



# IEEE Communications Innovation and Standardization Survey

## VERSION 1: PRE-ISICT REVIEW

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### Introduction

This report is an analysis of the results of the IEEE Communications Innovation and Standardization Survey. This survey was carried out on behalf of the Innovation & Standards in Information & Communication Technologies (ISICT) Emerging Technologies committee to help understand the knowledge and opinion of IEEE membership on the topics addressed by ISICT.

The survey consisted of 19 questions, including typical member demographic information such as gender, region, IEEE grade, etc. The majority of the questions requested the respondent to enter open text, which requires more time and effort to thoroughly answer when compared to the kind of multiple choice questions commonly found in surveys.

This report is divided into sections based upon the types of questions addressed by the survey. The first section, *Importance and Support for Innovation in Communications* (Questions 1 and 2) addresses members' opinions on the importance of innovation in communications, and how well the topic is being addressed within the IEEE as a whole and the IEEE Communications Society in particular. The next section, *Ability to Identify and Predict Innovation* (Questions 3 and 4), addresses how respondents identify and predict trends in innovation. The next section, *Scholarly Activities Addressing Innovation and Communications* (Question 5), is focused upon how respondents feel the topic should be addressed. In *Changing the Impact Factor to Address Innovation* (Questions 6, 6a, and 6b), the question of how bibliometrics should be used to better drive innovation is analyzed. Next, *Understanding Innovation* (Question 7) considers what members would like to see regarding studies on innovation and communication. The section, *The Relationship between Innovation and Standardization* (Questions 8, 9, and 10), considers how members view the relationship between innovation and standardization in communications. *Innovation and Standardization Publications* (Questions 11 and 12) seeks the opinions of respondents on what they would like to see in a transactions and magazine on innovation and standardization. Then we

move on to considering the primary challenges in understanding innovation and standardization in *Identifying Key Challenges to Understanding Innovation and Standardization* (Question 13). The section, *Papers and Experts on Innovation and Standardization* (Questions 15 and 16), seeks respondents' opinions regarding the best papers and experts on the topic of innovation and standardization. The section, *Tools and Processes for Innovation and Standardization* (Question 17), asks respondents' views on tools and processes that would best address standardization and innovation. Finally, the last section of the survey is discussed in *Unsolicited Feedback* (Question 18). This report ends by summarizing the main takeaways from the survey analysis in the *Conclusion*. There are two appendices: *Appendix 1: Latent Semantic Analysis* explains further detail on how the free-form text was analyzed. The survey questions, as presented to the respondents, are included in *Appendix 2: The Survey*.

A total of 208 out of 3,020 questionnaires were completed and returned. This is a return rate of approximately 6.9%. Comparison of the membership grades of the survey respondents versus the membership grades of IEEE Communications Society as a whole at the time the survey was taken is shown in Figure 1.

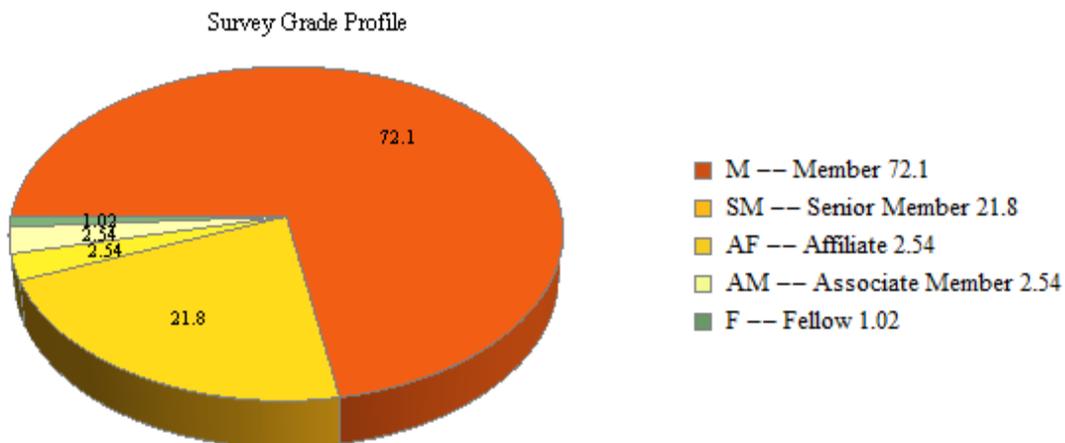


Figure 1: Member grade composition of the survey respondents.

Figure 2 compares the respondents' membership grade compared with the IEEE Communications Society grade distribution as a whole. More Members and Senior Members responded to the survey than comprise the general Communications Society population. Slightly fewer Fellows responded to the survey than exist in the population. While this could be an aberration, it could also reflect that Fellows are typically older and at a stage of their career where they are less interested in innovation or exploring innovative concepts.

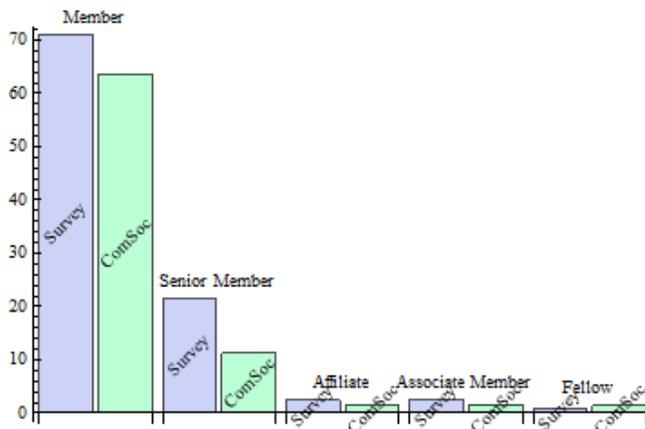


Figure 2: Survey respondent grade versus Communications Society membership grade.

## Executive Summary of the Survey

The survey has provided an interesting and useful perspective on innovation and standardization as summarized in this section. The subsequent sections of this report will discuss results in detail.

A significant result immediately apparent from the survey is that general knowledge of theories of innovation is lacking. No respondent had knowledge of general theories of innovation or related techniques, such as TRIZ, although there were vague references to the Theory of Diffusion of Innovations. While researchers with such knowledge, whether formally learned or instinctive, tend to have many more patents and useful publications, the number of publications and patents of respondents was not measured in this survey. There was relatively little distinction between innovations from the past century and prediction of future innovations in the survey. By definition, an innovation should be original. This shows that even precisely identifying an innovation is difficult. Understanding innovation itself was classified as a key challenge in the survey results.

There were many responses about having more conferences, workshops, and publications on this topic. A majority suggested that the current bibliographic metrics are insufficient to determine or drive innovation. Many insightful ideas were given for better metrics. Furthermore, there seem to be two groups of respondents that are interested in gaining knowledge on innovation and standardization, namely, the academic research community and industry. The former group of respondents has shown interest in understanding different ways by which knowledge of innovations can be effectively disseminated to the academic community in order for it to build upon them. Both groups are interested in understanding ways to manage innovation, starting from its inception until its effective and timely commercialization. A majority of respondents felt that standards and innovation were moderately to somewhat related. Only those who responded that they did not see innovation and standardization as related felt standards and innovation to be

antithetical. Few respondents, on the other hand, said that there is a positive interaction between standards and innovation, noting that they need and drive one another.

Respondents have listed a wide range of topics that can be considered by ISICT for the creation of a magazine and/or transaction on innovation and standardization. It is also worth pointing out that a significant number of respondents expressed that a magazine is more appropriate than a transaction to cover topics on innovation and standardization. A transaction is needed for a “theory” of innovation while a magazine can cover topics spanning examples of innovation. It is clear from the responses that a key challenge is closing the gap between industry and academia; this was classified as the most important challenge to understanding innovation and standardization followed by an understanding and precise definition of innovation itself.

As mentioned, theories of innovation were not something many of the respondents could comment upon. “Innovation” appeared to be often viewed as a business/managerial topic for enhancing researcher productivity rather than something that (industry/academic) researchers understand themselves. In other words, it is something that managers do to direct (academic/industrial) research. In that regard, it should be something professors are knowledgeable about in order to guide their own research or their graduate student research. But in all cases, knowledge of the topic was found to be lacking in this survey. Along similar lines, it was observed that a significant number of respondents left blank responses for the question about seeing good papers on this topic. With the exception of a couple of mentions about Clayton Christensen, who is a world-renown pioneer in disruptive innovation, not a single respondent identified a known expert on innovation theory nor any known innovation process such as TRIZ and the theory of diffusion of innovations. Some respondents identified organizations and leaders who they felt were in the forefront of innovation in communications. However, most of the respondents seem to be unaware of the difference between inventors and innovation theorists. As pointed out earlier, the responses to these questions clearly portray the lack of awareness about studies on innovation.

Respondents have shared creative ideas on tools and processes that may help to apply theories on innovation and standardization to work in academia and industry. They also have expressed the need for tools to analyze relationships between innovations, knowledge management, and learning aids.

The ISICT intends to utilize the results of this survey to plan activities that address various aspects of the study of innovation and standardization. ISICT can formulate and popularize better metrics. Clearly, promoting activities such as conferences, workshops, and publications on this topic is a key part of ISICT’s *raison d’être* (reason for being).

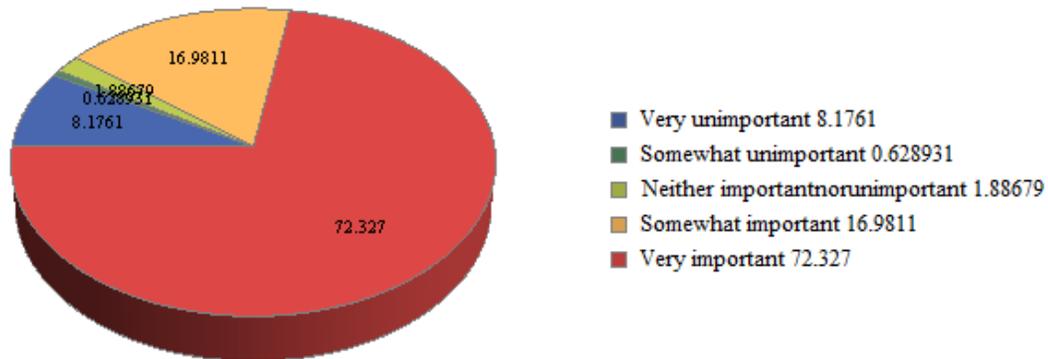
## Importance and Support for Innovation in Communications

Questions 1 and 2 were simple multiple-choice questions designed to ascertain whether the study of innovation is considered important by the respondents with regard to communication technology and whether the IEEE is performing well in this area.

