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Trends in Mobile Computing within the IS Discipline: A Ten-Year Retrospective

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Abstract:

We analyze mobile computing trends in research and practice between the years 2000–2009 with an inductive categorization of 806 articles in nineteen leading academic, crossover, and practitioner outlets. We integrate this categorization with previous research in mobile commerce and e-business in order to provide the most comprehensive categorization to date. Using this categorization, we next investigate trends in the discussion and research on mobile computing. From these trends, we develop a comprehensive framework that addresses both where mobile computing research has been over the past ten years, but also areas of opportunity for future research. Results indicate research is required in the areas of: (a) IT value stream proposition (both within and outside the firm), (b) human-computer interaction (designing usable mobile computing systems), (c) legal/ethical issues surrounding mobile computing-enabled activities, and (d) organizational/societal impact and change precipitated by mobile computing technologies.

Keywords: mobile, wireless, ubiquitous, mobile computing, Information Systems (IS), mobile theory, mobile application, mobile technology

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I. INTRODUCTION

Diffusion of mobile computing technologies has accelerated since the turn of the century [Harald and Frank, 2001; Lee and Cho, 2007; Sunanda and Louis-Francois, 2005]. For example, in ninety-four countries worldwide, mobile phones surpassed fixed phones in 2000—at 20–50 percent market penetration, then accelerated to 60 percent–100 percent penetration by 2004 [Lee and Lee, 2009]. This diffusion led to an ever-increasing market segment for mobile applications. For example, 102 million mobile Internet subscribers currently sustain a growing $7.2 billion per year market segment [Mobile Marketing Association, 2009]. Aside from the obvious economic implications of this rapid diffusion are the individual, organizational, and societal impacts of these technologies, as well [Lyytinen and Yoo, 2002a; Scheepers and Scheepers, 2003, 2004; Gopal et al., 2006; Oliveira et al., 2006; Yao and Murphy, 2007].

The larger question raised by recent growth of mobile markets and diffusion of mobile technologies is, "Are we as a discipline witnessing a phenomenon that is fundamentally different from previous IS phenomenon?" As suggested by Lyytinen and Yoo [2002b] eight years ago, the mobile computing phenomenon does hold a unique set of challenges that should be of particular interest to Information Systems (IS) scholars. Because of the unique combination of infrastructure and services in three areas: (a) mobility, (b) convergence, and (c) mass scale, mobile computing holds the potential to significantly alter the interactions of individuals, groups, organizations, and societies. Also, as they predicted, each of these areas has increased in importance over the past ten years and will only continue to increase in the future.

First, computing is increasingly mobile. Applications once relegated solely to raised-floor processing labs are now available on-demand, and on-the-go—either as stand-alone applications or as remotely-accessible, "thin" client applications. In fact, upwards of 70 percent of business users now report accessing their business data via a mobile device [Cox, 2010; Information Week, 2007a]. This creates an opportunity to mobilize jobs that were once dependent on support infrastructure, but also creates the challenge of properly sizing infrastructure and processing flexibility to support these new work norms. One particular infrastructure challenge arising over the past ten years has been the requirement for development of mobile middleware—software created specifically to allow access to data stores and processing capabilities by mobile applications [Floch et al., 2006]. Another more individual-level challenge created by an increasingly mobile workforce is that mobile users have begun reporting significant alteration of temporal work arrangements, including working longer hours, feeling less empowered to ignore off-duty work requests, erratic scheduling, and accelerating business processes [Prasopoulou et al., 2006].

Second, a key enabler of the mobile phenomenon is the convergence of infrastructure (e.g., radiofrequency, computer networks, and public-switched telephone networks, as well as convergence of interoperable applications and services on an integrated machine. In fact, at both the individual consumer and firm levels, infrastructure and application innovation appear to be self-reinforcing, with one driving the other [see, for example, Dekleva et al., 2007; Borriello et al., 2005]. Further, the integrated machines themselves appear able to create a second significant innovation phenomenon: that of personalized applications performing a sole function. Much as with the Palm III ten years prior, which stimulated its own innovation market, the Apple iPhone continues to verify consumer demand for mobile content innovation that simply does not exist on desktop machines [see, for example, Ziv, 2005; Information Week, 2007b]. Perhaps the next step in this direction is the much-discussed challenges of infrastructure and applications to support context-aware applications and marketing [Park, 2005; Carlsson et al., 2008].

Finally, the mass scale of adoption of wireless services, and the speed with which they have accelerated, will continue to create challenges in the future with respect to areas such as infrastructure and security. For example, public administrators are struggling to keep up with spectrum demand—punctuated in the United States by a recent threefold increase in wireless spectrum allocation to accommodate a thirty-fold increase in wireless traffic [Information Week, 2009]. The fact that spectrum is a limited resource leads to the requirement for technological advances to better allocate spectrum to match the pace of demand for mobile services. Another significant concern in mobile computing, much as with internetworking in the early 1990s, is that of mobile-unique security and privacy concerns. For example, earlier-mentioned context-aware applications contain significant concerns about how location-based information can/should be shared by users—concerns that must be addressed before consumers will be willing to adopt these services [Shilton, 2009]. Eventually, as global networks continue to merge, the final challenge is borderless interoperability between those networks [Angelov, 2006], as well as global quality-of-service standards that will enable this new interoperability [for example, see Seth, 2007].

As we now have passed the ten year "anniversary" of the mobile computing phenomenon, it is perhaps time to reflect on the unique nature of this broad topic as both academics and practitioners perceive it. In other words, if mobile computing is a legitimate subset of IS research, then what does it look like? What questions are the mobile computing sub-field currently attempting to answer, and what areas are yet to be answered? Answers to these research questions may help "identify trends and patterns," and, therefore, "serve as an instrument to reflect as a research community on our progress," and also identify "areas where more work needs to be done" [Dube and Pare, 2003, p. 599]. Therefore, this research addressed two main questions:

RQ1: What areas of mobile computing are IS academics and practitioners currently addressing?

RQ2: What areas of mobile computing remain under-explored?

As will be seen, the answers to these first two main questions enabled us to then speculate on how mobile phenomenon were interacting, and how areas of current and future interest might be interrelated. Therefore, we addressed a third research question specific to the question of representing mobile computing as a distinct IS phenomenon:

RQ3: Can a framework be developed that captures the mobile computing phenomenon?

This research follows the tradition of two recent analyses of mobile computing [Scornavacca et al., 2006; Ngai and Gunasekaran, 2007] that identified and quantified major areas of interest in mobile computing. It is our intention to build on these frameworks in three ways: increasing the scope of mobile contexts considered, increasing the timeframe of observation, and increasing the scope of sources considered. First, we increased the scope of mobile contexts considered from "mobile business" [Scornavacca et al., 2006] and "mobile commerce" [Ngai and Gunasekaran, 2007] to a more general scope: "mobile computing." Second, considering the accelerated recent history of mobile adoption, we increased the timeframe of observation, from 2000–2004 [Scornavacca et al., 2006] and 2000–2003 [Ngai and Gunasekaran, 2007] to 2000–2009. Third, while initial research concentrated on academic commerce and academic technical outlets, we increased the scope of sources considered by adding academic IS journals and conferences, crossover IS journals and conferences, and IS practitioner outlets.

This remainder of this article is structured in three sections. First, we describe the research method followed to gather and analyze the data. Second, we provide an analysis of the results of the study, introduce a framework to supplement this analysis, and offer recommendations for future IS research in the area of mobile computing. Third, we conclude with an overview of the findings and recommendations.

II. RESEARCH METHOD

In conducting our study, we followed the guidelines of Dube and Pare's [2003] inductive categorization method. Specifically, we: (1) carefully selected appropriate journals and conferences, (2) identified the articles relevant to our study, (3) created inductive categories and subcategories based on the content of the articles, (4) assessed the number of articles in each category and subcategory, (5) analyzed the percentages and trends, and (6) developed a mobile computing comprehensive framework.

