practices into organizations. However, an implicit expectation of Enterprise2.0 is the viral grofigurewth and enormous collective action and constructions that might be possible, but this expectation is not easy to meet (e.g., [4, 10]).

We developed and deployed Mail2Tag, an enterprise social software system for organizational information sharing. The design of the system builds on the ever-present use of email as a fundamental mechanism for sharing. By enabling knowledge workers to use freeform tags as addresses in an email, it leverages existing email practices to promote bottom-up folksonomy-based organization of the knowledge shared without the need to install any special email client. Studying the deployment, we wondered: How successful was Mail2Tag in being adopted? What criteria and comparisons should be used to evaluate its success?

Based on two years of Mail2Tag deployment, we have found that answering these questions is actually quite difficult. The first issue is that an organization's management often expects 100% adoption. Their comparison point is often the popularity of email, which is expected to be pervasive and attended to by all users [34, 9]. Email is now essential and adopted for a wide variety of purposes [9]. However, not all tools fit into work practices as pervasively as email. Second, the related literature shows that many volunteer-based contribution systems based on Web2.0 technology have similar contribution adoption rates, and in the range of 2-15% adoption rate (e.g., [4, 10, 13, 32, 38]). Ironically, this is consistent with power law adoption curves from consumer sites, where the minority (10-20%) of the users contributes the majority (80-90%) of the content (e.g. [1, 21]). With Mail2Tag we found adoption rates equivalent or slightly better than the current best cases [10, 32]: e.g., 17% of the employees contributed some content and 46% accessed some content at least once. Thus we ask if these best cases of 10-20% contribution rates in organizations are to be considered success stories.

In this paper, we use the Mail2Tag system and its deployment in an organization to understand how to measure the successful adoption of enterprise collaboration systems. Our approach is as follows:

- First, we describe our system's usage data, including production contribution as well as reading or 'lurking' behaviors to show the different levels of engagement. We show that the adoption story for different users leads to a stratification from readers to leaders [30].
- Second, we conducted an adoption survey with users across various degrees and forms of system use and measured the impact of perceived usefulness, ease of use, and social influence on system use. We present our findings about what predicted adoption in our study.
- Third, assuming that there is a natural division of labor in the organization, one would expect the functionality of an information sharing system to appeal to specific roles. We show how the brokerage in the sharing network correlates with use of the system. That is, the way features of the

system fit into workers' practices matters a great deal in the kind and level of adoption that we can expect by different individuals.

We discuss the related literature on adoption and then briefly describe the Mail2Tag system. A detailed system description is beyond the scope of this paper, which focuses on the adoption issues (see [25] for more system information). Next we describe a 20-month deployment and detail the analysis of multiple measures of system use during the deployment. We conclude with implications for adoption of information sharing tools in organizations.

Related Work

Adoption data of Web2.0 and Enterprise2.0

We report here findings about adoption for Web2.0 tools in the consumer domain and for similar Enterprise2.0 tools [24, 4].

Numerous success stories of adoption for Web2.0 tools have emerged in the consumer space. By significantly lowering the costs for users to share content and collaborate [26], several of these tools have succeeded in recruiting very large populations of users from the public Web. Evident successes include tools such as wikis (e.g., Wikipedia is edited by 300,000 users monthly), sites for sharing videos, photos or bookmarks (e.g. YouTube.com has 2 billion views daily), blogs and forums (e.g., Yahoo Answers has 15 million visitors daily), social networking sites (e.g., Facebook has 500 million users), and microblogs (e.g., Twitter has 190 million unique visitors monthly).

Organizations and researchers are now exploring how similar successes can be replicated in the context of organizations. A key question is *whether the processes that drive adoption in organizations are the same as in the consumer space*. Multiple researchers have described the participation rates for Web2.0 tools with power law or Pareto distributions (e.g., [1]). This distribution exhibits a narrow head and a long tail: that is, a minority of the users, or power users (the narrow head), generates the majority of the contributions; the majority of the users (the long tail) generates the minority of the contributions. This trend in the contribution rate is consistent across several Web2.0 communities: Wikipedia editors [21], Usenet discussions [36], and social tagging systems [15]. A first challenge for Enterprise2.0's success is to create the conditions so that the system is sustainable over time. A second challenge is to make sure that the tools reduce costs or increase benefits to a sufficient extent so that a critical mass of users is led to "inhabit" the head of the distribution.

While there is hope that Enterprise2.0 will replicate consumer space adoption, results suggest that Web2.0 tools recently deployed in organization are affected by low contribution rates. The rates range between about 2-15% and vary widely

by factors such as the specific tool, the organization and its size, and culture. The overall rates of contribution reported for corporate blogs in large companies such as IBM [10, 14] and Microsoft [11] is about 3%. Similarly, about 2-4% of the IBM workforce visited the Beehive social networking site monthly, while about 15% of the workforce had registered over two years [32, 13]. Brzozowski and collaborators [4] found that the participation rates in social media at HP varied widely depending on the country (10% in UK vs. 1.9% in Japan and Mexico), job function, group, and the manager's activity in the system. For example, among HP employees, the discussion forums were more popular than blogs and wikis (10 and 28 times more popular, respectively) [4]. Other statistics about corporate wikis from MITRE [19], IBM [2], and Microsoft [17] suggest that while many employees report that they used wikis, very few are those who actually contribute.