*Question 1: How important or not is the study of innovation in communications?*

*Question 2: How satisfied or not are you with how the IEEE Communications Society supports the study of innovation in communications technology?*

As one might expect, a majority of respondents felt that the study of innovation is important with regard to communication research. It was anticipated that everyone would suggest that innovation is important; yet unexpectedly, just over 10% of the respondents indicated that innovation is not important.



**Figure 3:(Q1) How important or not is the study of innovation in communications?**

Regarding how the IEEE is doing in the area of understanding innovation in Question 2, a majority feel “somewhat” to “very satisfied” that the IEEE is supporting this topic. On the other hand, just over 23% were less than somewhat satisfied. In fact, as we analyze the results further, we find that a large number of respondents are unclear regarding what innovation is and may not be fully aware of the role of IEEE in this area.

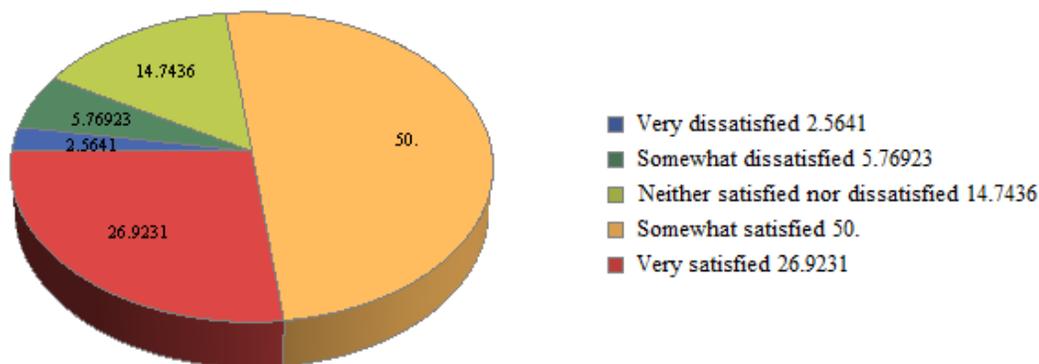


Figure 4:(Q2) How satisfied or not are you with how the IEEE Communications Society supports the study of innovation in communications technology?

### Ability to Identify and Predict Innovation

We asked open-ended questions for this survey because innovation, by definition, implies original solutions to problems and should not be constrained by closed, multiple-choice responses.

Question 3 asked the respondent to identify the top three innovations from the past:

*Question 3: What do you consider the top three innovations in communications within the last century?*

Question 4 was an opportunity to determine what the respondents felt the next major innovations would be:

*Question 4: What do you predict will be the next three important innovations in communications?*

The main purpose of these questions is to help understand how the respondents define innovation (based upon the examples they give). Questions 3 and 4 are related because they ask for the respondent to identify the top three innovations from the past century and then to predict the next three major innovations. One reason for these questions is to determine how respondents define innovation by giving examples. It is also interesting to see how the respondents' ideas of future innovation differs from those they identified as past innovations. In other words, were the respondents capable of either formulating or predicting future innovations that are markedly different from those of the past, that is, "think outside the box"?

Because these were designed as open-ended questions, they benefit from analysis using simple, natural language processing techniques. The simplest way to begin is to look at the word frequencies. There was some pre-processing; namely, obvious misspellings were corrected, words were changed to lower case, and common





private company and academia had many common terms, private companies tended to include more challenging restrictions such as “cost” and “limited.” Academia tended to use more general terms such as “abstraction” and “theory.”

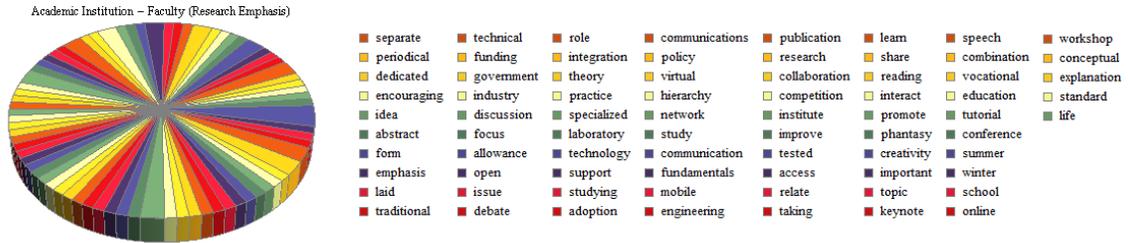


Figure 8:(Q4) Academic/Faculty/Institution terms predicting next three important innovations in communications.

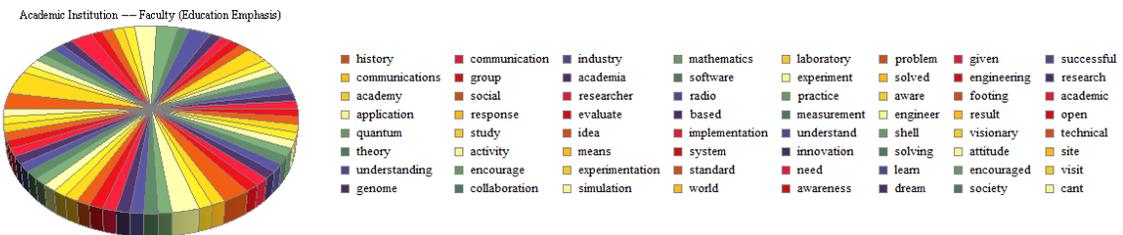


Figure 9:(Q4) Academic/Faculty/Education terms predicting next three important innovations in communications.

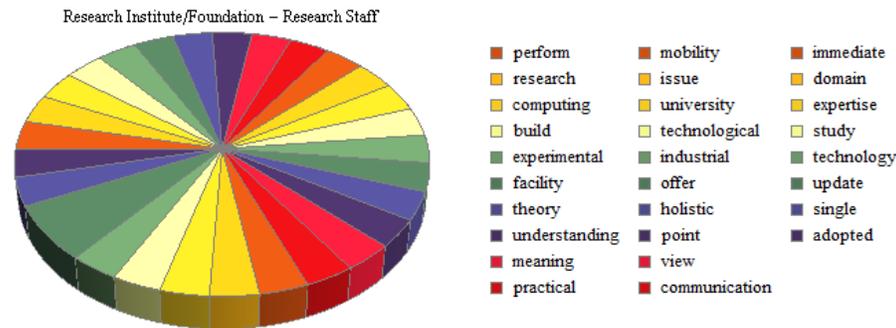


Figure 10:(Q4) Research Institute/Foundation Research Staff terms predicting next three important innovations in communications.

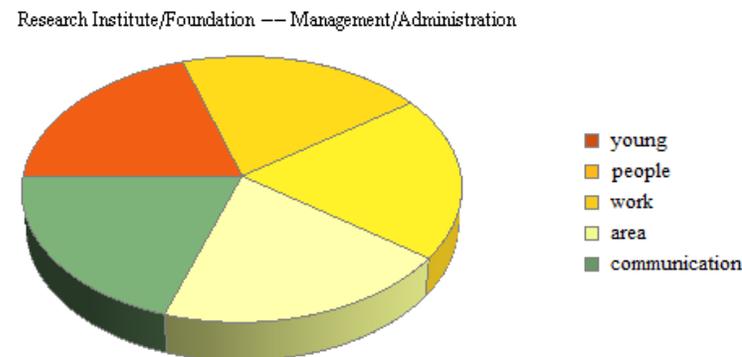


Figure 11:(Q4) Research Institute/Foundation/Manager terms predicting next three important innovations in communications.

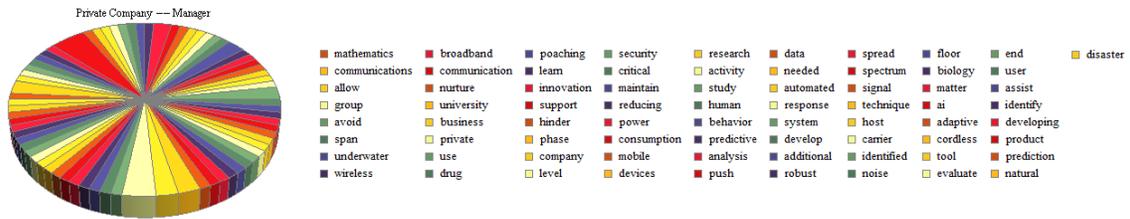


Figure 12:(Q4) Private Company/Manager terms predicting next three important innovations in communications.



Figure 13:(Q4) Private Company/R&D Staff terms predicting next three important innovations in communications.

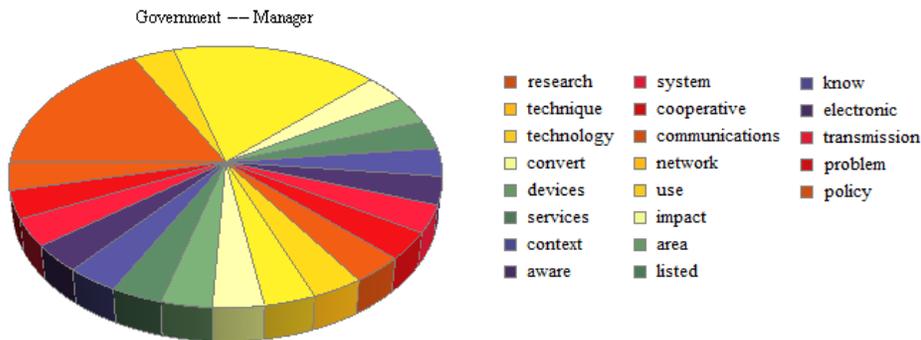


Figure 14:(Q4) Government/Manager terms predicting next three important innovations in communications.