Selection of Appropriate Journals and Conferences

In selecting appropriate academic research outlets for this study, we first focused on those considered most representative of the IS discipline.[1] Recently, many scholars weighed in on the subject of what constitutes a "top IS journal," with the most recent report produced in a 2007 formal statement by the AIS Senior Scholars Forum. We began by using the six "top tier" IS journals identified by this forum. Given that the intent of the Senior Scholars' statement was not to help focus research, we consulted other recent IS articles defining "top tier" IS journals to verify the list [e.g., Clark and Warren, 2006]. We also considered two top peer-refereed IS conferences that represent the cutting edge of IS research—often providing a preview of future top-tier publications. We included two widely-recognized e-commerce journals—one business-oriented, and one technical-oriented—to ensure the focus of the two previous studies was not under-represented in this study. We included one international journal to capture the diversity of challenges faced in global mobile communications. Finally, we included one widely-cited mobile "convergence" (hardware/software/user) journal.

[1] Appendix A includes a brief discussion of the differences in outlets searched for this research versus Scornavacca et al. [2006] and Ngai and Gunasekaran [2007].

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The journals and conferences selected were:

Electronic Commerce Research and Applications (ECRA)

European Journal of Information Systems (EJIS)

Journal of the Association for Information Systems (JAIS)

Journal of Management Information Systems (JMIS)

Hawaii International Conference on Systems Sciences (HICSS)

International Conference on Information Systems (ICIS)

International Journal of Electronic Commerce (IJEC)

International Journal of Mobile Communications (IJMC)

Information Systems Journal (ISJ)

Information Systems Research (ISR)

Management Information Systems Quarterly (MISQ)

Mobile Networks and Applications (MONET)

Next, acknowledging the applied [Benbasat and Zmud, 1999], trans-disciplinary [Galliers, 2003] nature of IS, we considered outlets that represented transitional or crossover spaces between academics and practitioners. Following the logic of Benbasat and Zmud [1999], it is at these junctions that one might expect to find research related to core questions asked by practitioners, as well as future interests that academics anticipate practitioners might have. Finally, it is at these outlets that sometimes publish broad research stream overviews that might enhance one's ability to categorize those research streams [e.g., Nunamaker et al., 1991]. Crossover journals and conferences selected were:

Communications of the Association for Computing Machinery (CACM)

Communications of the Association for Information Systems (CAIS)

International Conference on Mobile Business (ICMB)

Institute of Electrical and Electronics Engineers Software (IEEE S/W)

Finally, we considered IS practitioner outlets. Following the logic of Benbasat and Zmud [1999] it is in these publications that one might expect to find core practitioner questions not yet addressed in academic literature. Further, following the logic of Galliers [2003], it is in these publications that one might expect to find trans-disciplinary questions (e.g., technical, managerial, or sociological) that affect the mobile computing environment either within or outside the IT artifact itself. In terms of the practitioner articles, there is a wealth of outlets available; therefore, we focused on those used most commonly as reference and for knowledge acquisition by IS professionals managers [Hardgrave and Walstrom, 1997]:

Chief Information Officer Magazine (CIO)

Information Week Magazine (Info Week)

PC World Magazine (PC World)

Identification of Relevant Articles

We began the search for relevant articles by defining search terms, drawing on Scornavacca et al. [2006] and Ngai and Gunasekaran [2007], but broadened our search criteria beyond the business/commerce domain, as suggested by Lyytinen and Yoo [2002b]. We identified three search terms capturing the relative diversity of mobile computing literature: "mobile," "wireless," and "ubiquitous." Searching for these relatively generic terms cast a wide net that we felt captured a large number of articles germane to the mobile computing phenomenon without undue overlap outside our area of interest.

The article search used EBSCO Business Source Complete and the conference or journal's Web search capability as appropriate. The period analyzed was ten years, from 1 Jan 2000 to 31 Dec 2009. Upon using each of the search terms to complete separate searches, we eliminated duplicate entries. This initial search resulted in 1,406 articles.

Next, we focused our search by eliminating articles clearly not germane to the mobile computing phenomenon. In some cases, the search terms returned a positive result, but were used in a different context (e.g., "IS worker mobility"). We excluded papers solely discussing mobile technology features and feature comparisons (e.g., "Which 2005 mobile phone should you buy?"), as they represented customer-focused content, not IS academic or practitioner content. Next, we excluded book reviews, product reviews, editor's commentaries, and eulogies, as they did not represent IS academic or practitioner content. Application of this criteria resulted in 806 articles, distributed as follows: 310 academic, 340 crossover, and 156 practitioner. A more detailed analysis is provided in the next section.

Creation of Inductive Categories and Subcategories

Because there is no existing methodology for classifying mobile computing research, apart from its application to mobile business and commerce [Scornavacca et al., 2006; Ngai and Gunasekaran, 2007], we followed the guidelines put forth by Dube and Pare [2003] in their study examining the rigor of positivist case studies in the area of IS. First, three of the authors separately coded a significant portion of the articles (133), categorizing the articles into a broad category the raters' thought captured the primary intent of the paper. This scheme produced fifteen major categories. The authors then sub-classified a portion of the papers with the specific, granular issues they thought each paper addressed. This scheme produced eighty-one subcategories. Next, each of the authors met and discussed these categories, identifying overlap, as well as relationships between major and minor categories, narrowing the list to five major categories, and twenty-two subcategories. Finally, the verbiage was adjusted somewhat to stay congruent with the previous two studies where possible.

Table 1: Main and Subcategories

Main Category	Description of Main Category	Subcategories
Mobile Theory and Research	Development of theories and/or research methods to study mobile computing phenomena. Also included a specific subset of items exploring how to measure mobile commerce phenomena. Finally, any paper exploring theoretical implications of mobile computing phenomena, e.g., legal or ethical issues.	Theory Development Research Methods Mobile Commerce Theory and Research Legal/Ethical Issues
Mobile User	Exploring the mobile computing phenomenon *from the perspective of the user*; specifically, how mobile users behave, and their decision processes, e.g., technology acceptance.	Mobile Consumer Behavior Technology Acceptance/Adoption/Use
Mobile Business	Exploring the mobile computing phenomenon *from the perspective of a business or industry*. Explored business models and strategies, as well as specific types of mobile applications and services. Some articles looked at whether or not these applications and services were successful, by tracking consumer acceptance and adoption. Explored inter-firm use of mobile applications/services. Finally, they looked at macroeconomic and policy implications and infrastructure enabling successful strategies.	Mobile Business Applications/Services Economics, Strategy, and Business Models Consumer Acceptance/Adoption Macroeconomic Cycles Government-Industry Interaction Interorganizational Networks Infrastructure
Mobile Cases and Applications	Utilization of mobile computing applications in a specific field. Also looked at organizational implications of mobile products/services, as well as societal implications of mobile product/service use.	Vertical-specific Applications Organizational/Societal Impact and Change
Mobile Technology	Explored the development of, and use of mobile computing technologies; i.e., exploring the mobile computing phenomenon *from the perspective of the technology*. Some articles broke down usage into its usability and usefulness components. Some articles addressed the technical issues related to mobile security and mobile middleware from a designer's perspective.	Mobile Technology/Standards Development Mobile Technology Use Usability Usefulness Mobile Security Mobile Middleware Features

Using these major categories and subcategories, two of the authors separately coded all of the papers again. The goal was to capture the authors' main idea in writing an article; however, initial analysis showed that numerous articles spanned multiple major categories and subcategories equally. For this reason, the two authors allowed multiple major and subcategories for any given article.[2] In all, 1,006 main categories and 1,309 subcategories described the 806 articles. Upon completing the entire coding process separately, the authors met to resolve any discrepancies.[3]

Table 1 outlines the results of the article coding. In terms of main categories, this schema represents a synthesis of Scornavacca et al. [2006] and Ngai and Gunasekaran [2007] in that it delineates between "Business," "Technology" [Scornavacca et al., 2006], "Theory and Research," and "Cases and Applications" [Ngai and Gunasekaran, 2007]. With respect to "Consumer," "Industry" [Scornavacca et al., 2006], "Infrastructure," and "Middleware" [Ngai and Gunasekaran, 2007] in the mobile computing context, we found these to be more appropriately categorized as subcategories under "Mobile Business" and "Mobile Technology," respectively. Finally, in contrast to Scornavacca et al. [2006], we found an area in IS literature that focused on "Mobile User," but in a context other than that of m-business; therefore, we created a category dedicated to the mobile user.