Studies of adoption: key factors

Pioneering case studies of adoption of collaborative systems in organization were conducted on electronic calendars [12], Lotus Notes [27], and email [23]. Ehrlich [12] and Grudin [16] found that a key limit to adoption of electronic calendars in an organization is the disparity between those who do the work and those who get the benefit. In her study of Lotus Notes, Orlikowski [27] observed that organizational factors (e.g., policies and procedures) and individual factors (e.g. impact on individual productivity) are likely to "shape the adoption and early use" of collaborative systems. Studying email when it was still new for organizations, Markus [23] observed that the adoption and use of a new medium is affected by social factors of sponsorship, socialization, and social control.

Palen and Grudin [28] reviewed prior work on adoption and drew two general points. First, while there is consensus that upper management advocacy is a key top-down facilitator, prior success cases suggest that the bottom-up factors of having evangelists and peer pressure are equally important for adoption. For electronic calendar the peer pressure was channeled by the interface and by being integrated with email, as this reminded non-users of the use by others and benefits they might be missing. A similar condition was sought in the design of Mail2Tag.

A second general point proposed by Palen and Grudin [28] is that the term adoption has been used with different meanings in different research communities. For researchers of Management Information Sciences (MIS), who have an organizational focus, 'adopt' means 'acquire' or 'decide to use', at the level of the organization. Differently, for Human-Computer Interaction (HCI) researchers, who have a user-centered focus, 'adopt' means 'begin to use', at the level of the user. The Management Information System (MIS) perspective, which is closer to a managerial view, has tended to use more the term in the sense of acceptance, which assumes lack of choice (see Technology Acceptance Model (TAM), Davis [8]). For these researchers it would be possible to say a system was

adopted or accepted even when there was little usage. In contrast, for HCI researchers adoption, which in this case assumes presence of choice, implies that it was deliberately used at the user level. This discrepancy of meaning will gradually disappear as the theoretical models proposed in the context of MIS research are applied to study the actual usage. The results on adoptions presented in this paper, together with a few recent studies [7], are initial research efforts testing these theoretical models.

While HCI researchers have focused on usability and user choice, MIS researchers have found repeatedly that perceived usefulness is an even stronger predictor of use for systems. Davis [8] conducted two studies on the acceptance of technology. One of these pertained to the use of email and a file editor at a large IBM laboratory in Canada. In both studies, he found that perceived usefulness was a better predictor of system use than perceived ease of use.

MIS researchers have proposed revised or competing models to TAM that better predict acceptance and usage. Venkatesh et al. [33] developed the Unified Theory of Acceptance and Use of Technology (UTAUT) model. UTAUT considers four key factors of performance expectancy, effort expectancy, social influences, and facilitating conditions, as potential predictors of intention to use and actual use [33]. The first two factors correspond to the factors of perceived usefulness and perceived ease of use considered in the earlier TAM model [8]. Using data from two organizations Venkatesh et al. showed that performance expectancy continued to be the strongest predictor and that UTAUT outperformed eight existing adoption models [33].

In a few more recent studies, researchers have started examining the distinctive characteristics of the Enterprise2.0 deployments and identifying factors that may be limiting contribution rates on tools such as corporate blogs and wikis. These factors include high costs for contributing and maintaining content [19, 17], time [20] or attention [38], the large amount of irrelevant or outdated content [20, 17], or the limited relevance of the content for business goals [20], or other factors such as not knowing how to get started [20, 10], not wanting to share unfinished work or disclose potentially sensitive information [19]. Viewing Enterprise2.0 as a new domain, researchers are now experimenting with ways for facilitating adoption. For example, Blog Muse [10] increased the adoption rates compared to regular blogs. Our study and deployment are part of this ongoing effort.

Finally, studies have pointed to factors inherent to structures of the social network within organizations, which may affect (or be affected by) the use of tools for knowledge sharing. Knowledge sharing is effective and productive when there are proper network conditions and roles [3]. At the level of cohesive groups (or sub-network intragroup [6]), some advantages for the workers are obtained by bridging with like-minded people. There are advantages for some workers to bridge across expansive groups, or sub-networks [6]. Burt [5] proposes that, although bridging incurs extra costs in the short term, the people who bridge

structural holes have a long-term advantage of exposure to greater diversity of information and know-how. The brokers have opportunities to discover greater amounts of useful, productive knowledge. Thus having the right proportion of active brokers is functional to the productivity of workers in an organization [5, 29]. Information brokers represent a special class of users to be accounted for when reporting on the adoption of a knowledge sharing system.

