top of the Internet.[8] But that argument appears to be a retrospective justification: on-line discussions indicate that the winning forces were driven by an allegiance to *the spirit of the Web*, and that they only later began to offer economic explanations.

Nonetheless, in the long term, a royalty-free policy is probably better for the corporate community; as Lemley (2002) has shown, standards bodies can provide companies relief from complex legal negotiations over intellectual property (IP). More generally, it is doubtful that software vendors

[5]"W3C Patent Policy Framework: W3C Working Draft," http://www.w3.org/TR/2001/WD-patent-policy-20010816, August 16, 2001.

[6]"Public Issues for Patent Policy Framework of 20010816," http://www.w3.org/2001/11/PPF-Public-Issues, February 26, 2002.

[7]"Patent Policy Working Group Face-to-Face Meeting Summary," http://www.w3.org/2001/10/ppwg-cupertino-ftf-summary.html, October 15-17, 2001.

[8]"Director's Decision, W3C Patent Policy," http://www.w3.org/2003/05/12-director-patent-decision-public.html, May 21, 2003.

would have profited as much as they have from products that work over the Web if the Web had been designed by vendor-run coalitions. Thus, there is an irony: companies fight against the very policy that helps them make more money, and developers fight for the policy that in the long term enriches companies.

In summary, this episode indicates the influence of public pressure on the decisions of Internet standards makers. The public can mobilize an institution's own legitimacy against the short-term interests of its members. In ecological terms, a habitat that appeared to be dominated by a population of large corporations proved instead to be dominated by a population of vocal technical standard makers, who control the levers of acceptance. The sudden appearance of the critics can be seen as a Socratic gadfly invasion.

What We Learn from Economics and Ecology

Now that we have explored a case of Internet standard making, we look at what we have learned. In Table 1, we identify key aspects of the case and provide economic and ecological explanations for them. The economic and ecological perspectives appear complementary, each explaining what the other can't.

For example, when new industry groups form (row 1 of Table 1), there is a simple economic reason. Vendors are cooperating to expand their market size. An ecological explanation is more cumbersome: it would see the formation as the filling in of a niche, the result of a process that clones successful standards groups. The economic explanation is both simpler and more consistent with what vendors told us.

On the other hand, when new industry groups submit their standards to older institutions, as when WfMC submitted to IETF (row 2), the ecological reason is compelling: vendors go to the institution that will confer the greatest legitimacy. There is a way to state this in economic terms: vendors want a branding that will attract more adopters. The vendors, however, told us that legitimacy is their rationale.

Likewise, the rejection of a standard (row 3) has a simple ecological explanation: the institutions protect their niche by killing proposals they don't like. Economic theory suggests that the proposals are killed because they won't increase market size. The evidence goes the other way: even if the standard will increase market size, it may be rejected for ideological reasons, as in the IETF episode.

When it comes to explaining corporate thinking, the economic approach does well. For example, the push to protect intellectual property is clearly a push to protect profit, not a push to defend a niche (row 4). When it comes to explaining technical standard makers' thinking, however, an ecological explanation rings true (row 5). The technical standard makers fought against allowing companies to maintain ownership of their IP, thereby defending the spirit of the web.

We see other aspects of Internet standard making for which ecological explanations are strong. The movement of the standard makers (row 6) can be seen as the participants looking for the right community. Their continued work on standards even as they change jobs (row 7) points to an allegiance to ideas, not profit.

The overall pattern of movement, the seemingly chaotic movement patterns of Figures 2 and 3, and the 12 year time period, call for explanation (rows 8 and 9). From the economic viewpoint, the movement is part of a competitive/ cooperative game. But a competitive or cooperative game around a clear goal could have been completed in much less than 12 years, given the economic rewards at stake. The whole process appears incoherent and meaningless, a regrettably inefficient step on the path to the inevitable victory of a smaller set of players, most likely the large vendors.

