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The Internet of Things: Application of Content Analysis to Assess a Contemporary Area of Academic Research

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Abstract

The rate at which new technologies and technological innovations are being introduced and widely disseminated is increasing at an exponential rate. Consequently, technology concepts and topics tend to evolve significantly over time. Therefore, it is important to review, analyze and assess the current state of technology concepts and topics reported in the research literature. The concept coined as the Internet of Things (IoT) in 1999 initially referred to the use of radio frequency identification to send product data over the Internet. Over the next two decades the description of IoT has evolved and greatly expanded. This research project collects, synthesizes, and analyses both the research methodologies and content (e.g., topics, focus, categories) of the academic literature focused on IoT, and then discusses an agenda for future research efforts and opportunities. We conducted a structured literature search and analyzed 214 articles published over the past twenty years (1999-2018) in forty-three top Information Systems (IS) journals listed in the Australian Deans' Business Council's (ABDC) 2019 journal quality list review. We found (1) an increasing level of academic research activity during this 20-year period; (2) a biased distribution of IoT articles focused on exploratory methodologies; (3) several research methods that were underrepresented or completely absent from the pool of research articles; and, (4) identified several topics that need further exploration. The compilation of the methodologies used and IoT topics being studied can serve to motivate researchers to strengthen current research and explore new areas of this research.

Keywords: Internet of Things, Literature Review, Content Analysis

1. INTRODUCTION

The Internet of Things (IoT) can be described as a collection of autonomous devices, sensors, data analytics, artificial intelligence, and communications technologies that will evolve the Internet from an information system (IS) dependent upon humans to assist in the collection, analysis, and storage of data to a system of systems with a marriage of virtual and physical subsystems collectively working, learning, repairing, and improving the IoT's ability to collect data and make the data-driven decisions necessary to improve, learn, and adapt to new environments. The widely varied application of IoT includes continuous improvement of supply chains (Papert and Pflaum, 2017), cities (Hashem, Chang, Anuar, Adewole, Yaqoob, Gani, Ahmed, & Chiroma, 2016), homes (Talbot, Temple, Carbino, & Betances, 2018), autonomous cars (Derikx, de Reuver, & Kroesen, 2016), wearable devices (Liu, Liu, Wan, Kong, & Ning, 2016), and even toys (Brito, Dias, & Oliveira, 2018). There are no uniformly adopted protocols or standards on how the IoT will be built, and therefore the following issues must be addressed: (a) implementing technologies; (b) coordinating secure communication across an unprecedented number of devices in real time; and, (c) protecting the confidentiality, integrity, and availability of data collected via the IoT. The ability to acquire such large quantities of quality data about individual users, hardware, applications, metadata, and the environment through the IoT is a new phenomenon.

With implications as varied as these, a periodic review of the literature can be helpful to assess current research and plan for future research projects to investigate the results of these applications of the IoT to how we live and work. To this end, this paper is designed to be what Palvia, Kakhki, Ghoshal, Uppala, and Wang (2015) would categorize as a literature analysis because this paper critiques, analyzes, and extends existing literature and attempts to build new groundwork. A literature review which analyses the current literature is important to progress the field of IS (Webster & Watson, 2002). A systematic literature review subsequent analysis is difficult for a variety of reasons (vom Brocke, Simons, Riemer, Niehaves, Plattfaut, & Cleven, 2015). First, IS research is a diverse discipline with a variety of reference disciplines and research themes (Benbasat & Weber, 1996). Second, IS research results are created and published at an increasingly higher rate with a more frequent use of multiple authors across a wide variety of knowledge domains (Peffers & Hui, 2003). Third, literature searches can produce unknown results, are notoriously difficulty to plan, are dependent on wildly different research database results, and for these reasons terminating a literature review successfully can be difficult. Finally, while literature reviews are quite common in IS research, no common standards exist for conducting literature reviews (and subsequent analyses), and the nature of methodologies used in cross-disciplinary research studies in IS inhibits the creation and adoption of such strategies (vom Brocke et al., 2015).