Studies of participation and motivation

Several HCI researchers have also focused on the factors that affect participation or the motivations to participate. This new research, however, has not been connected yet with the prior work on adoption. Preece and Shneiderman [30] have studied the how users can move between different degrees of participations, from reader to leader, in an online community. Zhang [39] defines ten design principles that take into account people's motivations for usage based on known psychological, cognitive, social, and emotional sources of motivation. Lampe et al. [22] describe an empirical study of participation in a social website designed for sharing user-generated content. They found that participation was predicted by social motivations such as the desire to make connections. It was predicted by the value that individuals derive from providing informative content but not by social interaction. Moreover, the main barrier to participation was motivational and not due to usability, even though users had initially anticipated that it would be.

The Mail2Tag System

While email remains the channel of choice in the enterprise, keeping email interesting and relevant, reducing the amount of information noise, and enabling efficient reuse are growing challenges in knowledge work organizations. The system investigated in this research, Mail2Tag, was designed to address these challenges. In Mail2Tag the user can share by simply sending an email message with the content to be shared, and addressing the message to one or more topic-specific keywords. For example, one might use the address, bizdev@share.X.com, for referring to information related to the topic of "business development" (see Figure 2, top left). Thus, the content of that email is 'tagged' by the keyword 'bizdev'. Any mail may have multiple tags attached to it in this manner in the 'To' or 'CC' fields of an email using any client. Any keyword can be used on-the-fly, as in a social tagging system.

Mail2Tag works as an independent mail server running inside the corporate network (e.g., a host called share.X.com, where X is the company's domain name). A brief overview of the system follows:

- Workers send email messages with 1 or more tag addresses (tag@share.company.com) in the TO or CC fields of the message and, generally, also email addresses of colleagues who may be interested.
- This causes the Mail2Tag mail server to selectively receive theses topic-related email messages, parse the address fields, and sets up subscriptions between the tags, the message content, and the people involved. The content posted into the system can be anything expressible as an email message, including attachments.
- Then, these published messages can be searched, viewed, and edited via a web2.0 interface (Figure 1, bottom). The interface gives different views of the posted content and is available within the company network only (at http://share.company.com). The system allows sharing across the entire company or within groups that an administrator can easily create upon demand. The interface support functions to add more tags or people to an existing message or to reply to it via the web browser rather than via email.
- Digests of recent activities are periodically sent to users (Fig. 1, top right). The frequency is based on their preferences and their activity in the system.
- The workers who send or receive a message are implicitly subscribed to the message's tags by the system as they send or receive a tagged email message. They can also explicitly subscribe or unsubscribe to topical tags or specific messages (as for a discussion thread) via the web interface.

Thus the system augments existing practice of sharing information via email by allowing a tag address in a message. While enabling easy publishing and re-finding of this information, the system does not induce people to send additional emails other than those that they are already sharing and the periodic digests that the system sends (the user can regulate the frequency of these digests).

The different features leave traces of activity in the system logs that are the primary focus of this paper. Features that describe content consumption, or 'reading', include clicks on the website, feed requests of recent change, and receiving a tagged email. Features for contributing (or content production) include emailing content into the system, add tags in a form field directly on the website, and using the 'social' website features such as thanking, commenting, administering, and editing shared content. These features produce a range of activity for which logs are collected for measuring adoption.

Mail2Tag Deployment and Setting

Mail2Tag was deployed for 20 months in a research center with about 300 employees. Staff includes scientists, engineers, managers, support staff and administrators, and a temporary population of about 20-30 interns per summer.

There are three tiers of management in the company: executive, labs, and area or team levels. Each area or team has 4 to 17 people, and each lab has 4 to 8 areas

or teams. Almost all employees are located within a single three-floor building. There are two hardware labs located on the ground floor, two software labs groups on the middle floor, and business and operations teams on the third floor. Mail2Tag was introduced, promoted, and administered by one area or team in a software lab (we refer to them here as the "first adopters"). The system became available for limited use in December 2008 by a small team of users. Invitations for general use were announced in June 2009 and a second release of the system with interface changes and rebranding of the server to its permanent name, share.X.com occurred in August 2009. The technology was announced via word of mouth and presentations at lab meetings (one for each lab or business groups).

Figure 1 (Top). A contribution is sent to the system via email (left). Digests are received from the system in email (right). (Bottom) A web interface gives organization-wide access to posted content (see also [25]

Measures of Adoption

We used both quantitative and qualitative measures to examine people's engagement with Mail2Tag, based on activity log data, survey response data, and

direct feedback from interviews with users. Using these data, we applied a number of analytical methods to assess adoption from different perspectives.

Basic statistics of use: We logged postings of tagged emails and web site use. People have unique corporate email addresses. Accesses to the web site are made from computers with traceable unique IP addresses associated with the owner of that computer. Figures 2 and 3 show basic statistics for posting and clicking data, which reveal the production and consumption behaviors of users in the system.

Growth of the Mail2Tag social graph over time: The posts and clicks form a set of relationships between people (those producing the time-stamped, tagged content and those consuming that content by receiving a tagged email or clicking on the web page produced by an email). These form a directed graph with one-way connections of producers of information to consumers of that information (Figure 4, left, where the nodes represent aggregation of activity at the area / team level). Consistent with prior research on social capital of teams [31, 18], we mostly aggregate data at the area or team level, as this grouping is very cohesive in terms of physical location of people, their topics of interest, and work assignment. We may examine the growth of this graph over time to get a view of diffusion of adoption of Mail2Tag across the company.