In the subcategories, we integrated those found by Scornavacca et al. [2006] and Ngai and Gunasekaran [2007], with the following exceptions: first, we added a subcategory titled "Research Methods" and moved "Economics, Strategy, and Business Models" from "Mobile Theory and Research" to "Mobile Business." Second, we focused "Mobile Cases and Applications" on specifically "Vertical-specific Applications" and "Organizational/Societal Impact and Change," feeling that this better captured the articles we found in the broader mobile computing context. Many of Ngai and Gunasekaran's [2007] subcategories under this main category were, therefore, repositioned under "Mobile Business" or "Mobile Technology" because of their general (versus specific) business or technology focus. Finally, much the way Burton-Jones and Gallivan [2007] conceive of it, we classified mobile computing technology acceptance/adoption/usage according to the dominant perspective of its use: that of the *user*, that of the *business*, or that of the *technology*. We found that the sets of issues discussed were, indeed, affected by this context.

III. ANALYSIS AND RECOMMENDATIONS

This section continues with steps 4–6 of Dube and Pare's (2003) inductive categorization method: (4) assessment of the number of articles in each category and subcategory, (5) analysis of the percentages and trends, and (6) development of a mobile computing comprehensive framework. When this framework is applied to the research discovered, it is possible to discover areas that are under-represented and thus make recommendations for future research in those areas.

Assessment of Articles by Category and Subcategory

We first discuss the distribution of articles by year in an effort to identify the trends in mobile computing research. Table 2 summarizes the distribution of articles, with academic outlets shown in white, crossover outlets shown in grey, and practitioner outlets shown in dark grey.

From the results outlined in Table 2 and Figure 1, it is clear that interest in mobile computing topics is on a steady rise. The total number of articles increased yearly from 2000 to 2005, peaking in 2005 and remaining relatively stable thereafter. Within each outlet type, growth was consistent within the academic outlets, inconsistent within practitioner outlets, and virtually nonexistent within crossover categories after controlling for the overwhelmingly large contribution of ICMB. To control for the effects of special issues or other significant, one-time events, growth was analyzed using a two-year moving average (see the trend lines in Figure 1). Once again, when controlling for the overwhelmingly large contribution of ICMB, a linear, eightfold increase in the number of articles is apparent from the 2000–2001 cohort (11.5) to the 2008–2009 cohort (96). When considering the contribution of ICMB, it appears that overall counts peaked in the 2005–2006 cohort and have begun to plateau, but when controlling for ICMB, it appears too early to tell whether or not this trend extends beyond the crossover category.

[2] The raw inter-rater reliability for the two authors was .818 for major categories and .786 for minor categories. Because this coding schema allowed for multiple possible categorizations of the same article, it was not possible to calculate a Cohen's Kappa.

[3] The authors also initially used an "Other" category to ensure that the initial categorization was comprehensive. Of articles initially coded as "Other," the intent was to either: (a) include them into existing categories, (b) exclude them from consideration because of lack of fit, or (c) create a new category to capture them. Of the thirty-nine articles where "Other" occurred, it was possible to resolve every instance by assigning the article to an existing category.

Table 2: Distribution of Articles by Year (2000–2009)											
JOURNAL/ CONFERENCE	**Number of Articles by Year**										
	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	*TOTAL*
ECRA	-	-	3	1	3	1	8	7	6	1	*30*
EJIS	0	0	0	0	1	0	10*	1	3	2	*17*
JAIS	0	0	0	0	0	1	0	1	1	0	*3*
JMIS	0	0	0	0	1	1	0	1	1	1	*5*
HICSS	0	0	0	0	0	10	13*	1	22	18	*64*
ICIS	0	1	3	5	2	2	3	3	3	10	*32*
IJEC	1	0	0	6	3	0	0	2	0	0	*12*
IJMC**	-	-	-	N/A	13	14	26	26	31	21	*131*
ISJ	0	0	0	0	0	1	1	1	3	1	*7*
ISR	0	0	1	0	0	0	2	0	0	0	*3*
MISQ	0	0	0	0	0	0	1	0	1	0	*2*
MONET	0	1	1	0	1	0	0	0	1	0	*4*
CACM	0	1	6*	6	1	6	2	3	5	12	*42*
CAIS	0	0	0	2	3	1	2	2	2	2	*14*
ICMB**	-	-	N/A	N/A	N/A	94	42	59	33	49	*277*
IEEE S/W	0	1	1	0	0	0	3	2	0	0	*7*
CIO	0	0	0	0	3	1	1	9	9	12	*35*
Info Week	3	4	2	2	2	5	6	11	4	13	*52*
PC World	6	5	7	5	15	3	5	10	8	5	*69*
TOTAL	**10**	**13**	**24**	**27**	**48**	**140**	**125**	**139**	**133**	**147**	***806***

*CACM published a special section on ubiquitous computing in 2002, EJIS published a special issue in 2006, and HICSS held a special conference on mobile computing in 2006.

**ICMB began in 2002, available electronically in 2005; IJMC began in 2003, available electronically in 2004.

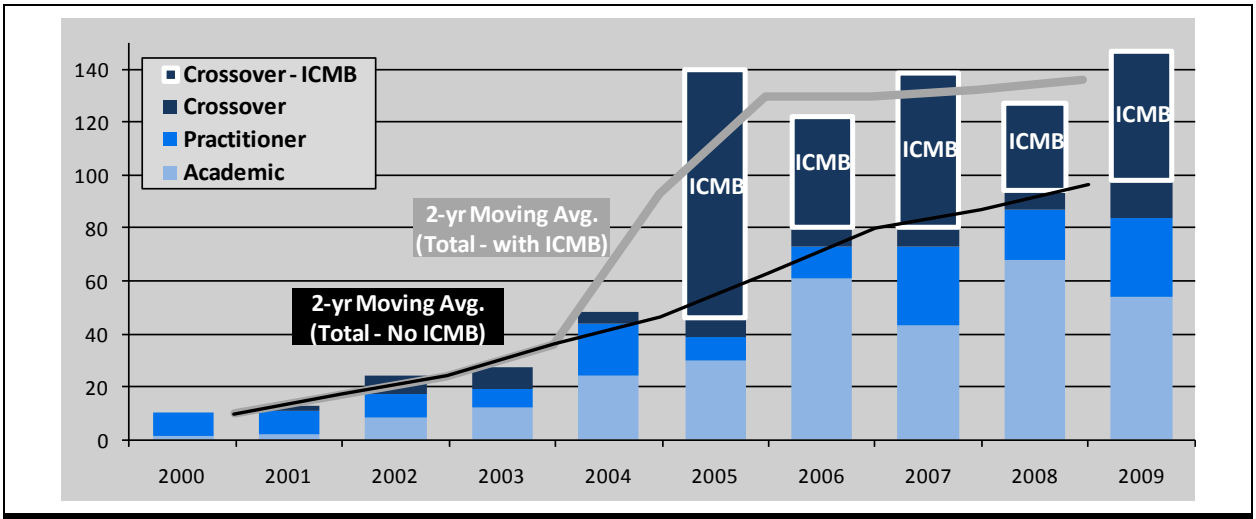

Figure 1. Distribution of Articles by Year (2000–2009)

Analysis of Percentages and Trends

Having established a coding schema representing extant literature in academic, crossover, and practitioner outlets, it was next useful to explore the distribution of articles and topics these articles were exploring, and which of the topics were under-explored in the main and subcategories.

Main Categories

Shown in Table 3, within the main categories the overwhelming area of interest was “Mobile Technology” (326), followed by “Mobile “Business” (237), and “Mobile Theory and Research” (183). Finally, the two least-represented

major areas were “Mobile User” (146) and “Mobile Cases Applications” (114), perhaps due to the small size of each of these categories, i.e., contained a small number of subcategories.