Building on the analysis of 127 IoT articles by Whitmore, Agarwal, and Xu (2015) and a co-citation analysis of 68 articles conducted by Ng, Wu, Yung, Ip, & Cheung (2018), this paper attempts to answer the research question: What is the current state of IoT research in the top academic information systems journals? The following sections of the paper will examine the current literature to determine what is known about the concept of the IoT. The remainder of this paper is organized as follows: a description of the methodology for the analysis of the IoT research is presented. This is followed by the results. Finally, the research is summarized with a discussion of the limitations of this project and suggestions for future research.

2. METHODOLOGY

The approach to the analysis of the IoT research is to capture the trends pertaining to (1) the number and distribution of IoT articles published in the leading journals, (2) methodologies employed in IoT research, and (3) the research topics being published in this research. During the analysis of this literature, we attempted to identify gaps and needs in the research and therefore enumerate and discuss a research agenda which allows for the progression of research (Webster & Watson, 2002). In short, we hope to paint a representative landscape of the current IoT literature base in order to influence the direction of future research efforts in this important area of study.

In order to examine the current state of research on IoT, the authors conducted a literature review and analysis in three phases. Phase 1 accumulated a representative pool of articles. Phase 2 classified the articles by research method. Phase 3 classified the research by research topic. Each of the three phases is discussed in the following paragraphs.

Phase 1: Accumulation of Article Pool
We used the Web of Science (WoS) citation database to search for research articles with a focus on IoT. The search parameters were constrained based on (a) a list of top ranked journals, (b) a specific time range, and (c) key search terms. First, the researchers chose to use the Australian Business Dean's Council (ABDC, 2018) ranking of journals because the ABDC is a newer ranking and to avoid the "ethnocentric American perspective" that Palivia et al. (2015) warned was prevalent in many IS journal rankings. Then, we filtered the ranking of journals to include only information systems journals (Code 0806) and collected the list of A* and A journals (see Table 1 in Appendix A). The journals Communications of the ACM and MISQ Executive were dropped from the search parameters due to their practitioner focus.

Kevin Ashton (2009) is credited with for coining the phrase "Internet of Things" during a presentation at Proctor & Gamble in 1999 which described his work as Executive Director of the Auto-ID Center at the Massachusetts Institute of Technology (MIT). The IoT is evolving into a system of systems using such varied technologies as cloud computing, radio frequency identification (RFID), wireless sensor networks (WSN), big data analytics, and an everchanging mix of architectures, protocols, hardware, and applications. Many of these technologies that enable the IoT did not exist prior to the widespread adoption and dissemination of the public Internet and the Worldwide Web (WWW). Therefore, the search parameters were further constrained based on the historical timeframe in which technologies capable of facilitating the development of IoT were first introduced. Therefore, the search parameters for the WoS search was constrained to the time period of January of 1999 through December of 2018.

The final constraint was based on the key search term "Internet of Things." In the WoS search engine scanned for the term 'Internet of Things" and close variations of this term found in the title, abstract, and keywords of articles published in the ABDC information systems' list of A* and A journals between January of 1999 and December of 2018. Once non-research articles (book reviews, editorials, commentary, etc.) were removed, 214 articles remained in the final composite article data pool for analysis. All 214 article files were collected in Adobe Acrobat form and loaded into NVivo 11 to run a word frequency query of the content without numbers and extemporaneous words (i.e. a, and, the, etc.). Figure 1 shows the word cloud that resulted from this query.

Figure 1. Word Cloud from NVivo 11

Phase 2: Classification by Research Methodology
Once the researchers identified the articles for the final data pool, each article was examined and categorized according to its research methodology. Due to the subjective nature of research methodology classification, content analysis methods were used for the categorization process. Figure 2 illustrates steps in the content analysis process adapted from Neuendorf (2017) and successfully employed by several similar research studies (Corley, Jourdan, & Ingram, 2013; Corley, Jourdan, & Rainer, 2011; Cumbie, Jourdan, Peachey, Dugo, & Craighead, 2005; Jourdan, Rainer, & Marshall, 2008). The fourteen research methodologies were adopted from Palvia, Kakhki, Ghoshal, Uppala, and Wang (2015), who extended the research methodologies initially described by Palvia, P., Mao, E., Salam, A.F., and Soliman (2003) and later updated by Palvia, Leary, Mao, Midha, Pinjani, and Salam (2004).