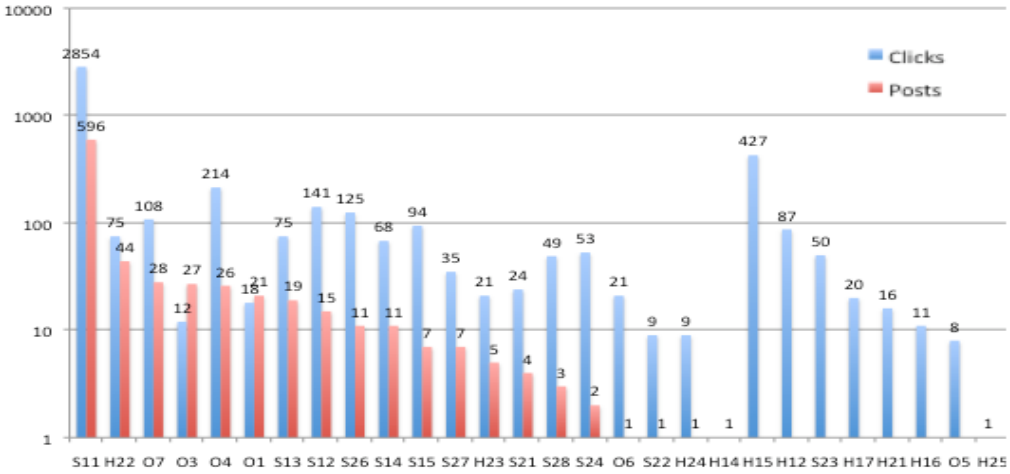

Figure 2. Frequencies of posts (production) and clicks (consumption) by team (x-axis)

Using the graph that reconstructs the information flow via Mail2Tag (Figure 4, left), we can calculate the centrality of the nodes in that graph. We used the NetworkX open source network analysis package (http://networkx.lanl.gov) to compute betweenness, degree, and closeness centrality. NetworkX defines the betweenness of a node as the fraction of all shortest paths that pass through that node; degree of a node as the fraction of nodes it is connected to; and closeness of a node is the reciprocal average distance to all other nodes.

Survey of Technology Acceptance and Comparison to Actual Use: We used the UTAUT survey [33], an established MIS questionnaire to measure the

adoption of systems in organizations and key known predictors. Here we apply it in the context of Human-Computer Interaction research. The survey provided us with self-reported measures such as Behavioral Intent (to use Mail2Tag) and possible predictors of adoption such as usefulness and ease of use of Mail2Tag.

We also gave the participants a small survey for feedback on specific system features. That is, combining the UTAUT and this small survey we evaluated both the adoption of the entire system ("I would find the system useful in my job") as well as at the use of specific features, such as the posting or browsing functions.

We sent the survey to 111 people, who represent about 47% of the active workforce at the time of the survey. This was a stratified sample composed by four strata, at four levels of activity (as measured by global use scores described below). Forty-five of the workers in this sample responded to the survey (i.e., 41%), including sets of employees from each of the four classes:

- Frequent users (5>score>14): 11 respondents.
- Occasional users (2>score=>5): 11 respondents.
- Rare users (0>score=>2): 13 respondents.
- Non-users (score=0): 8 respondents.

Use Scores: We collected both behavioral (or actual) and self-reported (or perceived) measures of use. For the behavioral measures of use, we computed an ad hoc measure based on the adoption of the multiple features of the system. That is, we count the levels of diversity of people's usage of the system features. This measure allows for calculating a use score that is a more fine-grained and *quantitative* understanding of 'reader to leader' behavior. Reading features include clicks on the website, RSS feed requests, and receiving a tagged email. Production features include creating tags, using tags, and using the 'social' website features of thanking, commenting, and administrative features of the website. We scored people's participation by looking at log data across the seven reading and production features, scoring 0 for non-use of a feature, 1 for below median use of a feature, and 2 for above median use. Summing across the feature set results in scores ranging from 0 to 14 (Figure 6).

Also, as our self-reported (or perceived) measures of use we considered: the Behavioral Intention (BI) score obtained from the UTAUT survey (i.e., based on ratings of questions such as "I intend to use the system in the next 12 months") and monthly use reported in response to the question "How many times have you used share.X.com per month (on average)?" (a survey question that we added).

Observation and interviews of exemplary use-cases: Finally, through observation and 20 interviews with users we also examined different usage scenarios of Mail2Tag that people worked into their current work practices.

Results on Adoption

The measures above allow analysis of adoption from different viewpoints.

Basic Overall Use Statistics: Posts and Clicks

We identified 295 workers who could have accessed system over 20 months based on logs and the company organization chart. Among these 295 workers, we find that 137 people have clicked on the web site at least once (46%) and 49 have posted some content via email (17%, 920 messages with 579 tags). 9% of the workers contributed 3 or more posts, which is the median level of individual use.