Finding a relatively large number of article categorizations in each of the main categories is encouraging because it indicates we were able to successfully find the main areas of interest in mobile computing; however, what it does not answer is whether or not there are main areas of mobile computing that may either not yet exist, or exist in such small numbers that they are not yet considered main areas. As was the case with Scornavacca et al. [2006] and Ngai and Gunasekaran [2007], these categories exist only through the lens of the type of study that was conducted.[4] In order to gain a better understanding of trends in mobile computing research, we must review the subcategories.

Table 3: Distribution of Articles by Category

	Main Category Totals		Subcategory Totals		
Category Name	Count	% of Total	Count	% of Category	% of Total
Mobile Theory and Research	**183**				
Theory Development			78	36%	6.0%
Research Methods			22	10%	1.7%
Mobile Commerce Theory and Research			104	49%	7.9%
Legal/Ethical Issues			10	5%	0.8%
Sub-Total		*18.2%*	*214*	*100%*	*16.4%*
Mobile User	**146**				
Mobile Consumer Behavior			42	26%	3.2%
Technology Acceptance/Adoption/Use			122	74%	9.3%
Sub-Total		*14.5%*	*164*	*100%*	*12.5%*
Mobile Business	**237**				
Mobile Business Applications/Services			118	35%	9.0%
Economics, Strategy, and Business Models			106	31%	8.1%
Consumer Acceptance/Adoption			72	21%	5.5%
Macroeconomic Cycles			11	3%	0.8%
Government-Industry Interaction			10	3%	0.8%
Interorganizational Networks			5	2%	0.4%
Infrastructure			16	5%	1.2%
Sub-Total		*23.6%*	*338*	*100%*	*25.8%*
Mobile Cases and Applications	**114**				
Vertical-specific Applications			76	62%	5.8%
Organizational/Societal Impact and Change			46	38%	3.5%
Sub-Total		*11.3%*	*122*	*100%*	*9.3%*
Mobile Technology	**326**				
Mobile Technology/Standards Development			150	32%	11.5%
Mobile Technology Use			43	9%	3.3%
Usability			46	10%	3.5%
Usefulness			68	14%	5.2%
Mobile Security			66	14%	5.0%
Mobile Middleware			14	3%	1.1%
Features			84	18%	6.4%
Sub-Total		*32.4%*	*471*	*100%*	*36.0%*
TOTAL	**1006**	**100%**	**1309**		**100.0%**

* Note: any slight summation inconsistencies are due to rounding of numbers

[4] Appendix B includes a more complete comparison of main categories found in this research versus Scornavacca et al. [2006] and Ngai and Gunasekaran [2007].

Subcategories

More fidelity is possible in examining the subcategories. We first look at the distribution of categories, and make note of areas that are commonly addressed, noting and analyzing an interesting trend in the subcategory counts over time. Finally, we make note of areas that are less commonly addressed, and begin to focus on areas that might prove fertile to future research. Ultimately, this analysis enables the creation of a mobile computing framework in the next section.[5]

With 1,309 instances of subcategory usage, and twenty-two subcategories, the expected value of any subcategory is fifty-nine, with the median count value of any given subcategory being fifty-six (or 4.3 percent of the total). As shown in Figure 2, six categories were positive outliers and six categories were negative outliers.[6]

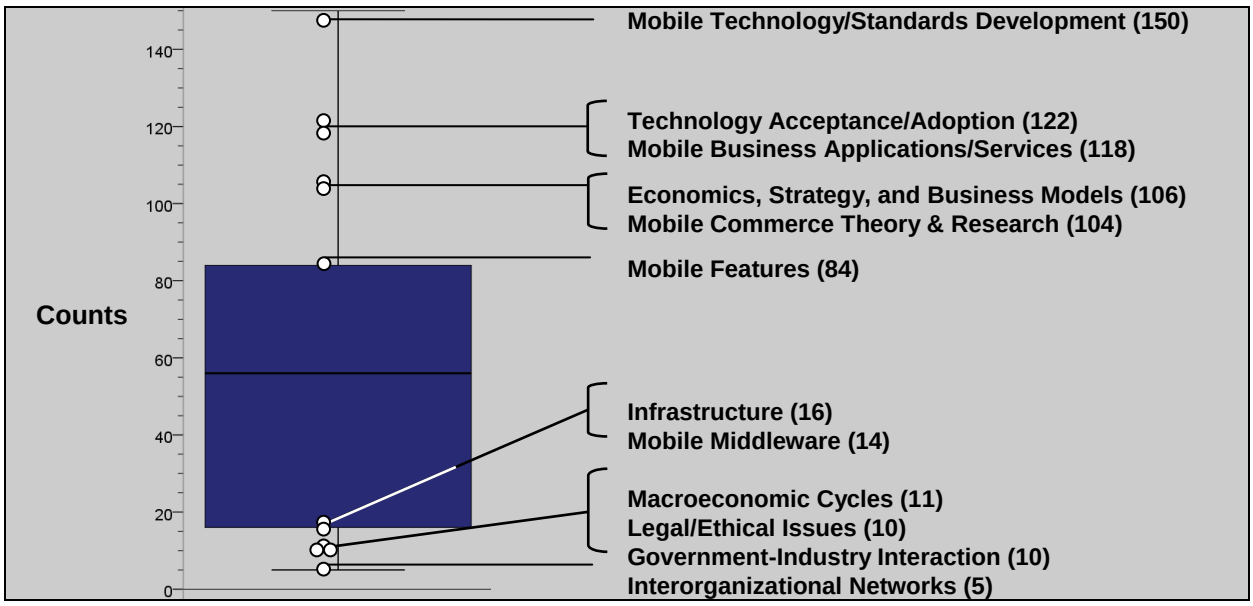

Figure 2. Distribution of Subcategories by Number of Articles Found

That the subcategories "Mobile Technology/Standards Development" and "Mobile Features" (*technology perspective*) are commonly addressed is unsurprising considering that mobile computing technology and features enable the current trend. The same is true for the subcategories "Mobile Business Applications/Services" and "Economics, Strategy, and Business Models," (*business perspective*) as companies race to capitalize on the immense revenue possibilities enabled by new mobile computing technologies. Finally, one would expect "Technology Acceptance/Adoption" (*user perspective*) also to be of importance, though one might expect this to lag behind technology and business somewhat. This may be the reason that this category was not identified in previous research concentrating on the 2000–2004 period. Finally, "Mobile Commerce Theory and Research" might also lag behind mobile technology and business research as firms and researchers the effectiveness of mobile business strategies.

This appears to be the case, as shown in Figure 3. When seen as a percentage of overall subcategories, and as a percentage of the six categories discussed above, "Mobile Technology/Standards Development" and "Features" initially comprised 50 percent of all subcategories coded overall, and 80 percent within the subset analyzed. This dominance shrank as the subcategories "Mobile Business Applications/Services," "Economics, Strategy, and Business Models," "Acceptance/Adoption/Usage" and "Mobile Commerce Theory and Research" began to increase. There appeared to be a time lag between categories: two years between the Technology and Business functions, three years between Technology and Acceptance/Adoption/Usage, and four years between the Technology and

[5] Appendix B includes a more complete comparison of subcategories found in this research versus Scornavacca et al. [2006] and Ngai and Gunasekaran [2007].

[6] This analysis was performed both on the set of all articles (1,309 subcategory instances), as well as on the subset of academic and crossover articles (1,102 subcategory instances) with nearly identical results.