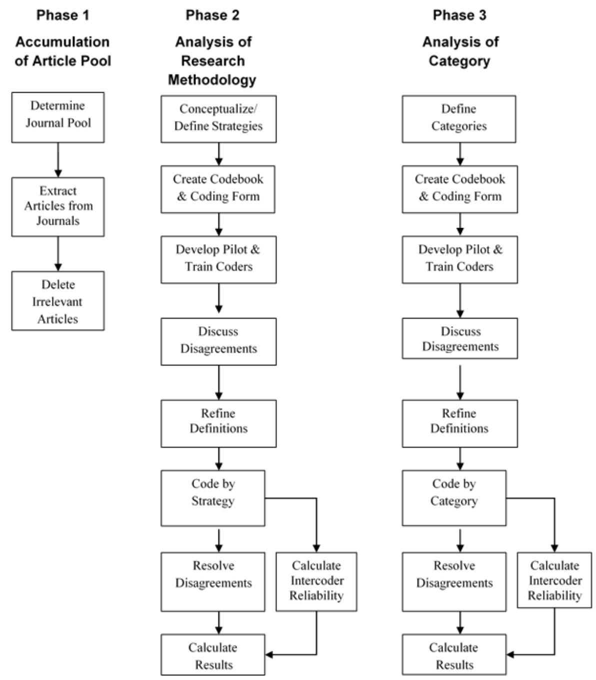

Figure 2. Overview of Literature Analysis Process

Second, to guard against the threats to reliability (Neuendorf, 2017), we performed a pilot test on articles not included in the final data pool for this study. Researchers independently categorized the articles in the pilot test based on the best fit among the fourteen research methodologies. After all articles in the pilot test were categorized, the researchers compared their analyses. In instances where the independent categorizations did not match, the researchers re-evaluated the article collaboratively by reviewing the research methodology definitions, discussing the disagreement thoroughly, and collaboratively assigning the article to a single methodology. This process allowed the researchers to develop a collaborative interpretation of the research methodology definitions. Simply stated, this pilot test served as a training session for accurately categorizing the articles for this study.

Each research methodology is defined by a specific design approach and each is also associated with certain tradeoffs that researchers must make when designing a study. These tradeoffs are inherent flaws that limit the conclusions that can be drawn from a particular research methodology. These tradeoffs refer to three aspects of a study that can vary depending on the research strategy employed. These variable aspects include: generalizability from the sample to the target population (external validity); precision in measurement and control of behavioral variables (internal and construct validity); and the issue of realism of context (Scandura & Williams, 2000).

Two coders independently reviewed and classified each article according to research methodology. The coders categorized only a few articles at a time to minimize coder fatigue and thus protect intercoder reliability (Neuendorf, 2017). Upon completion of the classification process, we tabulated agreements and disagreements. Then, intercoder reliability (κ = .82) using Cohen's Kappa (Cohen, 1960) and Krippendorf's Alpha (Krippendorf, 2013) for each methodology (α = .82) was calculated. Neuendorf (2017) suggests that a Cohen's kappa greater than .800 is considered acceptable. Krippendorf (2013) stated that researchers could use reliability scores greater than .800. Therefore, the calculations for intercoder reliability were well within the acceptable ranges. We calculated the reliability measures prior to discussing disagreements as mandated by Weber (1990). If the original reviewers did not agree on how a particular article was coded, a third reviewer arbitrated the discussion of how the disputed article was to be coded. This process resolved the disputes in all cases.

Phase 3: Categorization by IoT Research Topic

Typically, the process of categorizing research articles by a specific research topic involves an iterative cycle of brainstorming and discussion sessions among the researchers. This iterative process helps to identify common themes within the data pool of articles. Through the collaborative discussions during this process researchers can synthesize a hierarchical structure within the literature of overarching research topics and more granular level subtopics. The final outcome is a better understanding of the current state of a particular stream of research. This iterative process was modified for this specific study on the topic of IoT.