Alternatively, seen from the ecological viewpoint, there is a fight over the dominance of ideas. A technical ideology defends itself against a marketing ideology. In economic models, games usually reach equilibrium, and therefore we eventually expect a victor. Ecological models, in which different species are evenly matched, can easily produce the continuous boundary fights we see in standard making.

Those with standards to pitch threaten to disrupt the ecological equilibrium by moving into new habitats; the populations already inhabiting those habitats—the institutional defenders—are trying not to be overrun, fending off what they see as an attack reflecting commercial interests. Because of this dynamic, proponents of a particular standard can spend years searching for the right combination of like-minded individuals and an institution of sufficient legitimacy to bless their proposal. Their success may ultimately be contingent on the intertwined actions of many different participants.

There is a pattern to the explanations in Table 1. The motivations and behavior of corporations seeking to exploit the Internet are commercial, explained well by economic arguments. But the motivations of the earlier founders of the Internet were not commercial. The behavior of those who seek to uphold the founders' ideas are best explained through

Table 1. Explanations of Web Services Choreography Standard Making from Different Perspectives

#	Aspect of the Case	Economic Explanation	Ecological Explanation
1	Formation of a new industry group (for example, the BPEL consortium)	Vendors cooperate to expand market size.	Institutions are born through replication of existing prototypes that define an ecological niche.
2	New industry groups submit their standards to older bodies (for example, IBM et al. submit to OASIS; WfMC submits to IETF)	To build market size, vendors need a branded standard that will attract more adopters.	Vendors migrate to habitats that can confer the greatest legitimacy.
3	A standards effort is rejected by an established institution (for example, IETF prevents the formation of a working group around the WfMC proposal)	The institution doesn't believe the standard will increase market size.	The institution is protecting its niche; its criteria for rejection are an expression of its values.
4	Attempts to control IP (for example, the W3C proposal to change IP policy in vendors' favor)	Economic self-interest of vendors favors privately owned IP.	Companies will try to protect their niches.
5	Attempts to make IP public (for example, the W3C decision not to change IP policy in vendors' favor)	Shared IP is in the long run better for companies, as it reduces legal costs associated with disputes and expands markets.	The Internet emerged as an ecosystem where resources are shared, and this ethos persists. There is a battle between a technical population and a corporate population, where the values of the ecosystem are defended through an appeal to legitimacy.
6	Continuous movement of standard makers between institutions (as shown in Figures 2 and 3)	Participants look for the best deal in an inefficient market.	Participants are seeking legitimacy for their ideas, trying to find the right habitat of like-minded individuals.
7	Standard makers' continued involvement in the process, even across career changes	Standard makers work on behalf of companies and are therefore agents for hire.	Standard makers have allegiance to ideas as much as to companies and are willing to migrate to and from habitats, as well as to and from sponsoring companies, in the service of their ideas.
8	Web services choreography standards efforts considered as a whole, including all the events of Figure 2	An attempt by vendors to build a large market size for their products as part of a competitive/cooperative game.	Ecological competition within a population of ideas. Some vendor-driven ideas are opposed by a technically minded population that wants a standard consistent with earlier, open, technically parsimonious protocols. The ecological competition for survival plays out in a population of institutions, with varying degrees of legitimating power.
9	The length of time involved in the effort, 12 years	An inefficient marketplace.	A standoff between populations and their criteria of legitimacy. For corporations, IP and market size are good enough reasons to accept standards; for technologists, technical aesthetics and openness are important. There is no one strong institution to arbitrate the legitimacy criteria, so ideas and people can continue to migrate in reaction to inhospitable habitats.

Table 2. Conjectures

Conjecture	Examples of Evidence
Working groups in Internet standard making function as a population ecology.	The birth, death, and merger of the working groups are frequent. In the IETF episode, IETF fought to not let a working group get formed.
Standard makers function as part of an interactional field, in which their actions are interdependent with those of other standard makers.	There is a hyperawareness of what is happening in other places; we see this in the WfMC meeting minutes. More generally, there is much discussion of what others are doing in electronic forums. Figure 2 is itself evidence, and shows the extent of the field.
The bylaws of the organization are the source of institutional stability in Internet standard making.	The W3C episode focused on the bylaws of the organization related to IP attracted large-scale public participation. In the IETF episode, the old-time members used the bylaws to prevent a standard they did not like from being developed in their forum.

an ecological view. We expect that phenomena that are similar to the Internet would operate in a similar fashion. In other words, efforts sheltered from early commercial influence may be best examined by considering not only their surrounding economy, but also their ecology.