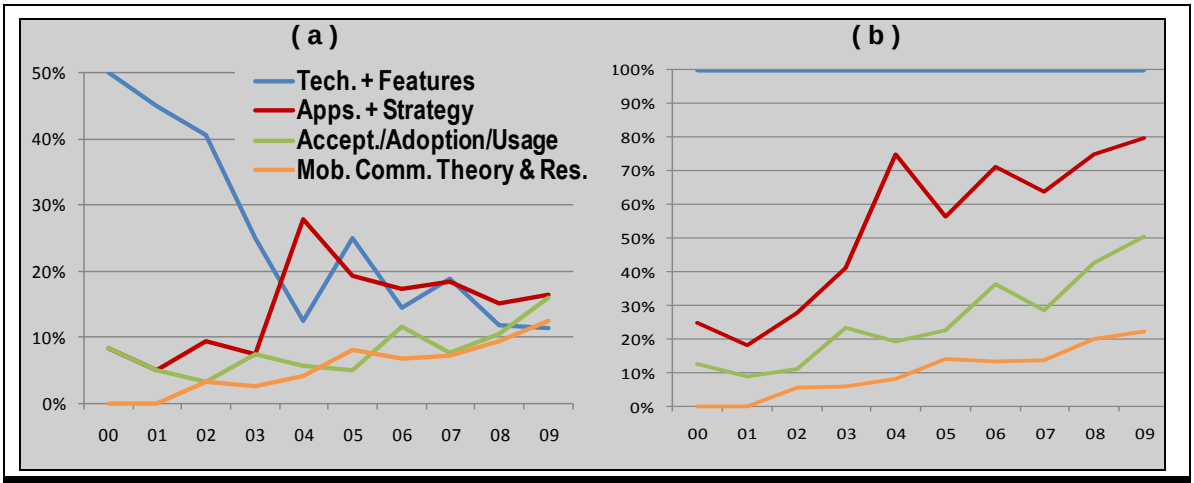

Figure 3. Distribution of Technology/Features, Applications/Strategy, and Mobile Commerce Theory & Research Relative to: (a) Overall, and (b) Each Other[7]

Mobile Commerce and Research. In other words, the technology itself was initially of interest, followed by business applications, user concerns, and finally research related to commerce applications of the technology. These six categories accounted for more than half of all categorizations made (684 out of 1309 total).

As discussed in Appendix B, the lack of "Mobile Middleware" and "Infrastructure" discussion seems reasonable considering the focus of this analysis. In fact, we note that both Scornavacca et al. [2006] and Ngai and Gunasekaran [2007] found a significant number of articles in these categories. However, considering the outlets chosen and the importance of infrastructure issues in enabling e-commerce and enacting mobile business strategy, it was somewhat surprising that there was little mention of infrastructure concerns in the business (versus technical) context. Infrastructure, or "infrastructure convergence" as it was termed by Lyytinen and Yoo [2002b] is at the heart of numerous internal business strategy questions not yet addressed with respect to mobile computing. Aside from the obvious question of whether or not a move to mobile infrastructure increases or reduces overhead costs, does mobile infrastructure enable new workgroup or firm structural configurations [see Miller, 1986, and Lyytinen and Yoo, 2002b]? It seems likely that they might, just as networked computing enabled distributed work groups did in the early 1990s.

To the extent that infrastructure enables usage, one could extend this line of reasoning to other internal strategy issues such as: activity integration, restructuring, process improvement, enabling of corporate learning, and organizational culture. Considering the types of changes discussed recently [in Prasopoulou, 2006] at the individual level in the nature of work and work–life balance, it seems likely that firm-level changes might also be occurring, for example, what are the cultural norms related to work–life balance in a firm that relies heavily on mobile computing, and what are the consequences on that firm's performance and worker retention? So, one could investigate these questions from an infrastructure perspective, i.e., "what types of infrastructures support or change these organizational variables," or alternately, from a usage perspective, i.e., "under what conditions (enabled by infrastructure) does usage of mobile computing resources lead to changes in these organizational variables?" Likewise, one might investigate these variables at the individual (performance) or firm (value) level.

In fact, from the articles reviewed in this study, few discussed the internal business value chain proposition, i.e., how mobile communication devices led to increased individual performance, and how individual/firm usage of mobile communication devices increased overall firm performance (for an example of this trend of thought, see Coursaris et al., 2006). In other words, it seems that attention in both practice and academic research is currently focused on technology as it relates to business (market) performance in firms that offer mobile computing services, but ignores the business value chain perspective of how mobile computing leads to business success within the firm itself. Therefore, we propose the following research questions related to mobile computing infrastructure, usage, and a firm's inward-focused strategy mechanisms:

- How do mobile devices, including enabling mobile technologies, increase overall business value?
- How do mobile devices, including enabling mobile technologies, affect individual (user performance?

[7] Both graphs were drawn from percentages versus actual counts because ICMB data was only available from 2005 onward. As shown in Figure 1, using counts resulted in a spike in the 2005 year in all article types—a potentially misleading representation.

The fact that there also exists a relative lack of discussion of the topics of "Macroeconomic Cycles," "Government-Industry Interaction," and "Interorganizational Networks," presents an additional opportunity, framed by Melville et al. [2004], to extend this same line of inquiry of how mobile computing affects business value to these significant external sources (and others). Long-discussed in strategy research, with perhaps the best example being Porter [1980], market-level forces have a direct effect on firm performance. While we found significant evidence of telecommunications firms' implementing mobile computing-specific strategy by experimenting with new product offerings and price-setting strategies (categorized as "Economics, Strategy, and Business Models"), we did not find evidence of discussion of the effect of the mobile computing phenomenon, through external sources, on non-telecommunications firms, nor did we find any evidence of discussion of mobile computing usage within the firm as a response to external pressures.

It would appear that the potential for mobile computing phenomena to affect firms through their environment exists. For example, mobile devices may increase the bargaining power of buyers. Much as was the case with internetworks in the 1990s, if a customer has the ability to perform real-time price checking when considering a purchase, then market segmentation may be lost, increasing price pressure. Contrarily, mobile devices may also create market niches for new entrants to exploit, such as mobile gaming, gambling, auctions, or charity—exemplified by the recent use of donations via cell phone to the Red Cross [Red Cross, 2010]. Additionally, the ubiquitous market created by mobile devices may create additional opportunities for impulse buying as predicted by Islam and Fayad [2003]. In short, mobile computing may be a source of short-term competitive advantage in firms.

In response to new market pressures enabled by mobile computing, it remains to be seen whether firms will respond with intensified competition, or with intensified cooperative behavior. One recent example of inter-firm cooperation made possible by mobile devices is the mobile logistics tracking network instituted by United Parcel Service (UPS). This network enabled cooperation between UPS and supported vendors, but also between those vendors and sub-vendors, such with Amazon.com and its numerous partners that share the Amazon.com "marketplace," but who then drop-ship to consumers.

With respect to government-industry interaction, Saraswat and Schiano [2006] used content analysis of U.S. Federal Communications Commission (FCC) actions and speeches to point out that, since the last major FCC legislation [the Telecommunications Act of 1996], items such as spectrum allocation and auction, satellite, and cellular phones have remained of interest, while wireless issues (excluding cellular phones) appear to have increased. Considering the projected increased in pressure on the spectrum by wireless applications, and the recent exhaustion of military band to commercial reallocation, spectrum management appears poised to become a larger topic of interest in the near future, as pointed out in the recently released National Broadband Plan [FCC, 2010]. While the specific policy initiatives in this document appear to be focused on telecommunications firms, it remains to be seen whether or not these issues will affect non-telecommunications firms (for example, in the form of increased local competition or increased per-unit data transfer costs).

Considering the relative importance of external factors in firm performance, we feel that it may be beneficial to address three core questions, adapted from Melville et al. [2004], with respect to mobile computing:

- What role do external entities (e.g., industry, government, and macroeconomic cycles) play in shaping business value attained through mobile computing usage?
- What role do mobile computing resources and mobile-enabled business processes of trading partners (interorganizational networks) play in shaping the business value attained through by the focal firm?
- Does use of mobile computing resources within a firm lead to improved efficiencies or competitive advantage?

The lack of discussion of Legal/Ethical issues addressed is surprising, considering the strong research streams in IS concerning issues of trust and security. Of the few topics that were discussed in the articles reviewed, it is clear that opportunities exist to explore legal and ethical considerations, for example: (a) e-Health—both access and privacy issues, (b) balancing convenience/accessibility with privacy—especially in location-based services, (c) RFID marking/tracking—individual privacy concerns, (d) intellectual property rights—especially information theft, (e) employee monitoring, (f) digital divide—equity in access and usage, (g) consumer advocacy—for example in number portability, and (h) user distraction by mobile devices. Lyytinen and Yoo [2002b] predicted that property and access rights might be a key area of study, but from the small number of articles generated in response to this question, we feel this still represents a future area of growth for IS researchers. In response, we propose the following general research question:

- What are the legal/ethical implications of mobile computing technologies and their usage?