To guard against the threats to reliability (Neuendorf, 2017), we once again performed a pilot test on articles not included in the final data pool for this study. Following the adoption of the six research topic categories, this second pilot study was used as a training session for categorizing articles by research topic. Researchers independently categorized the articles in the pilot test based on the best fit among the six research topics. After all articles in the pilot test were categorized, the researchers compared their analyses. In instances where the independent categorizations did not match the researchers re-evaluated the article collaboratively by reviewing the research category definitions, discussing the disagreement thoroughly, and collaboratively assigning the article to a single category. This process allowed the researchers to develop a collaborative interpretation of the research topic definitions.

Once we established the topic definitions, we independently placed each article in one IoT category. As before, we categorized only a few articles at a time to minimize coder fatigue and thus protect intercoder reliability (Neuendorf, 2017). Upon completion of the classification process, we tabulated agreements and disagreements. Then, intercoder reliability (κ = .84) using Cohen's Kappa (Cohen, 1960) and Krippendorf's Alpha (Krippendorf, 2013) for each topic (α = .84) was calculated. Again, the two calculations were well within the acceptable ranges (Neuendorf, 2017; Krippendorf, 2013). We again calculated the reliability measures prior to discussing disagreements as mandated by Weber (1990). If the original reviewers did not agree on how a particular article was coded, a third reviewer arbitrated the discussion of how the disputed article was to be coded. This process also resolved the disputes in all cases.

3. RESULTS

In order to identify gaps and needs in the research (Webster & Watson, 2002), we hope to paint a representative landscape of the current IoT literature base in order to influence the direction of future research efforts in this important area of study. In order to examine the current state of this research, the authors conducted a literature review and analysis in three phases. Phase 1 accumulated a representative pool of IoT articles, and the articles were then analyzed with respect to year of publication, journal, and author. Phase 2 contains a short discussion of the research methodologies set forth by Palvia et al. (2004) and the results of the classification of the articles by those methodologies. Phase 3 involved the creation and use of six IoT research topics, a short discussion of each topic, and the results of the classification of each article within the research topics. These results are discussed in the following paragraphs.

Results of Phase 1

Using the described search criteria within the selected journals, we collected a total of 214 articles (For the complete list of articles in our sample, see Appendix D). In phase 1, we further analyzed the articles' year of publication, journal, and author. Figure 3 shows the number of articles per year in our sample. There is a dramatically increasing trend over the last five years in the sample. The vast majority (80%) of the articles in the last twenty years have been published in the years 2014 through 2018. With issues related to the Internet of Things becoming ever more important to researchers and practitioners, this comes as no surprise.

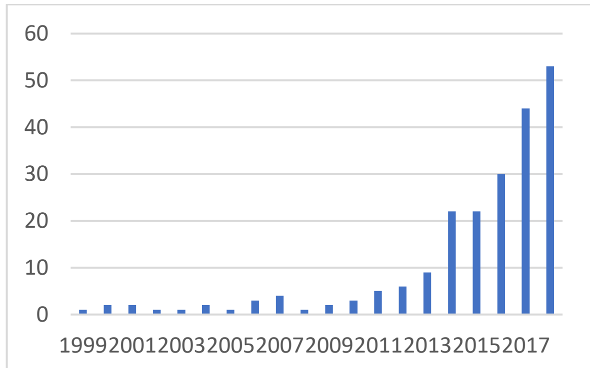

Figure 3. Number of IoT Articles per Year

In addition to number of IoT articles being published per year, we analyzed the productivity of authors who published in this research sample by assigning scores based upon each author's share of each article. Because most articles in our sample were projects with multiple authors, we decided that each co-author would be given an equal share of the credit. For example, an author who published an article alone was assigned a score of 1.0, two authors earned a score of .500 each, and so on. The scores for each author were totaled, the authors were sorted from highest to lowest scores, and the results of the top 49 authors are displayed in Table 2. Authorship order was not calculated into this formula. This system rewards both quantity of research and ownership of research. While the author ranked first (L. D. Xu) had the highest score by sharing in eleven different articles, our second ranked author (N. Kshetri) had two sole-author articles, and the third ranked author (A. J. Jara) had six multi-author articles in this sample. When two or more authors received the same score, their corresponding ranking was a tie. For example, 28-way tie existed for position seven, a 3-way tie for position nine, and a 67-way tie for the rank of twenty.