Aggregating the data at the area or team level, Figure 2 above shows the post and click data sorted by decreasing level of production, side by side with the consumption. The data is shown using a log scale, reflecting the power law nature of contribution. Toward the right of the figure we see groups of people consuming content, but not posting themselves. These readers might be considered 'lurkers'.

Figure 3 shows the results about adoption by feature. We find that the most prevalent feature used were those for information consumption: Clicks on the web site, receiving a tagged email. 46% of all people clicked on a piece of content in Mail2Tag at least once. About production features, 17% of people posted content at least once. Other features such as the social web features are below 10% use. Overall, the adoption rates of the Mail2Tag system appear equivalent or slightly better than other cases of similar systems deployed in organizations [10, 32].

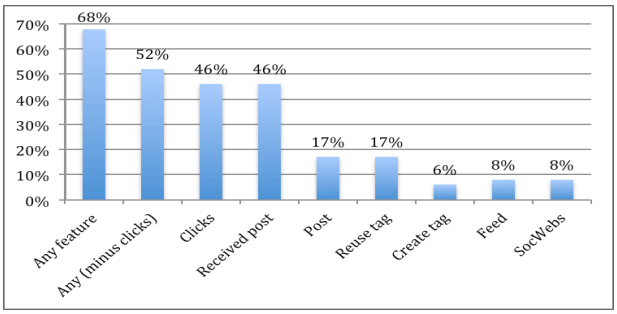

Figure 3. Percentage use by feature is shown for the 295 employees.

Growth of the Social Graph over Time

We also analyzed the activities of posting and clicking through a social graph to visualize underlying social patterns. This is a directed graph connecting those who produce information with those who consume it. Figure 4 (right chart) illustrates the accumulated exchanges over the 20-months deployment.

Three observations emerge from this graph (Figure 4). First, we observe some cluster of nodes illustrating groups with greater sharing activity amongst themselves than with others. See the blue and green nodes indicating the two hardware labs, on the first floor. This clustering effect is obtained using a minimum crossing graph layout algorithm, which computes shortest distance optimization (www.graphviz.org). Second, we notice that the labs that have

connections throughout the network, as the two software labs in yellow and orange, tend to get pulled in different directions and become intermixed with other labs. Third, the management and operations teams take a central role among the labs as shown by the central position of the gray nodes in the graph.

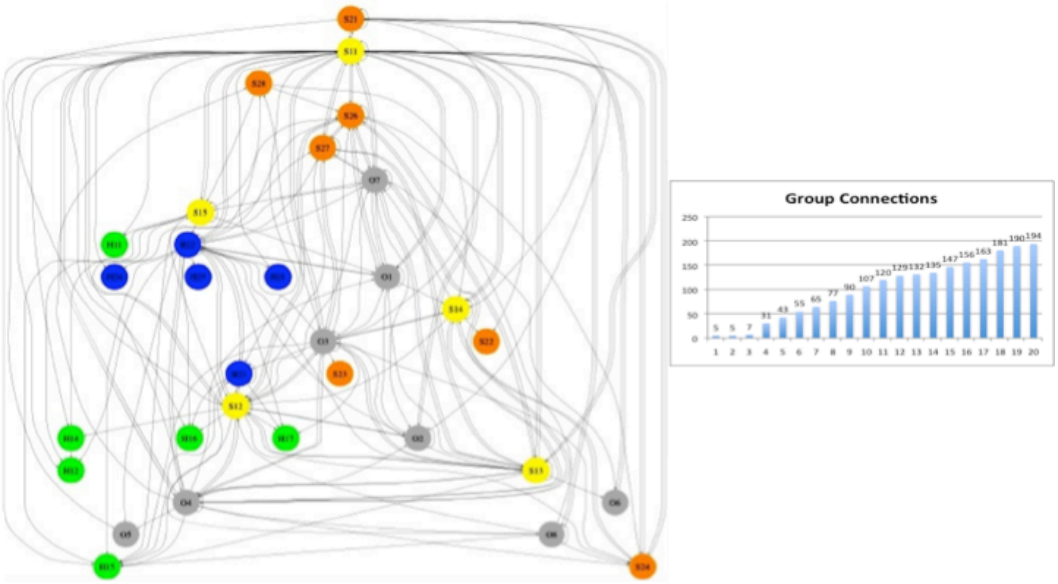

Figure 4. (Left) The post and click data forms a directed graph of inter-group connections observed over 20 months. Colors indicate teams belonging to one of the four labs, with management teams (e.g., Marketing, Human Resources) shown in grey. (Right) Cumulative frequencies of exchanges between teams over the 20 months of deployment is shown.

The rate of growth of directed connections between groups is given in the inset graph of Figure 4. We see a slow start typical of social system use, with a steady rate of group connections formed through efforts to promote the technology.

This graph also gives us a way to quantify the reader or lurker activity as a percentage of the network connection activity. Each arc in Figure 4 is created by one or more posts or clicks. If we separate the post and click contributions, we can see those arcs produced only by click behavior (i.e., one group clicking on the posting made by another group). We observed a monthly average of 3.2% of the arcs in the network are created by clicks or pure reader activity (with SD=2,1% and range 0-7.7%). If we count the total number of arcs touched by click activity monthly, the average is 12.7% (SD=4.3% and range 5.9-23.8%).