Another area that was under-represented in the sense of not being directly mentioned was that of human–computer interaction (HCI). Although the term *usability* was addressed regularly in articles (3.5 percent), what is not apparent from the coding schema is that nearly all of these articles were calls for usability (crossover publications), or promises of usability (practitioner publications), but not validations thereof. With the advent of 3G devices, it seems imperative that researchers begin to address the same list of issues first apparent when laptop devices were created (e.g., small screen sizes, slow download speeds, web-page display, etc.). It is possible, based on the above analysis of trends, that this research will be forthcoming now that mobile computing feature types are beginning to stabilize. Additionally, it is also possible that this type of research is being done by small item device manufacturers (i.e., Apple's iPhone), but just not being published.

Beyond simply considering usability are the core HCI concerns identified by Zhang and Li [2005], many of whom are directly applicable in unique ways to ubiquitous computing technology. These concerns include advanced *technological* considerations such as information visualization, portability/wearability and implanted devices. Further, there are the *human* considerations such as physical/motor, cognition, and emotion/motivation. Finally, there are *task/job* and *contextual* considerations that arise out of the technical and human interaction. These considerations strike at the heart of the ubiquitous computing phenomenon, namely that mobile computing devices—because of their portability and availability—have the potential to greatly enhance a user's existence, such as in the case of a networked, context-aware device for physically-impaired users. Further, mobile computing devices also have the potential to affect a user's life experience—such as concerns mentioned above about user distraction.

Lyytinen and Yoo [2002b] also anticipated the requirement for research into HCI issues, by positing that design and integration of personal services, data protocols, and transactive memory systems across multiple contexts was a key challenge of ubiquitous computing research. As computing power becomes ubiquitous, and hence inseparable from everyday existence, it seems that the requirement to investigate the user-level effects will increase. Again, perhaps as computing power becomes "more ubiquitous," the availability of opportunities to further research these areas will increase. In summary, we pose the following general research questions with respect to ubiquitous/mobile human-computer interaction:

- How does ubiquitous mobile computing affect individual users?
- How can ubiquitous mobile computing better enable individual user task performance?

Finally, one closely-related, and relatively underrepresented area of study (though it was not an outlier with a representation of 3.5 percent) was the "Organizational/Societal Impact and Change" literature—especially considering the inclusion of the "ubiquitous" terms in the initial search. As pointed out by Jessup and Robey [2002], ubiquitous computing has the potential not to just "… enable new ways of acting and interacting, but also stimulate [a] fundamental reassessment of the meaning of human action and interaction." This area of interest includes the *task/job* and *contextual* considerations identified by Zhang and Li [2005], extending individual-level effects to organizations and societies. The research discovered in this stream of research, primarily interpretivist by nature, seemed to produce some of the most compelling and insightful research on the impact of ubiquitous and mobile computing beyond its first-order usage effects [Gopal et al., 2006; Kauffman and Techatassanasoontorn, 2005; Oliveira et al., 2006; Prasopoulou et al., 2006; Yao and Murphy, 2007].

One example of this stream of research is how mobile computing is transforming societies for whom computing technologies have only become available in mobile form over the past 10-15 years. Considering that some assert that the "digital divide" may actually work in *reverse* with respect to mobile computing (because mobile computing adoption rates are higher in developing nations than in developed nations), one might expect to see cross-cultural analysis used to investigate some of these issues. Lyytinen and Yoo [2002b] addressed organizations and inter-organizations in their call for research, much of which is summarized elsewhere in this document; however, they did not address societies. It is possible to extend their thoughts outward to this level, though, considering the effects of increased information availability on societies, or how nomadic environments are affecting societies. For example, are we becoming more disconnected as a society, as individuals in a crowded shopping mall are texting their friends versus interacting with the humans around them—or is it simply that we must redefine what it means to be connected? It is our contention that this area of research is promising and might continue to grow in the future as the wider impact of mobile technology on individuals, organizations, and societies becomes apparent; therefore, we posit the following general research question:

- How are ubiquitous mobile computing phenomena transforming organizations and societies?

Development of a Mobile Computing Comprehensive Framework

Our review of mobile computing literature not only helped us identify the areas of interest, and the trends in those areas, but also helped us posit the interrelationships between these areas. We capture these areas of interest and

interrelationships in the process framework provided in Figure 4, with the grey text, boxes, and arrows representing those areas we believe require more research in the future, based on the analysis in the previous section.

The figure suggests that the IS field views mobile computing adoption and use as the primary dependent variable, whether it be from the firm perspective or the individual perspective. Mobile strategy and business models, as well as mobile technology and standards development and features are viewed as important for improving mobile technology adoption and have received sufficient attention. Partly because of the constant flux in technology itself and business models, we do not anticipate this trend reversing any time soon.

Although firm performance seems well established as an area of interest from the perspective of mobile service providers, the same investigation is lacking within non-provider firms. Since these firms represent the bulk of all firms, it would appear that more research is warranted into the specifics of enabling technologies, such as middleware and infrastructure, as well as external influences such as government, interorganizational networks, and macroeconomic cycles.

Further, in spite of calls by scholars within the discipline [e.g., Lucas and Spitler 1999] to extend adoption-related models on their right side, that is, examine the effect of adoption on other outcomes, in the context of mobile computing, there has been limited response, both at the individual level and at the firm level. In the case of the individual level, more empirical research regarding the human-computer interaction, specifically the result of HCI variables on individual performance, seems warranted. At the firm level, more research is required to determine how individual adoption of mobile computing technologies within the firm enhances firm performance.