#	Author	Score
1	**Xu, L. D.**	**2.06**
2	**Kshetri, N.**	**2.00**
3	**Jara, A. J.**	**1.49**
4	**Sun, Y. C.**	**1.33**
5	**Chang, V.**	**1.21**
6	**Sood, S. K.**	**1.08**
7	Adewale, O. S.	1.00
8	Beltran, M.	1.00
9	Best, K.	1.00
10	Bornman, E.	1.00
11	Bruce, H.	1.00
12	Bygstad, B.	1.00
13	Caelli, W. J.	1.00
14	Chmielewski, J.	1.00
15	Das, S.	1.00
16	Eachempati, P.	1.00
17	Frost, C.	1.00
18	Furnell, S.	1.00
19	Hale, T. M.	1.00
20	Hawryszkiewycz, I. T.	1.00
21	Jennex, M. E.	1.00
22	Khazanchi, D.	1.00
23	Kim, B. W.	1.00
24	Krawczyk, B.	1.00
25	Kuhn, E.	1.00
26	Lee, C. S.	1.00
27	Palmer, C. C.	1.00
28	Papsdorf, C.	1.00
29	Prasopoulou, E.	1.00
30	Shepherd, S. J.	1.00
31	Shin, D. H.	1.00
32	Veith, R. H.	1.00
33	Weber, T. A.	1.00
34	Zhu, D. J.	1.00
35	**He, W.**	**0.84**
36	**Barrett, M.**	**0.83**
37	**Skarmeta, A. F.**	**0.83**
38	**Zamora, M. A.**	**0.83**
39	**Sheng, Z. Q.**	**0.82**
40	**Zheng, L. R.**	**0.79**
41	**Manaa, M.**	**0.75**
42	**Bi, Z. M.**	**0.73**
43	**Chen, X.**	**0.67**
44	**Wang, J. P.**	**0.66**
45	**Zhou, Z. B.**	**0.62**
46	**Zhang, J. S.**	**0.58**
47	**Chen, Q.**	**0.55**
48	**Pang Z. B.**	**0.52**
	*** Bold = Multiple Articles**	

Table 2. Authors Ranked by Score

Results of Phase 2

The results of the categorization of the 214 articles in the sample published over the twenty-year period from January of 1999 to December of 2018 categorized with respect to the fourteen research methodologies described by Palvia et al. (2004) are summarized in Table 3 [See Appendix B]. Of the 214 articles, 71 articles (33.2%) were classified as Frameworks and Conceptual Model making it the most prevalent research methodology. This was followed by Mathematical Modelling with 43 articles (or 20.1%), Laboratory Experiment with 21 articles (9.8%), and Speculation/Commentary with 15 articles (7.0%). Case Study and Secondary Data tied at 13 articles each (6.1%). These six research methodologies composed 82.3% of the articles in the sample. No articles were classified as a Literature Reviews or Content Analysis. So, the remaining six research methodologies represented the remaining 17.7% of the sample with respect to research methodology.

Further analysis showing the research methodologies illustrates that Case Study, Interview, Field Experiment, and Field Study are poorly represented methodologies in this research sample. These four methodologies have a high degree of realism because the data is collected from individuals or organizations, and the low percentages of these research methodologies indicate the beginnings of a body of research (Scandura & Williams, 2000). Further categorization and analysis of the articles with respect to IoT topic categories was conducted in the third phase of this research project.

Results of Phase 3

Table 4 shows the number of articles per IoT research topic category. These six categories provided a topic area classification for all the 214 articles in our research sample. Of the 214 articles, 43.0% were classified as 'Architecture' making it the most prevalent IoT topic category. This category was followed by 'Applications' (21.5%), 'Privacy and Security' (20.1%), and 'Users" (8.9%). These four IoT topics accounted for 93.5% of the articles in the sample. The topics "Business Models' (3.7%) and 'Research' (2.8%) accounted for a very small percentage of the research. The high percentage of articles focused on the building phases of IoT (Architecture) indicates the IoT is still in the designing and build phase, and we could be years away from what the completely autonomous IoT world envisioned by futurists. The evidence that IoT technologies are being deployed in a variety of industries is indicated by the Application category which describes how these technologies are being used now by organizations in a variety of industries.