Conjectures

How can we learn more about standard making using an ecological approach? In the course of examining the case data, we formulated a set of conjectures. These conjectures and the evidence that supports them are summarized in Table 2.

Standards are generally created and discussed in working groups, which are formed and disbanded within standard-making institutions. We saw, for example, the attempts to get a standards effort started in IETF; the effort lasted two meetings and then died. This pattern recurred across many institutions. The central insight of organizational ecology was that institutions themselves can form a population. We want to take this a step further: within standards institutions, working groups are formed. These groups tend to align with particular standards, particular ideas. We formulate the following conjecture:

> **Working groups in Internet standard making function as a population ecology.**

Our data set offers some examples to suggest that this is the case, but a wider look at Internet standard making would yield information on the formation and disbanding of many hundreds of working groups. Applied to such information, the well-known mathematical techniques of natural ecology, as extended by Hannan and Freeman to organizational birth and death, could verify or refute the conjecture.

Furthermore, the inefficient-looking standard-making process may actually contain a mechanism that provides many Internet standards proposals the chance to briefly flare and be culled, whereas more stable areas of technology standardization might exhibit processes with far fewer efforts. In conditions of uncertainty, mechanisms that spawn many working groups that have short life spans are preferable to strategies that invest too much in single groups and, by extension, in single solutions. It is possible, then, that areas of standardization with a high degree of uncertainty will have histories that look similar to that of Web services choreography standards. An analysis of the birth and death of working groups could show this.

While the above conjecture looked at groups only, we also saw patterns in the behavior of individuals moving between institutions. Specifically, some of the more dedicated standard makers continued their efforts even after changing employers. Standard making may then be seen as a kind of profession and might be studied in the same way that other professions have been studied. In particular, Figure 3 is similar to, or at least suggestive of, what we might see in a vacancy chain (White 1970) or other interactional fields (Abbott 2001). These fields are characterized by the intertwining of narrative: someone who leaves a job creates an opening for someone else to walk into, so job lookers watch such moves carefully. Standard makers also seem to be con-

scious of where they can move next. From these ideas we can form the following conjecture:

> **Standard makers function as part of an interactional field, in which their actions are interdependent with those of other standard makers.**

To test its applicability to Internet standard making in general, we can apply the quantitative techniques of sequence analysis (Abbott 1995). The narrative sequences of standard makers might exhibit similarities, and some of these could also offer insights about standard-making institutions. For example, organizations such as OASIS are described by standard makers as being waypoints on the journey to other standards bodies. Sequence analysis might confirm that standard makers tend to have shorter affiliations with OASIS than with other institutions.

We can go further: identities form somewhere. Looking back through the education and the careers of standards makers, we might find antecedents to the allegiances they exhibit later. For example, Abbott (1996) points to the formation of identity in high school as a precursor to college choice.

Our look at the scripts used by institutional standard makers revealed their skill in wielding the bylaws of their organizations. In particular, the W3C episode illustrates the high degree of attention the standard making community pays to the bylaws of the crucial institutions. We form from this the following conjecture:

> **The bylaws of the organization are the source of institutional stability in Internet standard making.**

The conjecture implies that defending the existing Internet means defending the bylaws of the standard-making organizations, which are the source of a useful inertia that preserves the values in place at the Internet's founding. This conjecture can be studied with the techniques used by March et al. (2000) to understand changes in the written codes of universities. We looked at several examples of bylaws, but a further study might look at the way in which their texts change, and how these changes affect the birth and death rates of standards.