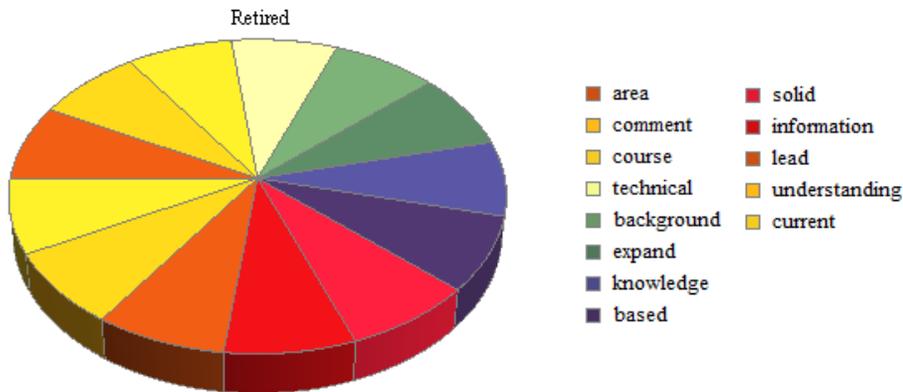


Figure 15: (Q4) Retired employee type terms predicting next three important innovations in communications

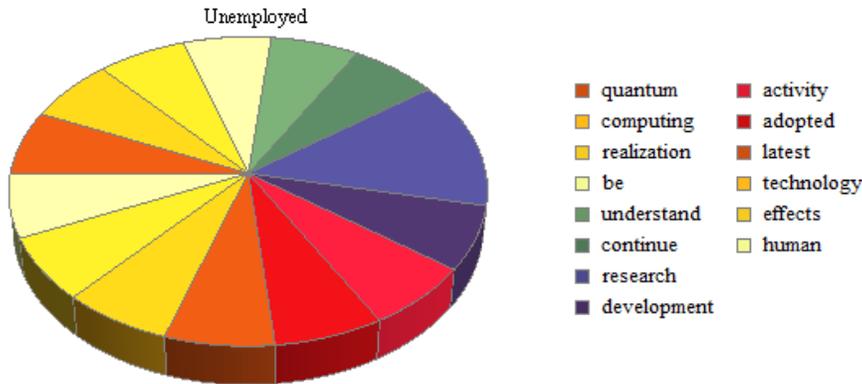


Figure 16:(Q4) Unemployed terms predicting next three important innovations in communications.

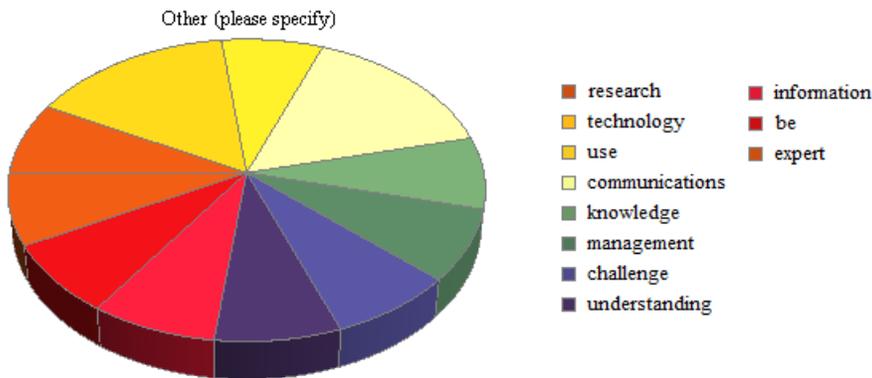


Figure 17:(Q4) Other employment type terms predicting next three important innovations in communications.

## Scholarly Activities Addressing Innovation and Communications

Question 5 determines what activities the respondents felt were needed to better understand the nature of innovation:

*Questions 5: What scholarly activities, if any, should be pursued in the area of understanding innovation in communications?*

Many respondents appeared to be challenged by this question. Some responded directly that they had no idea how to answer this question while others responded with lists of more technical ideas that they thought were innovative. The mental shift from thinking about specific technologies to thinking about innovation in general seemed to be a difficult one for the majority of respondents. However, those that could make the mental shift gave rather vague, general suggestions such as to hold more workshops, conferences, and create more publications to address the topic. In Figure 18, the concept of looking at word frequency is carried over to the question of scholarly activities needed to address innovation and standardization. Here we see the typical and expected heavily-used words such as “research” and “conferences.”



are found to be in direct contradiction to what the question is asking for. Respondents agree that market adoption of a technology, its utility, and its business success are measures of the innovative value of a research, and citations by academic research material is not sufficient. One respondent brings up an interesting point that current indices quantify the citation of an invention by other inventions only after the fact without providing any capability to predict and drive new innovation.

*Question 6b: If you feel a better rating is needed, how should it be formulated or what measurable parameters should it incorporate (e.g., standards references, patent references, citations by industry, number of downloads by industry and/or non-academic entities, etc.)?*

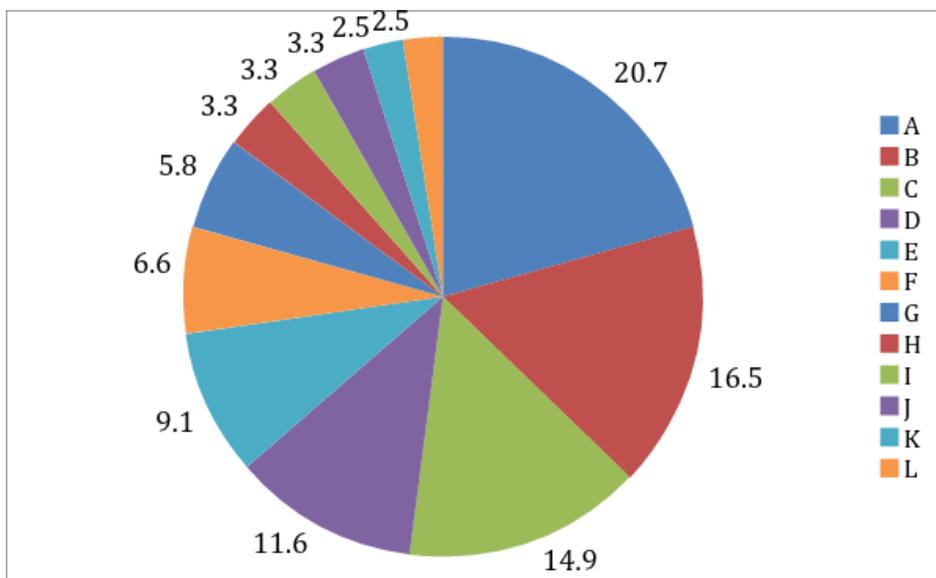


Figure 19: (Q6b) Various factors that have to be taken into consideration while computing impact metrics and their relative popularity among respondents expressed as a percentage.

The responses received for this question greatly help us identify the factors to be taken into consideration for computing impact metrics of innovation. These impact factors and their relative popularity among the respondents are presented in Figure 19. Note that, the values presented in Figure 19 indicate the percentage number of times the respective impact factor has been mentioned by respondents. A single respondent may propose more than one factor. The factors are elaborated as follows:

- A. Number of citations of an innovation by industry
- B. Number of patent references
- C. Number of downloads of the paper by industry or non-academic entities
- D. Number of references of the invention in standards
- E. Academic references and citations in papers, and citation in applied and theoretical research work
- F. Impact of the innovation on advancement of industry, which includes induction into new product development, creation of novel industrial

- paradigms, implementation or usage in industry, usage in existing products
- G. Human rating of an invention, which includes rating the invention by actually examining it, review by peer boards or industry panels, voluntary rating by experts, and citation by experts
  - H. Number of downloads of the paper by academic entities
  - I. General implementation, prototyping, or application of invention & its degree of realization
  - J. Impact of the innovation on community, which may be measured via citations in social internet media such as blogs, Tweeter, Facebook (number of likes to an article), and the growth of communities that are focused on this innovation
  - K. Clarity and readability of the paper which allows easy repeatability of the idea, and its appeal to professionals from outside the area of the innovation
  - L. Business success of the innovation in general, which includes business success of the patents that reference the invention, market volume, and impact on commerce.

In addition to these factors, the following factors have not been proposed by more than one respondent: citation of an innovation over a specified duration; number of end users (either consumers or industry players) of the innovation and its products; improvements provided by the innovation to end users; impact of the innovation on policy making; relevance of the innovation to major areas of research; and number of international projects based off the invention. In addition, one respondent urges that an impact metric should not merely take into consideration the number of publications and citations by a single guy, but from a large and diverse community of people. One respondent notes that impact factors such as business success or productization success of an invention are not useful since they are measured after the fact and it takes several years to fully measure them after the invention is made.

Respondents have also suggested the following procedures to compute the metrics:

- Apply an appropriate weight to all factors in order to compute a single metric. The weight can depend on the type of innovation. For instance, some innovations have a natural tendency to be inducted into standards while others may end up being adopted by different communities.
- Represent the metric in terms of several numbers or dimensions rather than restricting it to a single measure.
- Normalize the metrics in order to arrive at a fair metric. For instance, the number of citations should be normalized to the size of the appropriate community. This normalization is important, for instance, since the number of citations received for works in the field of wireless networking will be higher than those in wired networking.

## Understanding Innovation

*Question 7: What would you like to see included in primary results of studies on innovation?*

The responses received for this question help us identify topics of innovation of interest to the community. The topics and their relative popularity among the respondents are presented in Figure 20. Note that the values presented in Figure 20 indicate the percentage number of times the respective topic has been mentioned by respondents. A single respondent may show interest in more than one topic.