Research Topics	Key Concepts	IoT Articles	%
Applications	Using IoT in real-world implementations	46	21.5%
Architecture	How IoT is built and manages itself, hardware, organization of hardware, sensor networks, algorithms	92	43.0%
Business Models	Business methods using IoT technologies	8	3.7%
Privacy and Security	Privacy issues, security of IoT networks, secure communications among IoT devices	43	20.1%
Research	Research on information systems as a discipline	6	2.8%
Users	Issues related to users (examples: digital divide, intention to use, usage behavior, etc.)	19	8.9%
	Total:	**214**	**100.0%**

Table 4. Topics in IoT Research

By plotting IoT research topics against research methodologies (Table 5 – See Appendix C), many of the gaps in IoT research are exposed. The gaps are at the intersection of less used methodologies and less studied domains in IoT. In our minds, these gaps exist for two reasons. First, some of these research methodologies are not as prevalent in IS research, and some top IS journals do not accept papers that use unusual research methodologies. So, researchers avoid unorthodox methodologies. The reason that some of these IoT topics have not been studied is they represent a relatively new phenomena, the research has not caught up with the business reality, and it is difficult to find organizations who have data on their new IoT deployment even if those organizations were open to being studied. The great news for researchers interested in IoT is that this domain should provide research opportunities for years to come.

4. LIMITATIONS AND DIRECTIONS FOR FUTURE RESEARCH

The current analysis of the IoT literature is not without limitations and should be offset with future efforts. Future literature collections could expand article searches to search a broader range of research outlets (including B journals from the ABDC list) and include other IoT related search terms. Our literature analysis is meant to serve as a representative sample of articles and not a comprehensive and exhaustive analysis of the entire population of articles published on the topic of 'Internet of Things'. Future studies could explore the various architectural components used in these systems of systems and investigate how organizations are applying the IoT technologies and measure the results from an organizational perspective. As more firms deploy these technologies, new business models will emerge and will need description and measurement. As privacy and security threats emerge and countermeasures are developed, these too will need to be explored in the IS research. This IoT will operate on a global scale and will likely disrupt information ownership, economic systems, political power, and how humans exist in ways that can only be imagined in the same way our society knew the implications of the Internet as it was being implemented a generation ago.

Clearly, future studies should consider the identified gaps and consider developing future research projects using a variety of research methodologies across the six IoT research topics. Future efforts could consider applying methodologies across the six IoT topics and vice versa because this research domain is still in a very exploratory stage. This research sample analyzed showed much of the research the new technologies and issues in the IoT research without attempting to explain the fundamental issues of IS research. This is to be expected in the exploratory stages of research in a subject area. This absence of coordinated theory development causes the research in IoT to appear haphazard and unfocused as a knowledge stream and not speaking to any individual research project. The good news is that many of the topics and methodologies in this research are open for future development. We hope that this literature analysis has laid the foundation for such efforts that will enhance the IS body of knowledge and theoretical progression relative to the IoT.

5. CONCLUSIONS

This research study collects, synthesizes, and analyses both the research methodologies and content (e.g., topics, focus, categories) of 214 articles published over the past twenty years (1999-2018) in forty-three top Information Systems (IS) journals as ranked by the Australian Deans' Business Council. Over the twenty-year period from 1999 to 2018 we found a significant increase in the number of IoT articles published each year beginning in 2014 with a biased distribution of IoT articles focused on exploratory methodologies. Specifically, 33.2% of the IoT research articles in our sample were categorized as Frameworks and Conceptual Model making it the most prevalent research methodology. This was followed by Mathematical Modelling at 20.1%, Laboratory Experiment at 9.8%, Speculation/Commentary at 7.0%, and both Case Study and Secondary Data tied with 6.1%. These six research methodologies composed 82.3% of the articles in the sample.