There is another way to analyze bylaws: the availability of online transcripts makes it possible to find scripts of interactions among participants, which can be categorized using techniques such as Barley's (1986). We discussed only two illustrative episodes: those concerning IETF and W3C. Analyzing the other examples of bylaw usage and debate would increase our understanding of how standard-making bodies function.

The three conjectures are associated in the following way: we can think of standards ideas as being a form of relation between individuals, who generate and champion them, and institutions, which host and legitimate them. The relations work both ways, as individuals generate ideas reflecting values that become hardened in the institutions of which they are a part. Standard making is fertile ground for the study of complex social processes because it traces such a visible set of interactions between individuals, the ideas they generate, the legitimation of these ideas, and the habitualization of ideas into institutions.

Discussion

Why is it that standards can fail to emerge? And what types of standards have the best chance of winning consensus? The Internet standards community forms a weakly institutionalized field, yet this field has demonstrated a high capacity for innovation. We have described this field's emergent ecology of idea generation, standard making, and institution generation. We found that standards are the product of not only economic rationality but also institutional values and aesthetic preference. We have also shown how such ecologies can be sustained for long periods of time, during which no consensus on standards may be reached. But we didn't address why standards fail, or which standards are most likely to gain support.

The evidence in our case study does not provide clear answers to these questions. It does, however, narrow down the set of feasible hypotheses that would merit future empirical research. Some of the feasible explanations follow.

1. The weak institutionalization of Internet standard making means there is no coercive, normative power to drive a complex standards effort to completion.

This is a plausible explanation, but probably only a partial one. For standards do sometimes win consensus even in this weakly institutionalized environment. What is different about the ones that don't make it?

2. Standards motivated by business goals are immediately suspect among those with a technical aesthetic.

This would explain the particular difficulties that Web services choreography standards face. But technologists have settled on many standards that have been good for business. This leads us to consider that

3. Technologists will resist blessing ideas that haven't jelled into a clear technical solution.

We saw this in the IETF discussions. The IETF members not only suspected the motives of the WfMC, consistent with explanation 2, but they also didn't like the proposed technology. More generally, the fights over Web services choreography technologies were at their heart fights over aesthetics (zur Muehlen et al. 2005). Consequently, problems in stabilizing a standard may stem from the inability to find a technical solution that will satisfy both technically oriented and marketing-oriented participants. Indeed, Tuomi (2002, p. 210) argues that standard makers are motivated not only by external values, such as economic imperatives, but also by internal values, such as the technical purity of their solutions.

There may be a domain-related reason that this purity is hard to come by. Most of the current Internet standards are clean, formal protocols built at the foundational levels of the system. In contrast, Web services choreography standards encode business practices. Contractual law and liability enter into the picture, making it difficult to create simple, elegant technical designs. Yet technical standard makers may still be right to resist unaesthetic solutions. Complex designs lead to complex software development efforts and bug-ridden products (Pressman 1996).

Perhaps technologists actually like the chaos.

4. The current chaos of the Internet standards-making environment may be supported and perpetuated by standard makers, who value the freedom it provides.

The multiplicity of standards institutions means that new ideas can be developed and tested among peers, without being shot down prematurely by a prevalent orthodoxy. This argument has been made in political science. The federalism of the United States has been described as creating political vibrancy, because ideas can be tested in many institutions (Baumgartner and Jones 1993). Furthermore, in discussing standards, Tuomi (2002, p. 32) refers to the argument of Mokyr (1990) that as an environment for invention, the chaos of Europe's city states in the late middle ages compared favorably to the order of the Chinese polity.

These four explanations can be combined. For example, it could be that technologists prefer a weakly institutionalized ecology and that high-level, business-driven standards are more likely to run into resistance because they are aggressively promoted before technologists think they are ready. These explanations echo Stinchcombe's (1965) observation that institutions honor their founding ethos: at its inception, the Internet was not commercially driven, and therefore commercially driven standards will be resisted.