We look further into network activity by considering centrality measures of the graph. After a 20-month period we observe a flattening out of degree and closeness centrality across the groups, indicating formation of different hubs of activity. The primary brokerage may be seen in the betweenness centrality, with ‘first adopter’ departments (S11 and H22) dominating this measure, but decreasingly so over time as the other groups gain in betweenness (Figure 5).

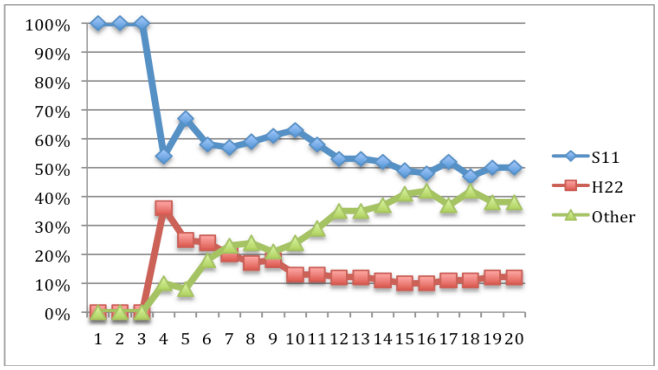

Figure 5. Betweenness centrality of early adopter teams (S11, H22) decreases as others increase.

Survey of Technology Acceptance

We measured adoption using two subjective measures, namely frequency of monthly use and behavioral intention (BI) to use Mail2Tag in the next 12 months, and two objective measures, namely feature use score and a score of use that excluded clicking actions (Table 2, rightmost columns). Monthly use correlated significantly with behavioral measures (Global use: $r=.55$, $p<.001$, Use [no clicks]: $r=.60$, $p<.001$). This supports the concurrent validity of these adoption measures. Table 1 shows the distribution of employees by level of use (Global use score). The score ranges from 0 (non-use) to greater levels of use, as more features of the system are adopted and added into an individual's use score.

Freq	97	64	53	20	12	18	9	5	5	6	1	2	2	2	1
Score	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14

Table 1. Employee distribution by Global use score. (N=295) based on uses of system features.

The UTAUT questionnaire [33] measured four potential predictors of adoption:

- Performance Expectancy (PE) (see Perceived Usefulness in [8])
- Effort Expectancy (EE) (see Perceived Ease of Use in [8])
- Social Influence (SI) (e.g., influence from colleagues or management)
- Facilitating Conditions (FC) (e.g., required knowledge, assistance)

The questionnaire measured intended use or Behavioral Intent (BI), with three questions, and we added a new question to measure actual monthly use.

We run a factor analysis with the responses to questions measuring the four potential predictors (PE, EE, SI, FC) and the intended use (BI). We used the factor analysis to verify that the questions loaded sufficiently on each factor, see [8, 33]. We extracted a single score for each factor, while ensuring that the questions with higher loading on that factor had higher impact on the score. As

shown by Cronbach's alpha values in Table 2 (second column), the reliability analysis confirmed that the clusters of questions that measured each of the four potential predictors and intended use (BI) were well inter-correlated.

To establish if any of these four factors were good predictors of use, we run correlation and regression analyses. As shown by the Pearson correlation values in Table 2 (PE' row), Performance Expectancy (PE), was the only factor that significantly correlates with and predicts intended (BI) and actual use (Monthly use, Global use, Use (no clicks)). Table 3 shows the results of the linear regression analysis.

About Effort Expectancy (EE), or perceived ease of use, while the ratings for this factor were higher (average score: 4.9, sd: 1.08) than for Performance Expectancy (PE), or perceived usefulness (average score: 3.6, sd: 1.18), its correlation with adoption was lower than between PE and adoption (Table 2). Similarly, the regression analysis did not exhibit a significant effect of this factor as for PE.

In the regression analysis, multiple alternative methods were used to select the predictors in the model (stepwise, backward, forward selection). All methods led to the same results: PE was the significant predictor and the other three variables were excluded. Among the response variables, BI and global use showed highest R-values for the model and monthly-use lowest (Table 3). While EE and SI have some correlation with some responses (0.4-0.5, Table 2) they do not reach significance as predictors in the regression.

Overall, these results are consistent with prior TAM findings [8, 22, 33].

		Predictors of use				**Self-reported or behaviors of use**			
	Alpha	**PE**	**EE**	**SI**	**FC**	**BI**	**Monthly use**	**Global use**	**Use (no clicks)**
PE (Perf. Exp.)	0.86		.59**	.52**	0.21	**.83****	**.37***	**.40****	**.33***
EE (Effo. Exp.)	0.90			.44**	.51**	.46**	0.18	**0.30***	0.19
SI (Soc. Influ.)	0.73				0.16	.51**	0.04	0.18	0.12
FC (Fac. Cond.)	0.52					0.15	0.11	0.06	0.13
BI (Beha. Inte.)	0.97						0.25	**0.39***	**0.33***
Monthly use								**.55****	**.60****
Global use									**.97****

Table 2. Pearson correlation. The r values marked with ** or * indicate correlations that are significant at the p<0.01 or p<0.05 levels, respectively (2-tailed test).