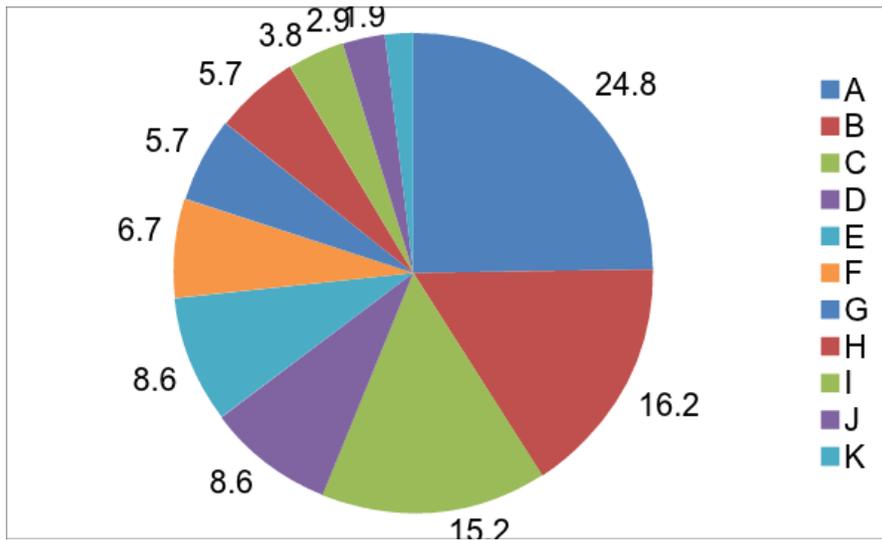


Figure 20: (Q7) Various topics that have received interest from the respondents, and their relative popularity among respondents expressed as a percentage.

The topics are elaborated as follows:

- A. Better ways for sharing awareness of innovations with the global community, including better ways to enable academia to learn about innovation in industry and improve innovation from industry; effective documentation of innovation in order to easily permit interaction of industry, market, research institutions, and regulatory government institutions, to drive an innovation to success
- B. Understanding what sparks successful innovation and creativity (work environment, access to state-of-the-art tools, level of mentoring, creativity, and intellectual capability); different ways to innovate (formulate and solve real-world problems)
- C. Understanding how to manage successful innovation and creativity and how to protect innovation from conventional approaches
- D. Processes academia can use to become more successful at innovation, and ways to foster innovation leadership in universities
- E. Commercialization of innovation, including the study of the processes involved in transforming innovation to successful commercialization, study of impact of industrial support (networking, institutional arrangements) and proximity of industry on this transformation, study on understanding how to effectively map innovation to real-world problems
- F. Processes academia can use to ensure ideas survive the “valley of death”
- G. Better ways on making timely decisions to fund creative ideas and turn them into

- products, including how to allocate resources to a research portfolio, how to differentiate between an idea and a tractable one, understanding when is a particular innovation ready for commercialization in current market conditions
- H. Understanding the impact of innovation on practical life situations, how does it improve the quality of life for common man, understanding the social context and social impact of innovation, impact of innovation on adding value to products
  - I. Better ways of collaboration between academia and industry to foster innovation
  - J. Analysis of dependency between major innovations and their future convergence, integration of innovative technologies with existing ones
  - K. Methods to critically evaluate technologies and their market relevance, ways to classify innovation as fundamental research, applied research, and engineering research.

In addition to these topics, the following topics have not been proposed by more than one respondent: history of innovators, including common principles followed by inventors in the past and the timeliness of innovation; the application of innovation theory to a broad range of platforms; and a description of the role played by IEEE in the field of innovation and its study.

Approximately five respondents have expressed skepticism towards one such study, pointing out whether it is too early for this study and whether formalization of innovation is possible. One respondent expresses contempt of existing material on innovation studies and indicates that his/her employer provides sufficient information on the study of innovation and its management.

## **The Relationship between Innovation and Standardization**

*Question 9: You indicated that you do not see innovation and standardization as related. Why do you say that?*

Based upon the responses received for this question, the reasons for perceiving innovation as being unrelated to standardization can be summarized as follows. Innovation happens as a result of out-of-the-box thinking and tackles issues of future concern. It can take considerable time, financial sponsorship, and strong industrial-political support to incorporate an innovation into a standard.

Standardization, on the other hand, is applicable to ideas that have matured and have potential commercial adoption. It tackles issues that are of current concern. Standardization may not necessarily be driven by the need for improvements over current state-of-the-art, but may be driven by profitability and mass adoption.

Innovation need not necessarily always lead to standardization. There are other avenues for innovation. In other words, standardization does not necessarily motivate innovation.

Innovation comes with a freedom for exploration and may risk the lack of clarity in its direction and use. On the other hand, standardization has a well-defined and well bounded process, which may in turn restrict further innovation. For instance, standards place restrictions on how fast small-scale companies can incorporate their innovative technologies into standardized equipment.

*Question 10: You indicated that you see innovation and standardization are related. Why do you say that?*

Standardization benefits innovations: Standardization of innovative technologies provides the following benefits to the innovations:

- Common platform for product development, wide-scale adoption. A common platform where different groups can participate and produce innovative results, multiple innovations can be tied together.
- Commercial success
- Standardization makes innovations practical, easy adoption by common man, ease of manufacturing
- Standardization incorporates repeatability and consistency in how innovation is used throughout the world
- Interoperability of products that use innovation
- It is pointed out that standards groups are usually the first to discuss innovations
- Innovations benefits standards
- Results of inventions are used in standardization and impact the standardization process
- Standards bodies are created after a particular innovation gains interest
- It points out that the two are inter-related. Standardization provides a framework for marketization of innovation. Successful marketization, in turn, further seeds innovation.
- There needs to be a balance between the two.
- It is pointed out that standardization should not limit innovation.

## **Innovation and Standardization Publications**

*Question 11: If IEEE were to publish a "Transaction on Innovation and Standardization in Communications," what should be included in the scope of such a journal?*

This question is seeking information about possible topics for a *Transaction on Innovation and Standardization in Communications*. Based upon the responses received for this question, 21% of the people who responded are either against or are "not sure" of having a transaction or journal on this topic. Several people suggested publishing a magazine instead of a transaction. One person commented that since innovation usually precedes standardization by a few years, we should focus on "disruptive technologies" instead of standardization in this transaction.

Many people suggested that the scope of this transaction should be wide open covering identification of gaps, challenges, applications, solutions, and future outlooks. There have been some suggestions regarding how we can bridge the gap between academia and industry in terms innovation. Based on all the responses, we have identified the seven topics for this transaction, as presented in Table 1.

Table 1: Summary of potential topics for the proposed transaction (ranked as highest to lowest)

	Topics	Sub-topics/Objectives
1	Innovative Communications Solution	communication metrics, new paradigm, future technologies, trend, wireless networking, distributed computing, software defined network, emerging areas, quantum communication, research activities of companies and labs, out of the box solution
2	Standardization Process	process to promote innovation, steps of standardization process, latest innovation related standardization, online media standardization and social networking, bridge from research to standardization
3	Case Studies and Examples of Innovation & Standards	previous studies, newest studies and examples of innovation and standardization process, both from academia and industry, new standards, best readings
4	Innovation Process	to bring academia & industry together, analytical model of innovation
5	Innovation in Organization	pursue, manage, promote, measure, share
6	Impact Factor	to evaluate impact of new technologies
7	Innovative Business Models	to promote innovation in telecommunication

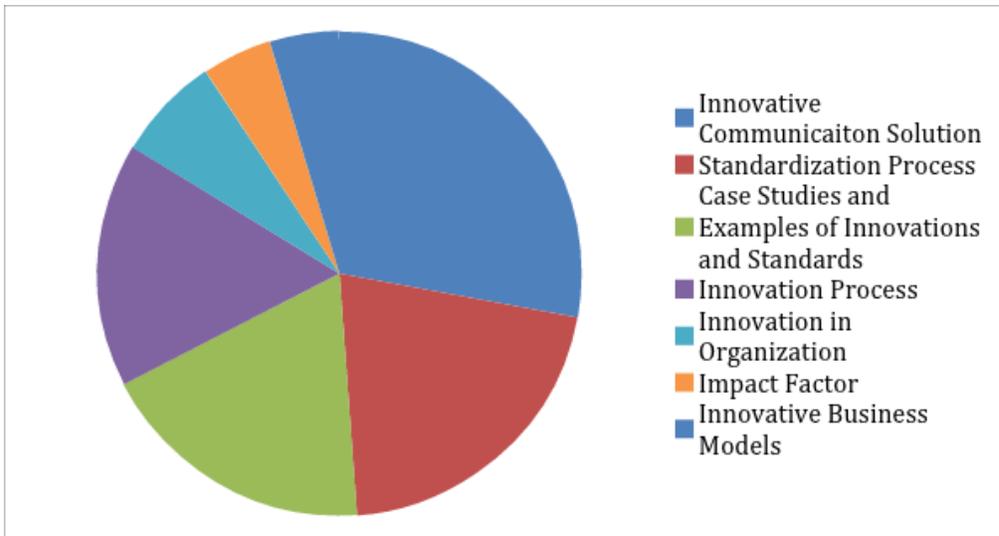


Figure 21: (Q11) Relative popularity of the topics for the proposed transaction expressed as a percentage.

*Question 12: If IEEE were to publish a "Magazine on Innovation and Standardization in Communications," what should be included in the scope of such a Magazine?*

Based upon the responses, approximately 16% of the respondents are either against or are "not sure" of having a magazine on this topic. Suggested potential topics for the proposed magazine have much similarity with the suggested topics in the previous question for the transaction, shown in the Table 1. Interestingly, ranking of these topics are slightly different than for the transactions. For the magazine, the topic of "case studies and examples" received more popularity compared to the topic of "innovative communication solutions", which is the most popular one for the transactions. There are also several suggestions to include patent issues, intellectual property-related laws, regulations, and policies as potential topics in the magazine. Table 2 summarizes the topics for magazine and Figure 22 shows the relative popularity of these topics.