We also found several research methods that were either underrepresented or absent from the pool of research. First, we would like to highlight the fact that no articles were categorized as a Literature Reviews or Content Analysis. Therefore, our research current study represents a significant contribution to the field of IoT research. The remaining six research methodologies combined (literature analysis, survey, field study, field experiment, qualitative research, and interview) represented the remaining 17.7% of the sample with respect to research methodology. This biased towards exploratory research methods typically occurs when researchers are investigating a new phenomenon.

We identified several topics that need further exploration. More specifically, of the 214 articles, 43.0% were classified as 'Architecture' making it the most prevalent IoT topic category. This category was followed by 'Applications' at 21.5%, 'Privacy and Security' at 20.1%, and 'Users" at 8.9%. These four IoT topics accounted for 93.5% of the articles in the sample. The topics "Business Models' (3.7%) and 'Research' (2.8%) accounted for a very small percentage of the research. The high percentage of articles focused on the building phases of IoT (Architecture) indicates the IoT is still in the designing and build phase, and we could be years away from what the completely autonomous IoT world envisioned by futurists. The compilation of the methodologies used and IoT topics being studied can serve to motivate researchers to strengthen current research and explore new areas of this research.

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Editor’s Note:

This paper was selected for inclusion in the journal as the CONISAR 2020 Best Paper The acceptance rate is typically 2% for this category of paper based on blind reviews from six or more peers including three or more former best papers authors who did not submit a paper in 2020.

Appendix A – Table 1

Rating	Journal	Abbreviation	Count	%
A*	ACM Transactions on Computer-Human Interaction	ACMTCHI	8	3.7%
A*	Decision Support Systems	DSS	8	3.7%
A*	European Journal of Information Systems	EJIS	3	1.4%
A*	Information & Management	I&M	3	1.4%
A*	Information and Organization	I&O	1	0.5%
A*	Information Systems Journal	ISJ	0	0.0%
A*	Information Systems Research	ISR	2	0.9%
A*	Journal of Information Technology	JIT	2	0.9%
A*	Journal of Management Information Systems	JMIS	1	0.5%
A*	Journal of Strategic Information Systems	JSIS	0	0.0%
A*	Journal of the Association for Information Systems	JAIS	2	0.9%
A*	MIS Quarterly	MISQ	1	0.5%
A	Applied Ontology	AO	2	0.9%
A	Australasian Journal of Information Systems	AJIS	1	0.5%
A	Behavior & Information Technology	B&IT	4	1.9%
A	British Journal of Educational Technology	BJET	1	0.5%
A	Business & Information Systems Engineering	B&ISE	1	0.5%
A	Communications of the ACM #	CACM	0	0.0%
A	Communications of the Association for Information Systems	CAIS	2	0.9%
A	Computers & Security	CS	26	12.1%
A	Data & Knowledge Engineering	D&KE	6	2.8%
A	Data Base for Advances in Information Systems	DBAIS	2	0.9%
A	Electronic Commerce Research	ECR	2	0.9%
A	Electronic Markets	EM	3	1.4%
A	Enterprise Information Systems	EIS	17	7.9%
A	IBM Systems Journal	IBMSJ	1	0.5%
A	Information and Software Technology	I&ST	1	0.5%
A	Information Communication & Society	IC&S	4	1.9%
A	Information Systems Frontiers	ISF	22	10.3%
A	Information Technology & People	IT&P	1	0.5%
A	International Journal of Cooperative Information Systems	IJCIS	1	0.5%
A	International Journal of Information Management	IJIM	9	4.2%
A	International Journal of Medical Informatics	IJMI	2	0.9%
A	Internet Research-Electronic Networking Applications and Policy	IRENA&P	2	0.9%
A	Journal of Computer Information Systems	JCIS	2	0.9%
A	Journal of Global Information Management	JGIM	3	1.4%
A	Journal of Knowledge Management	JKM	1	0.5%
A	Journal of Organizational Computing and Electronic Commerce	JOC&EC	4	1.9%