	BI		**Monthly**		**Global use**		**Use (no clicks)**	
	R-sq.	**Beta**	**R-sq.**	**Beta**	**R-sq.**	**Beta**	R-sq.	Beta
PE	**0.69**	**0.83*****	**0.10**	**0.32***	**0.16**	**0.40****	0.11	**0.33***

Table 3. Linear regression: Performance Expectancy (PE) was the only significant predictor. Beta values marked with ***, ** or * indicate correlations that are significant at the p<0.001, p<0.01 or p<0.05 levels, respectively.

The data did not violate assumptions of independence for regression analysis for any of the models run. The potential problem of multicollinearity among the predictors was ruled out based on several diagnostics: the values for Variance Inflation Factor, VIF<2.0 (i.e., smaller than 4), tolerance >.6 (i.e. bigger than .01), and Condition Index<2.7 (i.e., smaller than 15).

Adoption for Users with Different Social Roles

We find that knowledge workers who are more central in the network or who act as brokers are also those who show the greatest diversity in their use of Mail2Tag. This seems consistent with prior findings [5, 3]. Focusing on the users only, we analyzed the association of adoption measures with network metrics (closure, betweenness, and degree centrality), which characterized the positions of the users in the Mail2Tag social network. We found that betweenness had the strongest association with global use (betweenness: r=.75, p<.001) while betweenness and degree centrality had stronger association with intended future use (betweenness: r=.54, p<.001, and centrality: r=.48, p<.005). The survey-based score of Behavioral Intention (BI, which correlates with actual use, Table 2) correlated the highest with betweennes (r=.55, p<.001), which is an indicator of brokerage role. Both this role and the usage scores are affected the by job roles: 20% of top-25 scoring users are managers (score greater than 6, see Figure 6), while they compose only 10% of the total workers with access. Overall this shows the importance of being in a brokerage position, which is strongly associated with actual use and intent to use (BI from survey). Also, this role is related the user's job function (20% of top-25 users are managers).

Adoption at the Level of Specific Functions

In addition to measuring overall system adoption, we also collected data about the use of (or willingness to use) specific features of the system, such as posting a new message or replying to a prior message into the system (production) and interacting with the web interface (consumption). This allowed us to analyze more in detail the actual use or perceived need for specific functions of Mail2Tag.

On the feature of posting a message, we collected responses from 41 participants, of which 54% had not used it, and 12% and 34% had used it once or more times, respectively. Most reported using this feature for informing colleagues about useful information. Some reported sharing on generic topics, such as "conference announcements and article pointers" or "news-type items", while others preferred sharing on specific topics (e.g., "robotics" or "ethnography"). Among non-users, several emphasized that knowing if information is or will be relevant to other's would be critical for them to start contributing. They indicated that recommendations or clear visibility of others' interests would motivate them to post. Some reported being unaware of the

feature and a few noted that the presence of enough colleagues already in the system is another motivator.

Among the participants surveyed, about 18% had used the feature of replying to a tagged message. The motivations for using this feature were very similar to those of posting, namely, for sharing or informing. Differently, however, non-users seemed more apt to use this reply feature compared to initiating a thread themselves ("I probably would do this by default, if I had gotten emails this way."). Similarly, some non-users emphasized the need for providing relevant-enough content and reducing the current noise for them to start using the feature.

Regarding consumption, we asked participants about the use of the web interface feature. Among participants surveyed 11% and 46% had used it one or several times, respectively. The main reasons for visiting were monitoring and discovering information that was being shared in the organization. Several non-users of the website reported that they were not aware of it ("I didn't know that the web interface exists. I only occasionally received emails from the systems"), while others non-users did not feel the need for it since they had already enough sources of information. However, several non-users pointed, again, to the importance of having highly relevant information on the site for them to visit.

Mail2Tag Use Cases

Finally, use cases of people adapting Mail2Tag to their needs also informs us about adoption. We highlight two cases of unique appropriation of Mail2Tag.

First, several hardware teams have used the system for idea management. One 'grassroots' leader (an early adopter in a hardware group) introduced the system to those departments as a means for "documenting a business need or problem in 1-3 lines of free text, browsing through the recorded problems and get inspired (or tell a colleague), and searching (full text/tags) to see if one of your solutions fits a need out there". This 'problem matching' is an example of a unique appropriation for sharing within and across groups. It takes advantage of Mail2Tag's ability to serve ad hoc and transient group formation, that change as interests evolve.

Second, a group of employees who also speak German used Mail2Tag for an informal sharing in German. Content about events in the home country and issues relating to the expatriate experience are posted, usually in the foreign language. Other people not involved with that group would occasionally 'stumble upon' the foreign text and ask about it with curiosity. This use illustrates coexistence without interference among separate interest groups.