Table 2: Summary of potential topics for the proposed magazine (ranked as highest to lowest)

	Topics	Sub-topics/Objectives
1	Case Studies and Examples of Innovations and Standards	success & failure stories, latest communication applications, comparison of likewise innovations, examples from history, research activities of labs and industries, best readings, innovation deployed or used for commercialization
2	Innovative communications Solution	metrics, out of the box solution, internet of everything, innovation in different areas of communication, state-of-the-art communication systems, quantum computing
3	Standardization Process	steps of standardization process, new standardization topics, tutorial on standards
4	Innovation Process	analytical model of innovation, profiles of innovation leaders, bring academia & industry together, new innovation methods
5	Impact Factor	impact of innovation in technical area and in society/community
6	Innovative Business Models	to promote innovation in telecommunication, innovative way of product development, marketization, policy
7	Innovation in Organization	Pursue, manage, promote, measure, share, guide for innovation
8	Patent	Patent issues, IP law

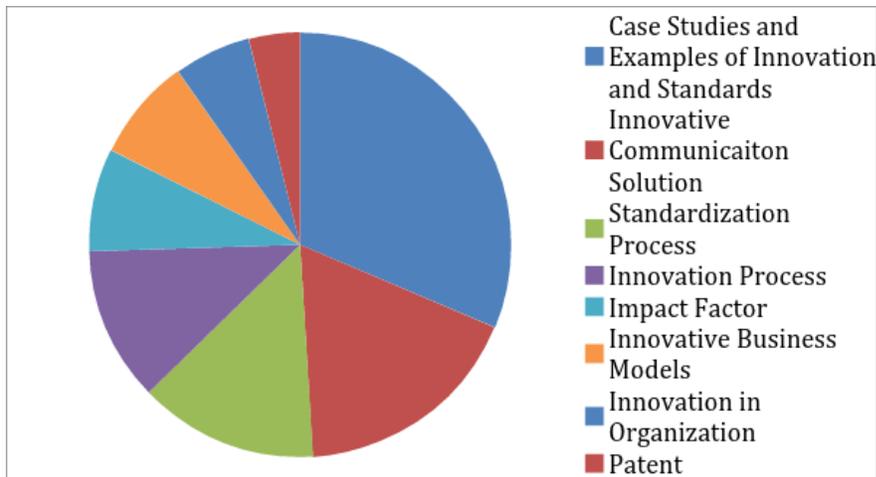


Figure 22: (Q12) Relative popularity of the topics for the proposed magazine expressed as a percentage.

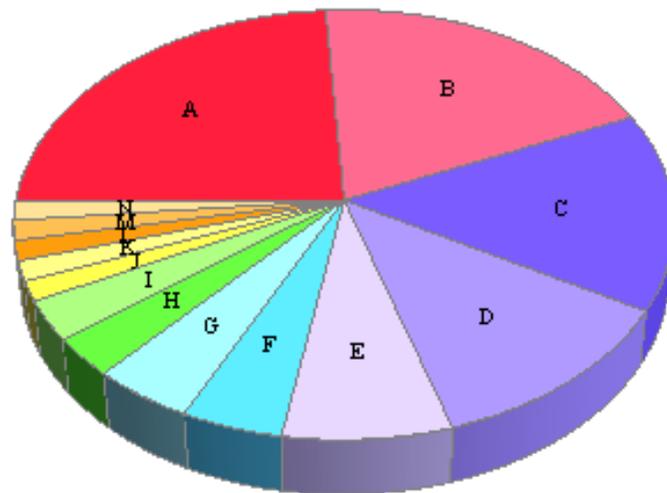
## Identifying Key Challenges to Understanding Innovation and Standardization

The goal of question 13 is to attempt to get at the core of the challenges to understanding the relationship between innovation and standardization. The hope was that respondents would think deeper about what relationships between innovation and standardization need to be better understood.

13. *What is the most significant hurdle or challenge in understanding innovation and standardization?*

Figure 23 shows what the respondents viewed as the most significant challenges in understanding innovation and standardization. Unfortunately, many of the respondents answered with a variation of the question itself as being the most significant challenge. In classifying the responses, we found that category A included a number of respondents expressing the fear that standardization constrains innovation. Category B included respondents who noted that researchers often don't understand real practical problems and thus there is a gap between practitioners and researchers. Within category C were respondents who noted that innovation is not well defined; defining it will be the real, key challenge. Category D includes the respondents who felt that understanding and quantifying value would be the most important, key challenge. Then, in category E were those who felt that the challenge to understanding innovation and standardization would benefit most by increasing access to standards information and making it easy to read and understand. The other categories should be straight-forward to understand. However, an interesting note is category I, which includes those respondents who felt that some type of new metrics, measurements, and tracking would be the key to better understanding innovation and standardization.

Most Significant Challenges



- A. Understanding Impact of Standards on Innovation
- B. Understanding the Gap Between Practitioners and Researchers
- C. Defining Innovation
- D. Defining Value
- E. Access and Difficulty Understanding Standards
- F. Handling Rapid Technological Change
- G. Complex Legal Implications of Standards (and Patents)
- H. Understanding the Relationship (between Innovation and Standards)
- I. Lack of Measurement and Tracking
- J. Timing
- K. Politics
- L. Openness of Standardization Process
- M. Funding (for this type of research)
- N. Low Quality Papers

Figure 23: (Q13) What is the most significant hurdle or challenge in understanding innovation and standardization?

Question 14 addresses the topic of awareness of scholarly theories of innovation:

14. *What theories of innovation, if any, should we be considering?*

The majority of responses were either blank, explicitly explained that the respondent had no idea, or attempts to list more specific instances of innovation in communications. However, there were a sparse set of responses that tried to address the question. Thus, because this appeared to be a difficult question with relatively few answers in scope, the most relevant answers are explicitly listed:

Cognitive aspects of innovations - History of innovations (or related innovations) - Interaction between innovative technologies over time - Relationship between Innovation and theoretical science - Interaction between innovations and existing or enabling markets
Brain storming
Diffusion (of innovations)
Disruptive innovations
Collaboration between academia and industry

How to document innovation beyond the legalese of patent applications
Innovation comes from knowing/learning many things and subjects, and then the (new) idea hits you.
I think innovations cannot be theorized by definition at their inception, but only long after their acceptance by the community.
IEEE On Innovation already discusses the major thoughts on the subject.
industrial economics
Horizon 2020 (European Union) study of innovation
Theories of survival
Diffusion: Innovations is a theory that seeks to explain how, why, and at what rate new ideas and technology spread through cultures
Just be open to ideas
Open and collaborative innovation
Problem solving approaches e.g. Ishikawa, Kepner Trejoe, other techniques of interest to traditional industries
Psychology
Theories that facilitate discovery of “new pathways”

## Papers and Experts on Innovation and Standardization

*Question 15: What good papers, if any, have you seen on the topic?*

There are a limited number of responses to this question, clearly indicating that there is less awareness of innovation and standardization. The following are a list of papers and other sources of results on innovation studies, as indicated by the respondents:

- Papers on innovation that are published in Harvard Business Review
- Book: “The Idea Factory: Bell Labs and the Great Age of American Innovation” by Jon Gertner
- The works of Clayton Christensen
- Resources made available by the Global ICT Standardization Forum for India (GISFI) and India Smart Grid Forum (ISGF)
- IEEE Communications Society’s compilation of inventions of the last century
- Link to an article on innovation and standardization: <http://www.fastcodesign.com/1664682/5-ways-that-standardization-can-lead-to-innovation>

One respondent points out that there is no work on reproducible mechanisms for innovation and standardization. Another respondent suggests that technical reports (such as the C++ standard specifications) ought to be used as references in place of academic papers.

Seven respondents left blank responses and 25 others either do not recall well-known work on this topic or do not know about studies on this topic.

*Question 16: Who, if anyone, would you recommend as experts on this topic?*

Responses received for this question are found to be one of two kinds. One group of respondents identified popular communications area researchers as experts on this topic. Another group of respondents have correctly identified people who are experts on the study of innovation and standardization, who are not necessarily experts on the research area of communications. It is to be stressed here that there can be differences between expertise in the field of communications and expertise in the study of innovation-standardization in communications. The latter expertise may not necessarily comprise purely technical/research skills but can also include skills to manage, invoke, and provide leadership to innovation processes. Interestingly, one respondent states the following definition of an expert in the field of innovation: a person who has more than once successfully created research facilities. The stress is on the fact that the person has provided consistent, successful leadership to the process of innovation (and not just developed an innovative idea), which involves nurturing and commercializing more than just one innovative idea.

We begin by listing responses by the latter group of respondents, starting from organizations and ending with individual experts:

- Wireless Innovation Forum's Cognitive Radio Group
- Standards working groups
- Research institutions in companies such as Samsung, Apple, Nokia, and Qualcomm
- Some authors in Harvard Business Review
- Experts on Entrepreneurial Management, including Dr. Clayton Christensen and Dr. Teresa Amabile
- Andrew Viterbi – for his leadership role in Qualcomm
- Leonardo Chiariglione, for his role in standardization of MPEG and the media industry as a whole
- Bruce Kraemer and Paul Nikolich, for their leadership roles within the IEEE 802.11 working groups
- Marcello Coppola of ST Microelectronics

The former group of respondents has listed the following as experts:

- Internet and distributed systems experts, particularly Vint Cerf, Ivan Edward Sutherland, Andrew S. Tanenbaum and George Coulouris.
- Edison

## Tools and Processes for Innovation and Standardization

*Question 17: What tools or processes, if any, would you like to see developed that would help you apply theories on innovation and standardization to your work in academia or industry?*

The following are the tools and processes that respondents wish to use in order to study innovation and standardization:

- **Analysis tools**, including cognitive tools and heuristics to discover patterns in innovations; tools to establish relationships and linkages between past and/or present innovations in order to support new innovations; and data mining tools to establish connections between seemingly unrelated areas of research
- **Knowledge management**, including shared databases of publications on this topic; knowledge management platforms that document the innovation value chain; and effective search tools to identify relevant works
- **Incorporating incentives** into R&D culture to nurture innovative ideas, such as scholarships
- **Education tools**, including low-price or even free home kits or labs that help gain fundamental knowledge on the topic so that it can be taught to others
- **Joint Academia-Industry sessions** at IEEE Conferences
- **Improved awareness of patents**
- Access to problem solving approaches
- Analysis of case-studies rather than study of theories on innovation

There have been a handful of responses that indicate the need for tools that aid communications research and not necessarily the study of innovation-standardization. These include open source simulation software. About 17 respondents had absolutely no idea what tools or processes they want.

## Unsolicited Feedback

*Question 18: If you have any other comments on the topics asked in this survey, please indicate them here.*

Some of the notable comments are listed below:

- A couple of respondents have expressed satisfaction with the survey. A respondent has expressed interest on viewing the results of the survey.
- One respondent notes that similar surveys will have to be conducted with focus on research staff in research institutions.
- A couple of respondents have expressed skepticism of the survey and the topic in general. One states that innovation cannot be theorized but should be studied in terms of examples. Another respondent points out that the survey is biased as the respondent felt that the survey is attempting to support a

particular position on the topic.