At the same time, our case evidence would rule out the following types of explanations:

5. The process of Internet standard making is random.

There are too many repeating elements and too much awareness of what is happening for the process to be random. There is some randomness in the system; for example, a participant may be delayed by personal business from attending a crucial meeting. But usually, participants are intentional in their actions.

6. The process is a rational multiparty negotiation.

While everyone is aware of what everyone else is doing, there is no one place where all parties can put everything to be negotiated on the table. There are pockets of negotiated settlement, but only pockets. Since there is no single, coercive, overarching body, negotiations don't have to be completed. As in natural ecologies, participants who don't like the way a deal is going can exit and try again elsewhere.

Limitations

While we have looked at thousands of pages of documents, the ones that supplied most of our data are publicly available. Our generalizations (Lee and Baskerville 2003) may thus be skewed, as some participants may have been reluctant to publicly discuss their motivations. Likewise, our vignettes were selected from dramatic public confrontations and therefore may not offer a balanced view of the everyday operations of standards bodies.

While the focus of our paper has been to illustrate a theory rather than derive one, our conjectures are tentative theories generalized from rich descriptions. These generalizations have emerged from the study of Web services choreography standards and therefore cannot be assumed to hold true in

other domains without first being tested and confirmed there (Lee and Baskerville 2003).

Implications

The Internet is an example of an information system that was created in a protective environment, and therefore has a different dynamic than a system created in the open market place. There is virtue in the community formed through the growth of Internet standards, and this virtue is defended by blocking unwanted standards. But just as the ecological and the economic are intertwined, the Internet standard making communities have links to both the founders' ideology and to the profit imperatives of the participating corporations. Companies will continue to strive for control.

Cerf and Kahn (2005) advocate starting over. Can a new Internet really arise? There is an obstacle: network effects favor an incumbent technology and disadvantage a challenger. But such an obstacle shouldn't be overestimated: AT&T mistakenly thought network effects would protect their switching network from the Internet alternative (Hafner 1996). Furthermore, the same government agencies that funded the Internet are now funding large research projects to radically reinvent the Internet.[9]

There are theoretical implications stemming from this. An ecological approach to standard making makes sense in the case of the Internet, because the Internet was in its original conception not a commercially motivated invention. We have shown that economic self-interest alone cannot explain all aspects of the Internet standard-making process; it is not simply a matter of rational actors gaming each other. An approach that describes an ecology (a set of relations between different standards institutions, ideas, and participants) provides needed explanations. It is likely this approach can be successfully applied to other artifacts which share characteristics of the Internet (for example, open source development). An ecological perspective will also be applicable to the next new invention that is incubated in isolation from the market, whether this invention is the next Internet or the first of some new technological species.

There are also pragmatic implications to our research. In the case of Internet standard making, the forces that were at work in the creation of the Internet are still present. Even after the birth and death of many different standard-making institutions, the original ethos of the Internet often prevails among both officers of these institutions and outside observers. Institutions formed a long time ago can refuse to legitimate standards and endorse others, thereby keeping alive the spirit of the Internet.

Ecologies are fragile; small changes can produce unexpected results. It is clear that many of the actions we described occurred only because Internet standards are designed and debated in numerous institutions with overlapping mandates. Without the overlap, there would be no freedom of movement, and standard makers would behave differently. Changing the bylaws of even one institution might disturb the ecology, for bylaws help define the participants' range of possible moves.

Eliminating the multiple-institution system might make standard making faster, but it might also let cumbersome designs pass through, in the same way that heavily amended bills pass through legislatures. This should be kept in mind as governments press for control of the Internet (e.g., UN Working Group on Internet Governance 2005). The push for shared international ownership of the Internet could result in a legislative governance structure. To say, as the UN Working Group did, that the governance will be democratic is not enough; its exact mechanisms need to be thought of in constitutional terms.

Participants in the standard-making process have found ways of preserving the values that prevailed at the creation of the Internet. These participants use the product of their labor, the Internet itself, as a way of maintaining vigilance and expressing opinion. Inertia is currently working in their favor. But in order to preserve the status quo, still greater vigilance is necessary, as even well-intentioned changes to Internet governance could have unanticipated consequences for the current standard-making ecology.