Discussion

Case studies have pointed to relevant factors facilitating or hindering adoption of new systems in organizations. Palen and Grudin [28] remind us that

management's sponsorship is a key top-down factor. However, for discretionary systems, versatile functionality and ease of use combined with adequate infrastructure, integration with email, and peer pressure have led to success. Brzozowski [4] found that peer pressure and feedback are good facilitators for workers' adoption of Enterprise2.0 systems. Extending these findings, our results from the 2-year deployment of Mail2Tag suggest that 'grassroots' systems for sharing may have their own adoption patterns in organizations.

We found that, even if our Enterprise2.0 system was discretionary and volunteer-based, its *perceived usefulness* was the key predictor of actual use, rather than its perceived ease of use or formal management's sponsorship. Related to the effect of perceived usefulness, is also our finding that the social role in the organization is likely to affect if the worker will see this type of system as useful and usable.

Taking Mail2Tag as an example, if we design a tool that is specifically attractive to brokers of information, then those are the people who will gravitate to it, and that could likely set a bound on the people who will be vigorous contributors. Brokers feel that it is part of their job to disseminate such information. We designed Mail2Tag as an organization-wide information-sharing tool. As a result, the functionality of our information sharing system appealed to brokers more than others. There is a complex relationship between the sanctioned job role individuals have in the organization (e.g., managers) and their actual social role in the network (e.g., brokers). In our deployment this relationship appeared to be at the heart of adoption. An implication for future deployments of Enterprise2.0 systems that support specific functions for the organization (e.g., sharing, awareness, or coordination) is that the adoption process could be scaffolded more effectively if the system is targeted to workers who hold *'relevant' roles*.

We find lurkers matter when assessing adoption. Readers (or 'lurkers') accounted for about ~12% of activity recorded in Mail2Tag (see similar results about Enterprise2.0 [13] and online communities [30]). Our findings suggest that in an organization there are distinct audiences for, or groups drawn to, the system who will exhibit different levels of participation. These observations raise questions.

How much effort does it take for going to the next level of participation and what is the process for allowing others to step up? Mail2Tag has a unique approach for bringing people into its network: via email (see also [28]). The contributors at lowest level of use (score = 1, Figure 6) made their first contact with the system by either receiving a tagged email or visiting the web site (e.g. via a intranet search). 22% of all the employees with access to the system are in this first level (64 users, Figure 6). Most users interact with the system via email. Then, it is the email digest received that draws some of the users over to the web

site, which has the other features that can be used. Designing this *ladder of involvement* may be very important for leading ‘readers’ to become ‘leaders’ [30].

How many brokers can realistically participate in the system? This is a management issue for the adoption process. The proportion among all the job roles that have information sharing as a critical function will set the participation level. One of our goals in Mail2Tag was leveraging the popularity of email use, but also helping 'un-silo' email for more effective information routing and reuse in the organization. We find it is mainly brokers (as identified by ‘official’ job role or individual predisposition to promote ‘grassroots’ sharing) who carry this forward by using our variant of email practice.

Finally, what are the goals a system is meant to address as use evolves? Mail2Tag was originally designed for 'information sharing'. However, we observed that while sharing is much talked about and an ‘obvious’ organizational objective, for knowledge workers it is a means rather than an end. In fact, we saw several bursts of activities in Mail2Tag when sharing, as-means, found a good match with specific ends or goals of groups of users: e.g. idea management or cultural groups with distinct interest. Thus, a system invokes a wider audience when it can be appropriated for a wider range of goals; e.g., as in the uses of ‘plain-old-email’. We note that such flexibility may also imply that reappropriation will contribute to information overload (e.g., as with keeping up with email). Past an initial phase when the priority is to evoke adoption, systems may need to transition into a later phase when the priority becomes limiting information overload. For this reason we designed adaptive digests, tracking interests in topics and tuning delivery.

We measure adoption by the numbers for use, the network structures elicited in an organization (for sharing), and accounting for the contribution from all users in relation to their organizational roles. Mail2Tag has made inroads in these areas but has room to grow. We would like to see more users involved in brokerage between groups. This will rely on awareness of features as it applies to daily routine. And that relies on promoting the end goals for brokerage as in idea management and the facilitating of community interest groups.

Conclusion

We developed and deployed Mail2Tag, an enterprise social software system for information sharing. We use its 2-year deployment as a lens to understand how to measure the adoption of an organizational sharing system. In response to the current need for common methods to compare adoption of systems across deployments [35], we provided an operationalization of how adoption occurs in one organization, what factors can affect it, and what measures can help us assess it. We presented a suite of measures: quantifying the role of lurkers; measuring the social graph over time both in reach and network structure (centrality);

explicitly checking for acceptance, as well as identifying criteria for extending participation; pursuing the acceptance of features; and combining the above with qualitative results about reasons for using the technology.

Our results suggest that 'grassroots' systems for sharing, such as Mail2Tag, may have their own adoption patterns in organizations. We find that perceived usefulness is a key facilitator and that users are drawn to different level of contribution depending on their roles in the organization. The functionality of our system seemed to appeal to one class of worker more than others; namely, brokers. We also find that lurkers matter when assessing adoption, since they account for a good deal of the activities recorded in the system.

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