- As suggested by one respondent, journals on innovation and standardization can have two sections, one for small scale innovations that can be incorporated in standards immediately, and the other for innovations that are far reaching.

A respondent has expressed interest in low-priced tools that enable engineers who are in advance stages of their career to easily learn new topics and make a seamless shift to work on them.

## Appendix 1: Latent Semantic Analysis

Analysis of the open text responses can be done relatively easily using vector space models to implement vectorial semantics. The vector space model is particularly useful in the case of respondents whose English grammar is unclear. This is because while their grammar placed words in an order that left ambiguity as to the precise meaning, many of their words were clear and can be analyzed. For this purpose, we used KH Coder and the Carrot2 Clustering Engine. Both of these tools utilize techniques such as word cluster analysis and multidimensional scaling analysis to better classify and understand free text responses. KH Coder correspondence analysis determines key words of responses and uses multidimensional scaling to position them on a two-dimensional space. KH Coder document cluster analysis uses a similar approach to group responses into clusters of similar answers. Explaining the details of these algorithms would be a paper in itself, so we defer the interested reader to the tools.

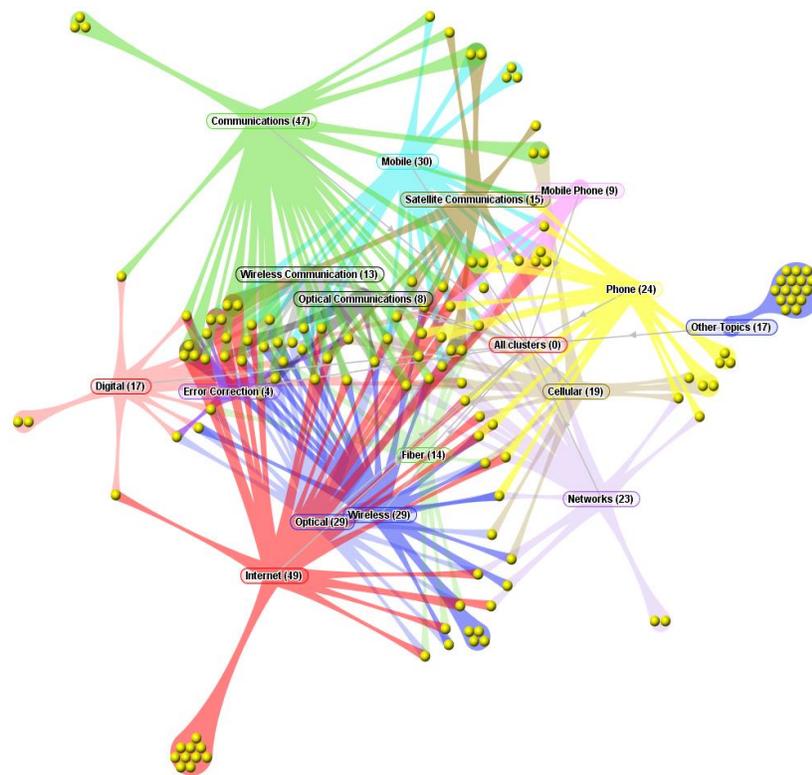


Figure 1: (Q3) What do you consider the top three innovations in communications within the last century?



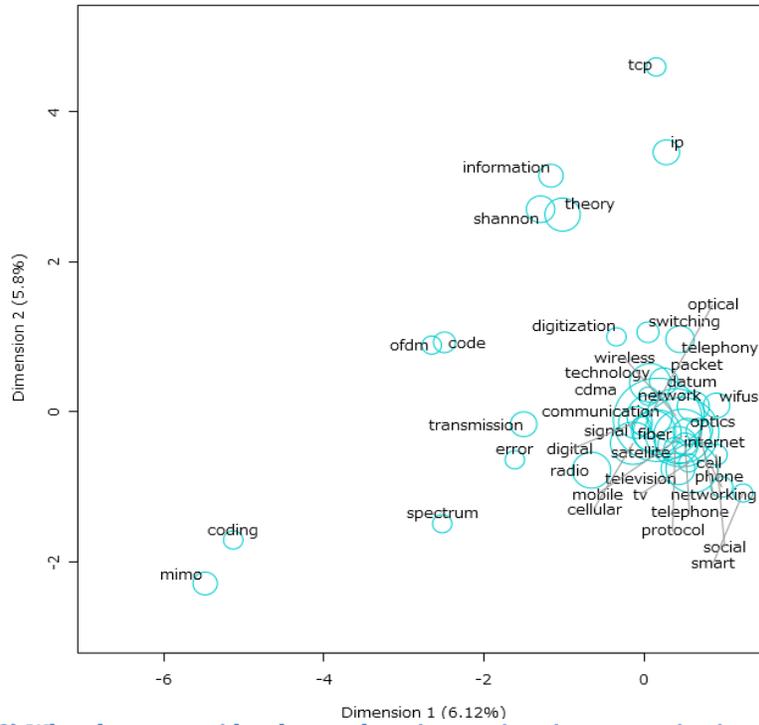


Figure 4: (Q3) What do you consider the top three innovations in communications within the last century?

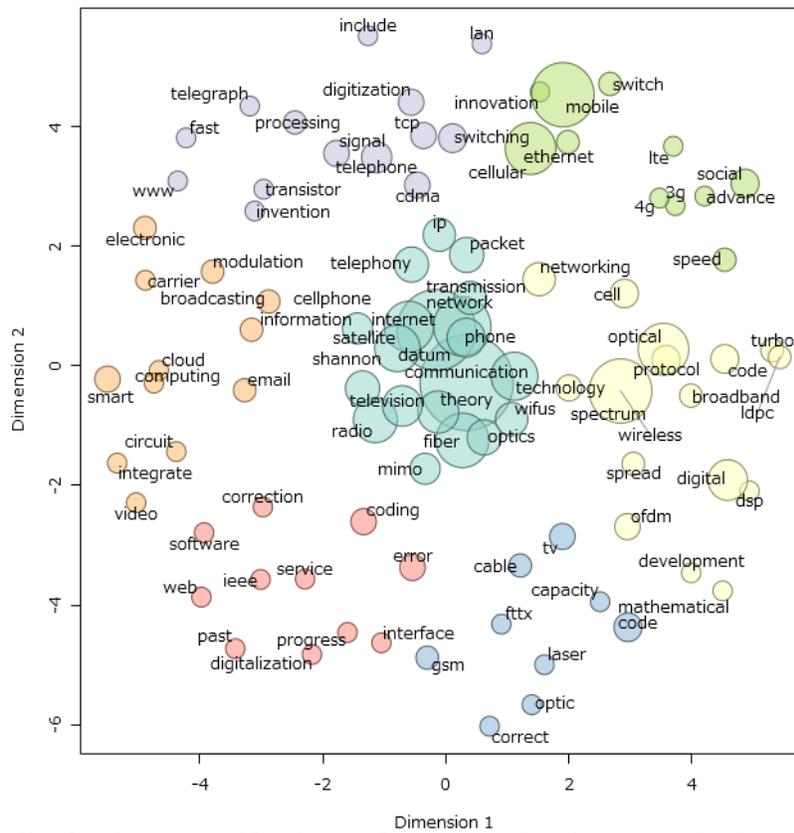


Figure 5: (Q3) What do you consider the top three innovations in communications within the last century?

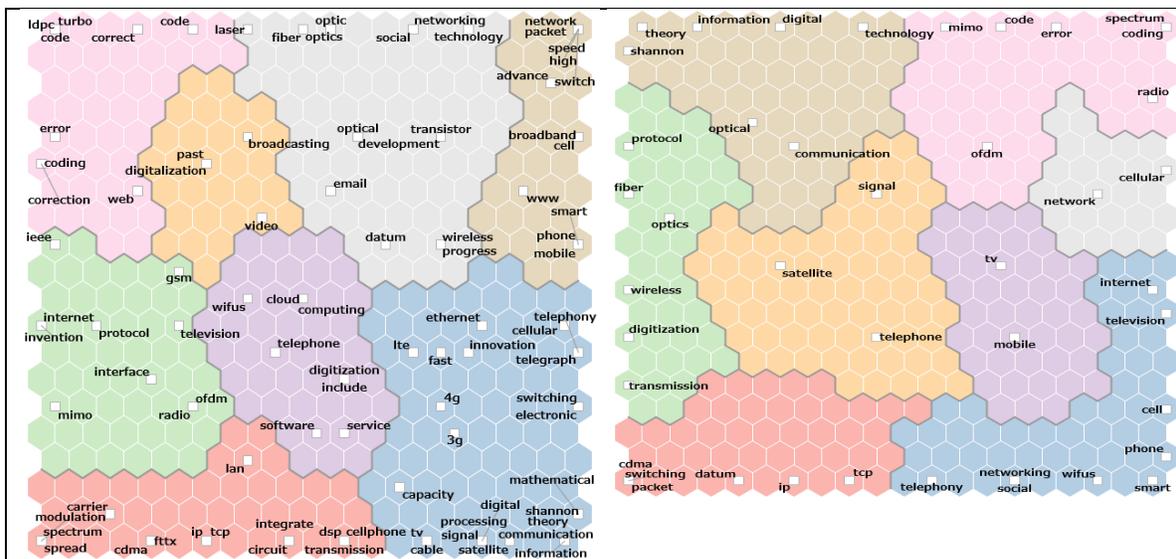


Figure 6: (Q3) What do you consider the top three innovations in communications within the last century?

Correspondence analysis (CA) is a multivariate statistical technique conceptually similar to principal component analysis, but applies to categorical rather than continuous data. In a similar manner to principal component analysis, it provides a means of displaying or summarizing a set of data in two-dimensional graphical form.

Multidimensional scaling (MDS) is a means of visualizing the level of similarity of individual cases of a dataset. It refers to a set of related ordination techniques used in information visualization, in particular to display the information contained in a distance matrix. An MDS algorithm aims to place each object in N-dimensional space such that the between-object distances are preserved as well as possible.