A	Journal of the American Medical Informatics Association	JAMIA	2	0.9%
A	Journal of the American Society for Information Science and Technology	JASIS&T	2	0.9%
A	Journal of the Association for Information Science and Technology	JAIS&T	1	0.5%
A	Knowledge-Based Systems	KBS	6	2.8%
A	MIS Quarterly Executive #	MISQE	0	0.0%
A	Personal and Ubiquitous Computing	P&UC	48	22.4%
A	The Information Society	IS	4	1.9%
		Total:	**214**	**100.0 %**

Table 1. A* and A Journals from ABDC and Number of Articles

Appendix B – Table 3

Methodology	Definition	IoT Articles	%
Speculation/Commentary	Research that derives from thinly supported arguments or opinions with little or no empirical evidence.	15	7.0%
Frameworks and Conceptual Model	Research that intends to develop a framework or a conceptual model.	71	33.2%
Literature Review	Research that is based mainly on the review of existing literature.	0	0.0%
Literature Analysis	Research that critiques, analyzes, and extends existing literature and attempts to build new groundwork, e.g., it includes meta-analysis.	4	1.9%
Case Study	Study of a single phenomenon (e.g., an application, a technology, a decision) in an organization over a logical time frame.	13	6.1%
Survey	Research that uses predefined and structured questionnaires to capture data from individuals. Normally, the questionnaires are mailed (now, fax and electronic means are also used).	12	5.6%
Field Study	Study of single or multiple and related processes/ phenomena in single or multiple organizations.	2	0.9%
Field Experiment	Research in organizational setting that manipulates and controls the various experimental variables and subjects.	5	2.3%
Laboratory Experiment	Research in a simulated laboratory environment that manipulates and controls the various experimental variables and subjects.	21	9.8%
Mathematical Modelling	An analytical (e.g., formulaic, econometric or optimization model) or a descriptive (e.g., simulation) model is developed for the phenomenon under study.	43	20.1%
Qualitative Research	Qualitative research methods are designed to help understand people and the social and cultural contexts within which they live. These methods include ethnography, action research, case research, interpretive studies, and examination of documents and texts.	7	3.3%
Interview	Research in which information is obtained by asking respondents questions directly. The questions may be loosely defined, and the responses may be open-ended.	8	3.7%
Secondary Data	A study that utilizes existing organizational and business data, e.g., financial and accounting reports, archival data, published statistics, etc.	13	6.1%
Content Analysis	A method of analysis in which text (notes) are systematically examined by identifying and grouping themes and coding, classifying and developing categories.	0	0.0%
	Total:	**214**	**100.0%**

Table 3. Methodologies in IoT Research (from Palvia et al., 2004)

Appendix C – Table 5

	IoT Topics							
Methodology	1	2	3	4	5	6	Total	%
Speculation/Commentary	3	4		5	2	1	**15**	**7.0%**
Frameworks and Conceptual Model	14	37	5	15			**71**	**33.2%**
Literature Review							**0**	**0.0%**
Literature Analysis		1	1		2		**4**	**1.9%**
Case Study	10	2			1		**13**	**6.1%**
Survey	1	3	1	1		6	**12**	**5.6%**
Field Study	2						**2**	**0.9%**
Field Experiment	3	2					**5**	**2.3%**
Laboratory Experiment	1	11		8		1	**21**	**9.8%**
Mathematical Modelling	8	23	1	10		1	**43**	**20.1%**
Qualitative Research	1	3		1	1	1	**7**	**3.3%**
Interview		1		1		6	**8**	**3.7%**
Secondary Data	3	5		2		3	**13**	**6.1%**
Content Analysis							**0**	**0.0%**
Total	**46**	**92**	**8**	**43**	**6**	**19**	**214**	**100.0%**
Percentage	**21.5%**	**43.0%**	**3.7%**	**20.1%**	**2.8%**	**8.9%**	**100.0%**	

1=Applications
2=Architecture
3=Business Models
4=Privacy and Security
5=Research
6=Users

Table 5. Research Methodologies vs. Topics in IoT Research

Appendix D – Data Sample (214 IoT Articles)

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