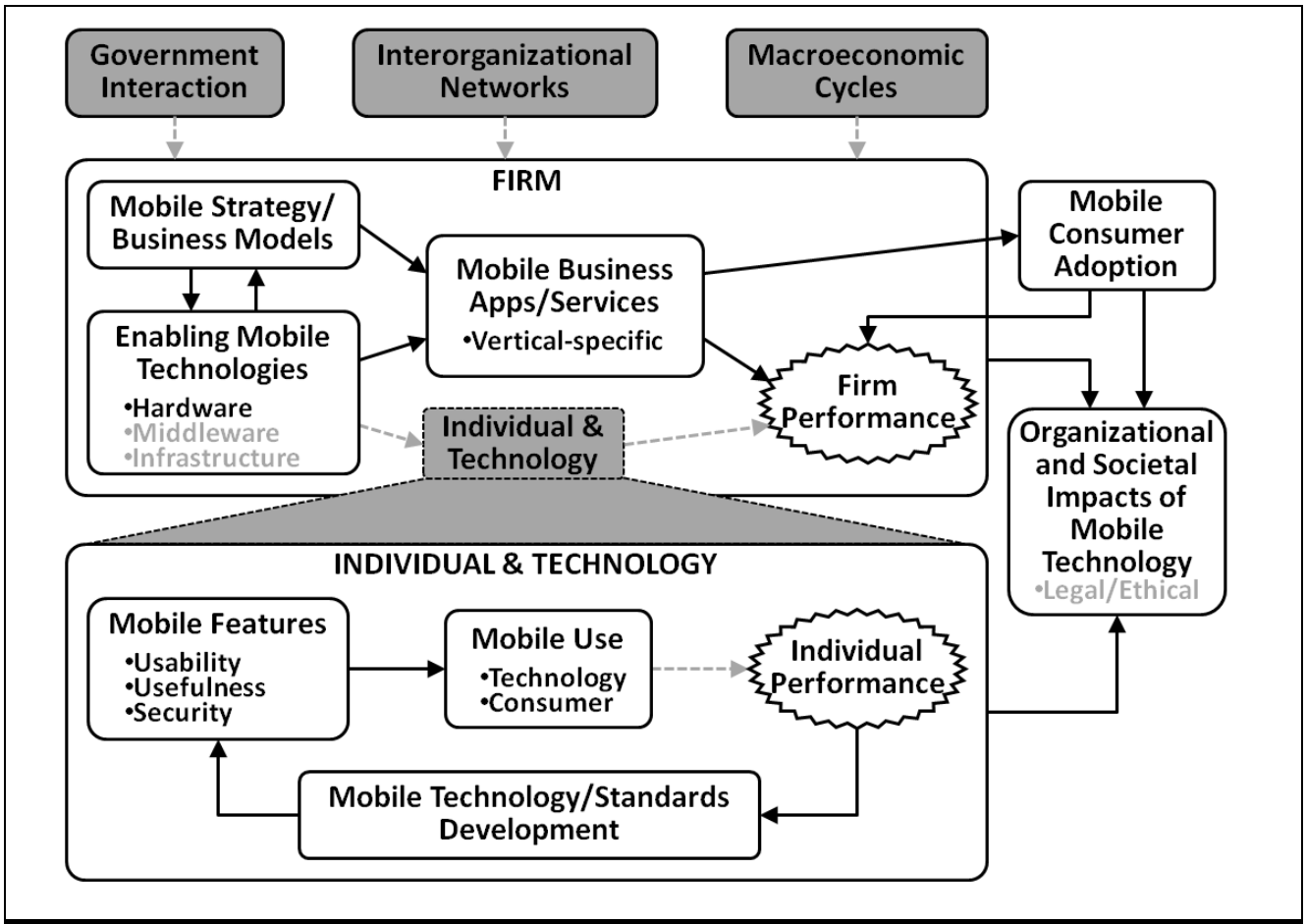

Figure 4. Facets of Mobile Computing and their Inter-Linkages (Areas Lacking Research Shown in Grey)

Finally, in spite of the identified potential of mobile technology adoption to impact organizations and societies, this stream of research appears in its infancy, with little empirical or theoretical research surrounding legal and ethical implications of mobile computing technologies.

IV. SUMMARY AND CONCLUSION

Table 4 summarizes the results and integrates the salient points from the analysis, organized according to the main and subcategories identified in this research. We use "+" and "–" symbols in the second column of the table to highlight the trends discovered; corresponding conclusions and recommendations are provided in the third column.

This research attempted to answer three questions: (1) What areas of mobile computing are IS academics and practitioners currently addressing? (2) What areas of mobile computing remain under-explored? and (3) Is it possible to capture the mobile computing phenomenon in a framework? To answer these questions, we used an inductive categorization of 806 articles in nineteen leading academic, crossover, and practitioner outlets from 2000–2009 to develop a coding schema for describing current areas of mobile computing discussion and research. Next, using this categorization schema, we analyzed the trends in interest in the mobile computing phenomenon over the past ten years, identifying areas we feel require additional attention by researchers. Finally, we developed a comprehensive framework that integrated the categorization system developed with the areas requiring additional attention.

The first contribution of this study is in the development of a mobile computing framework itself. In creating a framework that encompassed all mobile computing discussion and research—in both academic and practitioner outlets—we attempted to expand the scope of our understanding of the mobile computing phenomenon. This mobile computing framework will enable future researchers interested in this topic to frame their research within the mobile computing domain, but also to focus on areas requiring additional attention.

Table 4: Results and Integrated Salient Points

Main Category	Findings and Trends	Conclusions/Recommendations
Mobile Theory and Research	(+) Mobile Commerce Theory & Research	Lags behind technology/business/adoption
	(–) Legal/Ethical Issues	Address legal/ethical issues (e.g., location-based services, privacy) outside the security realm
Mobile User	(+) Technology Acceptance/Adoption/Use	Lags behind technology/business. Little analysis of ubiquitous computing effect on users or on user task performance.
Mobile Business	(+) Business Applications/Services	Lags behind technical
	(+) Economics, Strategy, and Business Models	Lags behind technical; industry velocity will require ongoing research in these areas
	(–) Infrastructure	Technical issues addressed in other outlets; however, little discussion on how infrastructure contributes to business value chain in firms
	(–) Macroeconomic Cycles (–) Government-Industry Interaction (–) Interorganizational Networks	Business value chain analysis required, e.g.: a) How external entities (industry, gov., macro. cycles) shape mobile computing value-added b) Role mobile computing resources of trading partners in shaping focal firm business value c) How mobile computing leads to improved efficiencies or competitive advantage
Mobile Cases and Applications	(–) Organizational/Societal Impact and Change	Some compelling qualitative research to date; better understanding required of the impact of mobile computing on organizations/societies
Mobile Technology	(+) Technology/Standards Development (+) Features	These areas lead all others in volume of interest and timeliness of interest; technical velocity will require ongoing research in these areas
	(–) Middleware	Technical issues addressed in other outlets; little discussion on middleware enabling business value chain in firms.
	(–) Usability (HCI)	More mobile computing HCI research using individual cognition/affect/performance as DV

(+) indicates abundance of the category within the investigated time period
(–) indicates lack of the category within the investigated time period

The second contribution of this study is its focus on the information systems discipline, versus the more e-business/commerce and technical studies of previously attempted, making it more relevant to the IS discipline. This broad review and analysis also allowed us to identify the different facets of mobile computing research beyond the sub-domains previously studied, as well as the inter-relationships between them.

The third contribution of this study is its inclusion of a longer time period, 2000 to 2009, that appears to capture both the rise of mobile computing discussion and research, as well as its current state. The trends observed helped lead to, and validate, the framework developed. Overall, the inclusion of a decade of research and practitioner interest allowed us to build on previous research calls [e.g., Lyytinen and Yoo, 2002b; Zhang and Li, 2005] by noting which of the areas of interest were currently receiving significant interest, which were not, and how this interest might be temporally ordered.

We believe this study identifies several avenues for future research. First, it identifies the opportunity for business value chain analysis, both within and outside the firm. Second, it identifies the opportunity for mobile computing usability (HCI) research, as well as into user-level cognition/affect/performance issues. Third, it identifies the opportunity for research addressing legal/ethical issues in mobile computing, aside from security issues. Fourth, it identifies the opportunity for research into broader impacts of mobile computing technologies on individuals, groups, and societies.

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Editor's Note: The following reference list contains hyperlinks to World Wide Web pages. Readers who have the ability to access the Web directly from their word processor or are reading the article on the Web, can gain direct access to these linked references. Readers are warned, however, that:

1. These links existed as of the date of publication but are not guaranteed to be working thereafter.
2. The contents of Web pages may change over time. Where version information is provided in the References, different versions may not contain the information or the conclusions referenced.
3. The author(s) of the Web pages, not AIS, is (are) responsible for the accuracy of their content.
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APPENDIX A

Appendix A: Comparison of Outlets Searched			
Outlet Title	**Current**	**Scornavacca et al.**	**Ngai and Gunasekaran**
Electronic Commerce Research and Applications (ECRA)[8]	X	X	X
International Journal of Electronic Commerce (IJEC)[8]	X	X	X
Mobile Networks and Applications (MONET)[9]	X	X	X
International Journal of Mobile Communications (IJMC)	X	X	X
Journal of the Association for Information Systems (JAIS)	X	X	
Journal of Management Information Systems (JMIS)	X	X	
Hawaii International Conference on Systems Sciences (HICSS)	X	X	
International Conference on Information Systems (ICIS)	X	X	
Management Information Systems Quarterly (MISQ)	X	X	
European Journal of Information Systems (EJIS)	X		
Information Systems Journal (ISJ)	X		
Information Systems Research (ISR)	X		
Bled e-Conference[10]		X	
European Conference on Information Systems (ECIS)[10]		X	
Pacific Asia Conference on Information Systems (PACIS)[10]		X	
Australasian Conference on Information Systems (ACIS)[10]		X	
Americas Conference on Information Systems (AMCIS)[10]		X	
International Conference on e-Business (ICEB)[8]		X	
International Conference on Electronic Commerce (ICEC)[8]		X	
International Journal of Electronic Business (IJEB)[8]		X	
e-Service Journal (e-SJ)[8]		X	
Electronic Markets (EM)[9]			X
Internet Research: Electronic Networking Applications and Policy[11]			X
Info—The Journal of Policy, Regulation and Strategy for Telecomm.[12]			X
IEEE Transactions on Systems, Man, Cybernetics, Part A[9]			X
Journal of Database Management (JDM)[13]			X
Communications of the Association for Computing Machinery (CACM)	X	X	X
Communications of the Association for Information Systems (CAIS)	X	X	
International Conference on Mobile Business (ICMB)	X	X	
Institute of Electrical and Electronics Engineers Software (IEEE S/W)	X		
Mobility Roundtable[10]		X	
Chief Information Officer (CIO)	X		
Information Week Magazine (Info Week)	X		
PC World Magazine (PC World)	X		
Computer[9]			X

[8] Most e-commerce/business journals/conferences were too broad for this article; however, two high-quality outlets—ECRA and IJEC—were included to ensure this relevant subset of mobile computing research was not under-represented.