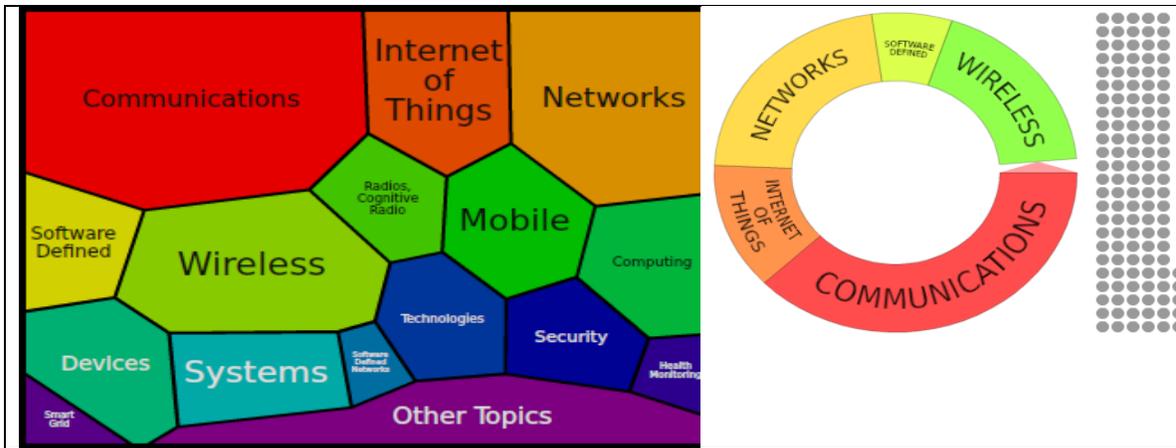


Figure 9: (Q4) What do you predict will be the next three important innovations in communications?

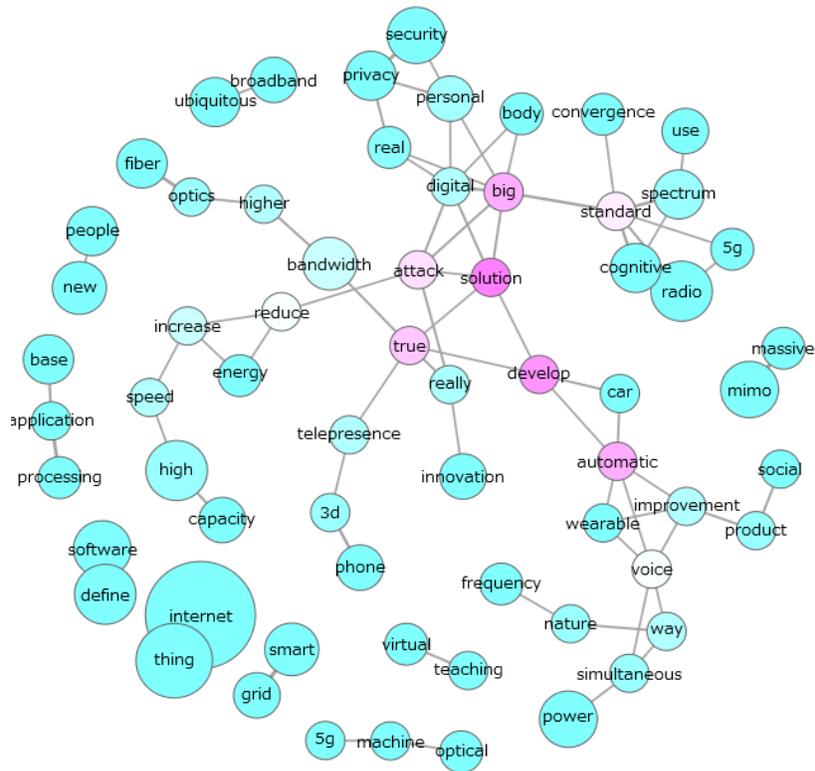


Figure 10: (Q4) What do you predict will be the next three important innovations in communications?

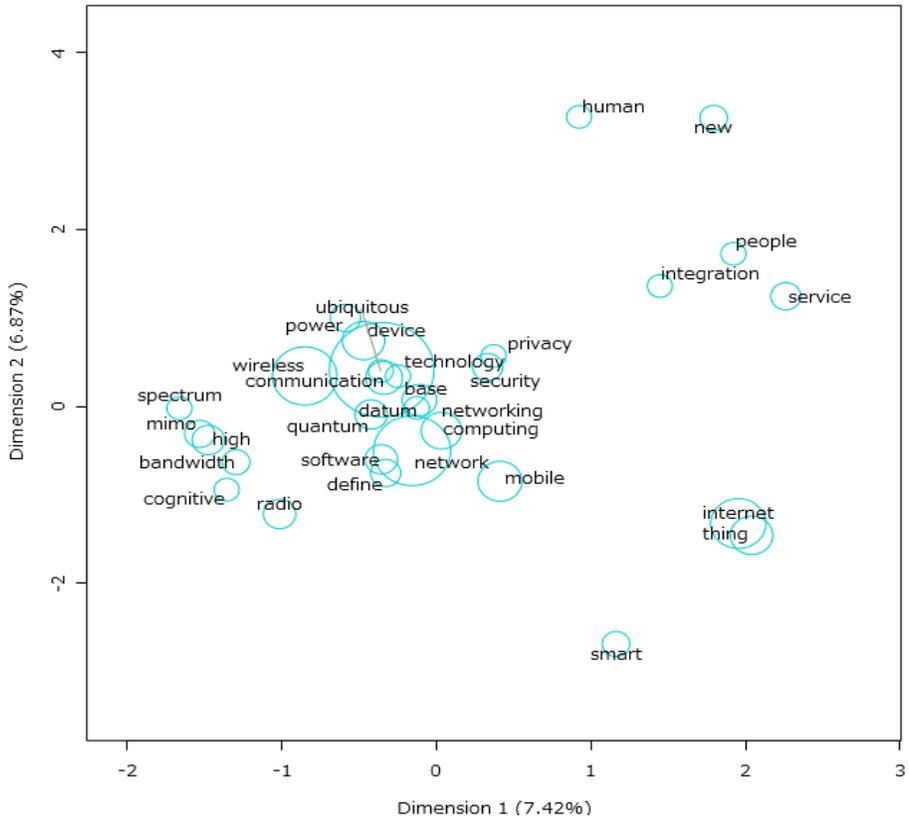


Figure 11: (Q4) What do you predict will be the next three important innovations in communications?

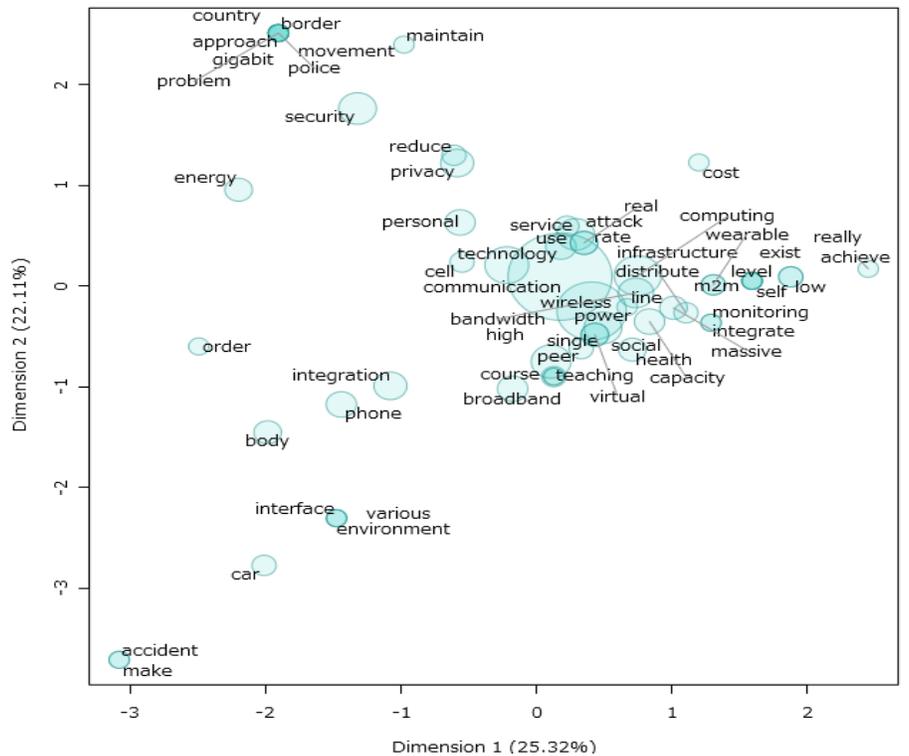


Figure 12: (Q4) What do you predict will be the next three important innovations in communications?

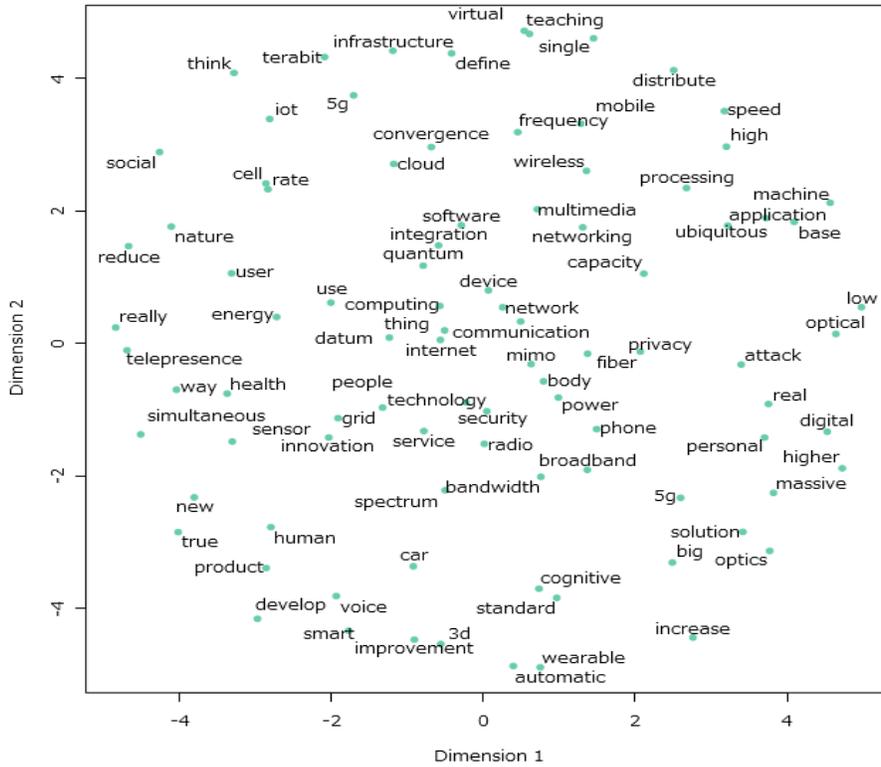


Figure 13: (Q4) What do you predict will be the next three important innovations in communications?