There is an alternative to defensive vigilance: invention, so that another community can form, spawning new institutions for participants to rally around. As with the Internet, incubated ideas hatch, then live their lives. An ecological approach suggests we should keep on conceiving.

Glossary

ASAP	Asynchronous Service Access Protocol
BPMI	Business Process Management Initiative
BPML	Business Process Modeling Language
BPEL(4WS)	Business Process Execution Language (for Web Services)

[9]For example, in 2005, DARPA's Advanced Technology Office was funding through its "Control-Based Mobile Ad Hoc Network Program" (http://www.darpa.mil/ato/solicit/cbmanet/) and NSF was funding through its "GENI (Global Environment for Networking Investigations) Initiative" (http://www.nsf.gov/cise/geni/).

CDL	Conversation Definition Language
DARPA	Defense Advanced Research Project Agency
ebXML	Electronic Business XML
EDI	Electronic Data Interchange
ETSI	European Telecommunications Standards Institute
FDL	IBM FlowMark Definition Language
HTTP	Hypertext Transport Protocol
IETF	Internet Engineering Task Force
NSF	National Science Foundation
OASIS	Organization for the Advancement of Structured Information Standards
OMG	Object Management Group
REST	Representational State Transfer
RFC	Request for Comment
RFP	Request for Proposal
RosettaNet	Manufacturing industry consortium named after the Rosetta Stone
SGML	Structured Generalized Markup Language
SOAP	Simple Object Access Protocol
SWAP	Simple Workflow Access Protocol
TC	Technical Committee
TCP/IP	Transmission Control Protocol/Internet Protocol
3GPP	Third Generation Partnership Project
UN	United Nations
WfMC	Workflow Management Coalition
Wf-XML	Workflow XML
W3C	World Wide Web Consortium
WS-CDL	Web Services Choreography Definition Language
WSCI	Web Services Choreography Interface
WSCL	Web Services Conversation Language
WSDL	Web Services Description Language
XML	eXtensible Markup Language

Sources

In our efforts to understand the activities associated with Web services choreography standard making, we looked at several thousand documents. The most important sources were the minutes and discussions of the standards organizations. We looked at the WfMC meeting minutes for the following dates (bold dates are meetings that were attended by one of the authors): 02/28/94, 05/26/94, 08/05/94, 11/10/94, 02/22/95, 06/14/95, 08/11/95, 11/08/95, 02/09/96, 05/13/96, 07/31/96, 10/30/96, 03/10/97, 05/21/97, 08/13/97, 10/20/97, 02/04/98, 05/08/98, **07/24/98, 10/08/98, 01/28/99, 04/14/99, 07/01/99, 12/01/99, 03/07/00, 06/12/00, 09/06/00,** 01/23/01, **05/03/01, 10/08/01, 03/03/02,** 06/24/02**, 11/11/02, 03/07/03,** 06/23/03, 10/27/03**, 03/09/04, 06/21/04**, 10/11/04, **05/17/05**. In addition, we looked at archived WfMC mailing list postings from 1996 onward. Data was drawn from W3C WS-CDL meeting minutes for the following dates: 03/13/03, 06/18/03, 09/15/03, 12/17/03, 05/11/04, 08/04/04. We referred to OMG documents from the following dates: 01/14/97, 08/29/97, 05/29/98, 07/29/98. We consulted IETF attendance sheets and meeting minutes for the following dates: 03/30/98, 08/24/98, 12/08/98.