[9] Primarily a technical publication (focused exclusively on technology)

[10] Authors felt conferences included (ICIS and HICSS) were representative of regional ones over time.

[11] Primarily an Internet research publication, with mobile computing representing a small subset

[12] Primarily a telecommunications policy publication

[13] Primarily a database and systems analysis publication

APPENDIX B

Appendix B: Comparison of Categories Across Three Studies (2006–2009)			
	Subcategory (% of Total)		
Category Name	(Scornavacca et al., 2006)	(Ngai and Gunasekaran, 2007)[14]	(Current, 2010)
Mobile Theory and Research ***Sub-Total***	***0.0%***	***4.7%***	***16.4%***
Theory Development	–	–	6.0%
Research Methods	–	–	1.7%
Mobile Commerce Theory and Research	–	–	7.9%
Legal/Ethical Issues	–	4.7%	0.8%
Mobile User ***Sub-Total***	***1.7%***	***7.2%***	***12.5%***
Mobile Consumer Behavior[15]	1.7%	2.7%	3.2%
Technology Acceptance/Adoption/Use	–	[16]4.5%	9.3%
Mobile Business ***Sub-Total***	***56.9%***	***46.2%***	***25.8%***
Mobile Business Applications/Services[17]	37.0%	18.1%	9.0%
Economics, Strategy, and Business Models[18]	12.7%	14.8%	8.1%
Consumer Acceptance/Adoption	–	[16]4.5%	5.5%
Macroeconomic Cycles	–	–	0.8%
Government–Industry Interaction	0.4%	–	0.8%
Interorganizational Networks	–	–	0.4%
Infrastructure[19]	6.8%	8.8%	1.2%
Mobile Cases and Applications ***Sub-Total***	***12.0%***	***6.7%***	***9.3%***
Vertical-specific Applications[20]	11.1%	6.7%	5.8%
Organizational/Societal Impact and Change	0.9%	–	3.5%
Mobile Technology ***Sub-Total***	***29.3%***	***35.4%***	***36.0%***
Mobile Technology/Standards Development[21]	20.8%	16.2%	11.5%
Mobile Technology Use	–	[16]4.5%	3.3%
Usability (includes: Mobility)	1.7%	–	3.5%
Usefulness (includes: Content, Context)	5.1%	–	5.2%
Mobile Security	1.7%	9.4%	5.0%
Mobile Middleware (includes: "Agent Tech., dB Mgt.)	–	5.3%	1.1%
Features	–	–	6.4%
TOTAL	**100.0%**	**100.0%**	**100.0%**

Main Categories

Overall, these three studies were similar with respect to "Mobile Cases and Applications" and "Mobile Technology." They differed primarily in the current study's discovery of significant areas of interest with respect to "Mobile Theory and Research" and "Mobile User" issues, as well as the current study's relative de-emphasis of e-commerce, resulting in a smaller percentage of papers found in Mobile Business.

Perhaps because of our re-purposing of the subcategories contained under "Mobile Theory and Research," the sub-total of article codes found in this main category (16.4 percent) was significantly smaller than that of Ngai and Gunasekaran [2007] (this category contained 43.1 percent in their original paper). For example, their two most significant subcomponents, "M-commerce Behavioral Issues" (13.6 percent) and "M-commerce Economics, Strategy and Business Models" (12.9 percent) were addressed elsewhere in our model.

[14] This column's percentages recalculated from the original (in this article, we rounded down < .5)

[15] Includes: Mobile Entertainment Services/Games, Product Locating/Searching

[16] M-commerce Behavioral Issues (13.6 percent in original paper) is split evenly across these three categories

[17] Includes: M-commerce Overview, Context, Usage, Location-based Services, Mobile Financial Applications, Enterprise

[18] Includes: Mobile Advertising, Wireless Reengineering

[19] Includes: Networking, Networking Requirements, Wireless and Mobile Network

[20] Includes Healthcare, Emergency Alerts, Education, Media, Agriculture, Insurance, Real Estate

[21] Includes: Wireless and Mobile Protocols, Software, Wireless and Mobile Comm. Systems, 3G, Mobile Interfaces, Mobile Handheld Devices

Next, our "Mobile User" (12.5 percent) category absorbed some aspects of Scornavacca's [2006] "Consumer" (55.7 percent) category, as well as a portion of Ngai and Gunasekaran's [2007] "M-commerce "Behavioral Issues" (13.6 percent) category. As noted above, this category was small, but significant in our research.

Our re-purposing of "Mobile Cases and Applications" (9.3 percent) may explain the drop in representation from Ngai and Gunasekaran's (2007) "Mobile Commerce Applications and Cases" (20.4 percent) category. The only subcategory not moved was "M-commerce in individual companies or industries or countries" (6.8 percent), which was roughly equivalent to our subcategory "Vertical-specific Applications (5.8 percent).

Finally, our "Mobile Technology" (36.0 percent) category included Scornavacca et al.'s [2006] "Technology" (16.2 percent), "General" (7.2 percent), and "Industry" (3.4 percent), and some of the "Consumer" (55.7 percent) category. Adding up the components from Ngai and Gunasekaran's (2007) numerous technical categories ("Interfaces," "Handheld Devices," "Agent Technologies," "Database Management," "Security Issues," "Wireless and Mobile Communication Systems," "Wireless and Mobile Protocols," "Networking Requirements," and "Wireless and Mobile Network") yielded a similar percentage (36.7 percent) to our study.

Subcategories

The first item that a comparison with previous research enables is a determination of whether or not the current categories found are more comprehensive than that found in Scornavacca et al. [2006] and Ngai and Gunasekaran [2007]. As one might expect, because of the broader search criteria, this categorization includes numerous areas not represented in previous studies. Under the main category "Mobile Theory and Research, the subcategories "Theory Development," "Research Methods," "Mobile Commerce Theory and Research" were all new to this research, perhaps because we included more theory-development journals, but also perhaps because the field is beginning to mature.

Next, we found two new areas of study under the main category "Mobile Business": "Macroeconomic Cycles," and "Interorganizational Networks." Although both of these categories were under-represented, they are indicative of an initial inquiry into the context in which firm's operate, and the extent to which mobile computing enables or constrains that environment, and vice versa.

The lack of "Infrastructure" and "Mobile Middleware" articles was in stark contrast to Ngai and Gunasekaran (2007), who found 8.8 percent and 23.8 percent of their articles in these categories (although when re-categorized according to our schema, the "Mobile Middleware" figure dropped to 5.3 percent). This difference was almost certainly due to a different sample of journals drawn on in their research.

Finally, we found an initially surprising difference under the main category "Mobile Technology" in that "Features," which represented 6.4 percent of the total categories found was not present in previous research. This could be because of the representation by practitioner outlets, but is more surprising when comparing the trend over time, as features articles dominated the early discussion. Especially when comparing to Scornavacca et al. [2006], this might account for the discrepancy between the subcategory "Mobile Technology/Standards Development." In other words, although both Scornavacca et al. [2006] and Ngai and Gunasekaran [2007] called these subcategories by different names, it is possible that they were referring to the same set of issues.

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