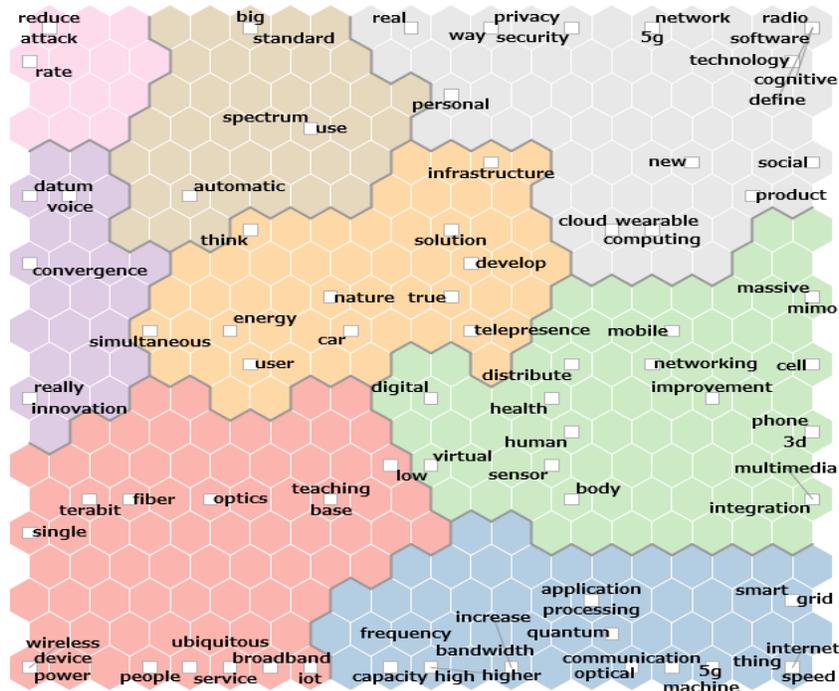


Figure 14: (Q4) What do you predict will be the next three important innovations in communications?

Cluster analysis or clustering is the task of grouping a set of objects in such a way that objects in the same group (called a cluster) are more similar (in some sense or another) to each other than to those in other groups (clusters).

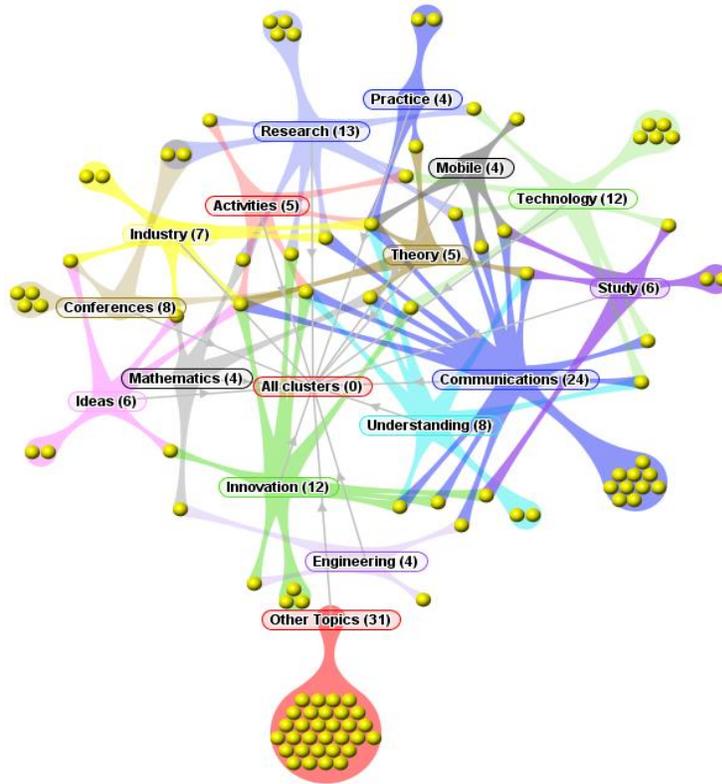


Figure 15: (Q5) What scholarly activities, if any, should be pursued in the area of understanding innovation in communications?

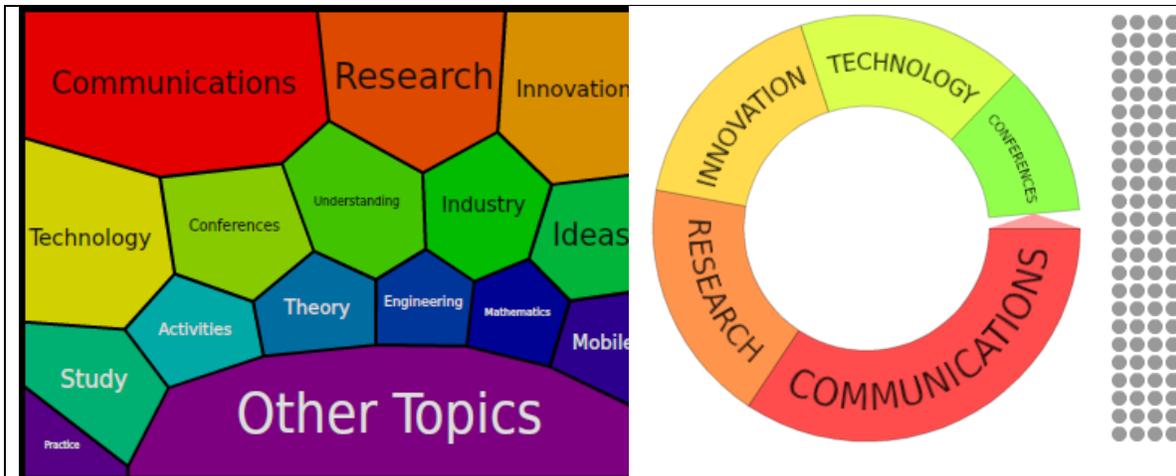


Figure 16: (Q5) What scholarly activities, if any, should be pursued in the area of understanding innovation in communications?

Co-occurrence networks are the collective interconnection of terms based on their paired presence within a specified unit of text. Networks are generated by







## Appendix 2: The Survey

The IEEE Communications Society is interested in your thoughts on the study of innovation in communications technology.

We appreciate your thoughtful assistance.

For questions related to the survey, please contact:

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Variables from database:  
 - Standard Demographic Variables (e.g., Region, Age, Years as Member)  
  
 Sample: 3,000 randomly selected  
 Higher Grade, non-student, non-life  
 status members?

Every scholarly paper operates within a common framework or context. This framework, or standard, sets a common conceptual understanding for a problem, allowing researchers to focus on developing solutions within that common context. It is important for all researchers to understand that how they choose this framework (standard) impacts the potential for innovation. Our goal is to better understand the relationship between innovation and standards with this survey.

Do you work primarily in:  academia  industry  government  other. If other, please specify.

### 1. How important or not is the study of innovation in communications?

	Somewhat important	Neither important nor unimportant	Somewhat unimportant	Very unimportant
Very important				

### 2. How satisfied or not are you with how the IEEE Communications Society supports the study of innovation in communications technology?

	Somewhat satisfied	Neither satisfied nor dissatisfied	Somewhat dissatisfied	Very dissatisfied
Very satisfied				

3. What do you consider the top three innovations in communications within the last century?
4. What do you predict will be the next three important innovations in communications?
5. What scholarly activities, if any, should be pursued in the area of understanding innovation in communications?
6. How important or not is it to develop and use a new bibliometric rating (other than the traditional impact factor based on academic citations) for journals and papers in order to capture meaningful, successful impact on innovation and help better stimulate innovation in academia and industry?

[If rate question 6 as 1 or 2]

6a. If you feel the current types of impact factors are adequate, how do you feel they are capturing the notion of successful innovation?

[If rate question 6 as 4 or 5]

6b. If you feel a better rating is needed, how should it be formulated or what measurable parameters should it incorporate (e.g., standards references, patent references, citations by industry, number of downloads by industry and/or non-academic entities, etc.)?

7. What would you like to see included in primary results of studies on innovation?

Examples might include:

Understanding what sparks successful innovation and creativity?

Understanding how to manage successful innovation and creativity?

Processes academia can use to become more successful at innovation?

Processes academia can use to ensure ideas survive the “valley of death?”

Better ways to enable academia to learn about and improve innovation from industry?

8. How related or not do you see innovation and standardization?

Very related 5	4	3	2	Not all related 1

**[If rate question 8 as 1 or 2]**

**9. You indicated that you do not see innovation and standardization as related. Why do you say that?**

**[If rate question 7 as 4 or 5]**

**10. You indicated that you see innovation and standardization as related. Why do you say that?**

**11. If IEEE were to publish a “Transactions on Innovation and Standardization in Communications,” what should be included in the scope of such a journal?**

**12. If IEEE were to publish a “Magazine on Innovation and Standardization in Communications,” what should be included in the scope of such a magazine?**

**13. What is the most significant hurdle or challenge in understanding innovation and standardization?**

**14. What theories of innovation, if any, should we be considering?**

**15. What good papers, if any, have you seen on the topic?**

**16. Who, if anyone, would you recommend as experts on this topic?**

**17. What tools or processes, if any, would you like to see developed that would help you apply theories on innovation and standardization to your work in academia or industry?**

**18. If you have any other comments on the topics asked in this survey, please indicate them here.**