Online, we read the postings to the IETF SWAP discussion forums in their entirety (http://lists.w3.org/Archives/Public/ietf-swap/) as well as those to the W3C choreography group (http://lists.w3.org/Archives/Public/public-ws-chor/) and the OASIS ASAP and WS-BPEL groups (http://www.oasis-open.org/committees/tc_home.php?wg_abbrev=asap and http://www.oasis-open.org/committees/tc_home.php?wg_abbrev=wsbpel). We also looked at the W3C patent policy working group documents and mailing lists (http://www.w3.org/2001/ppwg/), and researched the bylaws of the other standards groups. We asked questions, sometimes in person, sometimes over e-mail, of several of the participants, to triangulate memories and causes; these participants included Gregory Bolcer, Christoph Bussler, Fred Cummins, Betsy Fanning, Dave Hollingsworth, Rohit Khare, Frank Leymann, Jon Pyke, Keith Swenson, and Wolfgang Schulze.

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Appendix

Bylaws of Different Standardization Organizations

	IETF	W3C	OASIS	WfMC	BPMI.org	OMG	RosettaNet
Structure							
Date founded	1986	1994	1993	1993	2000	1989	1998
Date merged					2005		2002
Parent	IESG and IAB (at founding)	MIT, ERCIM, Keio			OMG (from merger)		GS1 US (from merger)
Membership	Individual	Corporate and individual[1]	Corporate and individual	Corporate and individual	Corporate and individual	Corporate	Corporate
Membership levels	1	2	3	5	1	6	5
Annual fees	$0	$5,750 - $57,500	$250 - $13,500	$500 - $3,500	$2,500	$500 -$70,000	$375 - $50,000
Group organization	Working groups with oversight	Working groups	Committees with working groups	Working groups with oversight	Working groups	Task forces with oversight	Working groups
Governance	Not incorporated	Not incorporated	Incorporated	Not incorporated	Incorporated	Incorporated	Incorporated
Work Organization							
Working Group Formation	Formalized process, approval	Formalized process, only within current W3C activities, approval	Formalized process; maximum decision cycle is 15 days	Ad hoc, not regulated by bylaws	Not documented	Ad hoc, chartered by Domain or Platform Technical Committees	Ad hoc, approved by RosettaNet board
Topic Selection	Ad hoc, as long as it fits in one of the existing IETF areas	Ad hoc, as long as it fits in one of the existing W3C activities	Ad hoc	Determined by two-thirds majority vote	Predefined areas	Ad hoc	Oriented along RosettaNet PIPs
Participation Rules	None specified	2 out of 3 meetings should be attended, enforcement is left to WG chairs.	2 out of 3 meetings have to be attended	None specified	None specified	2 out of 3 meetings have to be attended, specified only for AB	Members are required to staff at least two working groups per year
Voting Rights	IESG members	Advisory Committee members	Members in good standing	Members in good standing, full and associate in all cases	Corporate members only	Members in good standing, registration required	Council members only
Implementation	Precondition for “Draft Standard” and “Internet Standard” designation	Not required: call for Implementations is optional	Not required	Not required	Not required	Required within 12 months, precondition for “Available Specification” designation	Not required

	IETF	W3C	OASIS	WfMC	BPMI.org	OMG	RosettaNet
Standards Publication							
Standardization Process	Formalized	Formalized	Formalized for revision	Not formalized	Not formalized	Formalized	Not disclosed
Specification Levels	3	4	2	2	2	4	Not disclosed
Intellectual Property Rights (IPR)							
IPR in Standards Specification	IETF style[2]	W3C license[3]	IETF style	Jointly owned by WfMC members	IETF style	Disclosure required	Have to be assigned to RosettaNet
IPR Covered by Policy	Patents, copyright	Patents, trademarks, copyright	IETF style	All intellectual property rights	IETF style	All intellectual property rights	Patents, copyright
IPR Licensing	Licensing on reasonable and nondiscriminatory terms; terms must be specified	Royalty-free license required	IETF style	Royalty-free license required	IETF style	Licensing on reasonable and nondiscriminatory terms	Royalty-free license required

[1]W3C does not support individual membership, but individuals may be invited as experts to participate in working groups.
[2]IETF requires disclosure of IPR claims and requests licensing on reasonable and nondiscriminatory terms.
[3]W3C requires a royalty-free licensing of intellectual property that is covered by a standards specification.