

MIS 580 - KNOWLEDGE
MANAGEMENT PROJECT

Patent Analysis of RFID Technology

Shilpa Govada | Shirish Kandekar | Rachana Pejaver | John Wahlman

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TABLE OF CONTENTS

I. Introduction to RFID	1
II. Objective	1
III. Previous work /Literature review	1
1. Decoding Patent Information using Patent maps	1
2. Patent Analysis for Competitive Technical Intelligence and Innovative Thinking	2
3. RFID Technology Innovations: Use of Patent Data	2
IV. Methodology	3
i. Data Extraction	3
ii. Data Parsing	3
iii. Data Analysis	4
V. Analysis	4
i. Patent Publication Analysis	4
a. Patent Publication Analysis based on Countries/ Countries	4
b. Patent Publication Analysis based on Assignee	6
c. Patent Publication Analysis based on Technology field	7
d. Inventors with most patents	8
e. Patents most cited	9
ii. Analysis on Patent Importance and Strength	9
a. Patent citation analysis based on Countries	9
b. Patent citation analysis based on Assignee	10
c. Patent citation analysis based on Technology fields	10
iii. Knowledge Diffusion	10
a. Country citation network analysis	10
b. Institution citation network analysis	11
c. Technology field citation network analysis	12
iv. Co-Author Analysis	13
iv. Co-occurrence analysis	13
VI Conclusion	15

TABLE OF FIGURES

Figure 1: Research Design	3
Figure 2: Patents Issued by Continent -1987 - 2007	5
Figure 3: Top 20 Countries by Patents Issued - 1976-2008	5
Figure 4: Top 20 Countries in Patents Issued in each year - 1987 - 2007	5
Figure 5: Top 20 Countries excluding USA in Patents Issued in each year - 1987 - 2007	6
Figure 6: Top 20 Assignees by Patents Issued - 1977 – 2008.....	6
Figure 7: Top 10 Assignees by Patents Issued each year - 1976-2007.....	7
Figure 8: Patents by Technology Field	7
Figure 9: Top 10 Technology Fields by Patents Issued Each Year - 1983- 2007.....	8
Figure 10: Top 10 inventors with the most patents	8
Figure 11: 10 Most Cited Patents	9
Figure 12: Country citation network analysis – links of 10 or greater	11
Figure 13: Institution citation network analysis - link of 15 or greater	12
Figure 14: Technology Field Citation Network Analysis – links greater than 15.....	12
Figure 15: Co-author analysis	13
Figure 16: Patent title co-occurrence analysis.....	14

RFID PATENT ANALYSIS

I. INTRODUCTION TO RFID

Radio-frequency identification (RFID) is an automatic identification method, relying on storing and remotely retrieving data using devices called RFID tags or transponders. An RFID tag is an object that can be applied to or incorporated into a product, animal, or person for the purpose of identification using radio waves. Some tags can be read from several meters away and beyond the line of sight of the reader.

RFID has been around since the early 1920s. Mario Cardullo's U.S. Patent 3,713,148 in 1973 for a passive radio transponder with memory was the first true ancestor of modern RFID. The first patent to be associated with the abbreviation RFID was granted to Charles Walton in 1983 (U.S. Patent 4,384,288). Since 1973 there have been 3,952 patents that used the term RFID. The RFID market has grown rapidly and reached \$5 billion in sales in 2007 according to U.K based RFID analysis firm IDTechEx. The RFID market is predicted to hit \$7 billion in 2008 and \$25B by 2012.

II. OBJECTIVE

The goal of this project was to conduct original knowledge management research of RFID patents. This research resulted in competitive intelligence that may be useful to organizations investing in RFID. It also enabled our team to find the most prominent persons in this field. Patent Analysis of RFID helps us keep in touch with technology innovations in this field and understand the processes of technology innovations by local and international enterprises.

III. PREVIOUS WORK /LITERATURE REVIEW

1. DECODING PATENT INFORMATION USING PATENT MAPS

Chen-Yuan Liu, James Chingyu Yang, " Data Science Journal" Vol. 7 (2008): 14-22

Extracting patent information using Patent technology offers a novel method for industries to survive in the cutthroat competitive market by enhancing a product's competitive edge. This paper uses careful search techniques, retrieval, consolidation and analysis of the patent data to represent the knowledge in the form of a patent map. Organizations in industries can use this to further analyze the interesting findings, forecast tendencies and plot out strategies for themselves. The paper describes three analyses which contribute in making a patent map:

- Quantitative analysis: including patent number statistics, changes, sequences, market shares, and clusters.
- Qualitative analysis: including technical development contents, key technology, trends, and forecasts.
- Relationship analysis: studying the mutual relationship among differing data terms and data relation changes derived from other factors.

This paper does not provide the technical details of how to search, retrieve and analyze the data from patents. It just gives an overview of the importance of patent technology. It also does not provide visual examples of how a content map should look and how it can be used by industries to use it to their advantage. It does, however, identify all the different criteria to consider when extracting and analyzing patent data; for instance, assignee name, number of times the patent has been referenced, degree of referenced patents, relative R&D capability etc.

2. PATENT ANALYSIS FOR COMPETITIVE TECHNICAL INTELLIGENCE AND INNOVATIVE THINKING

H Dou, V Leveille, S Manullang, and JM Dou Jr., Data Science Journal Vol. 4 (2005): 209-236

This paper provides a new way of looking at patent analysis. In the authors' opinion patents could be used also to promote ideas and to view the background of an invention, which could lead to innovation.

They explain with the use of the EPO database (ESPACENET) and their own software, Matheo Patent and Matheo Analyzer, how to perform analysis on patents that could lead to creation of new products. According to them, there are two groups of data in the EPO database that are useful for the use of patents in Competitive Intelligence (CI), Competitive Technical Intelligence (CTI) and innovation. The first group of data may give rise indirectly to various correlations, while the second group provides immediate information about the patent content to the user (reader). For example, Group 1 could contain Inventors, IPC codes and Group 2 can contain titles, abstracts etc.

The authors say that tacit knowledge limits innovation, since new applications and uses are unknown to these knowledgeable people. Along with the goal to stimulate thinking, we should also know that the EPO database is a free information source and this is important for developing countries which can bear new products and applications directly linked to their local natural resources. It is also necessary to focus search efforts on patents that can develop applications which can be achieved through locally available facilities. The whole point of performing patent information analysis is to gain knowledge and to benefit from that knowledge gained. If an analysis leads you to an application which cannot be acted upon because the facilities are not available, then there is very little chance of that application succeeding and the goal is lost.

3. RFID TECHNOLOGY INNOVATIONS: USE OF PATENT DATA

Yen-Chun Wu and Tzu-Chin Yen, International Journal of Manufacturing Technology and Management Vol. 10 No. 1 (2007): 106-120

The main objective of this research was to produce patent information for data mining and analysis by experts in order to turn the information into knowledge of business value. The authors used 'USPTO' database and systematic tools like 'Patent Guider' to explore tens of thousands of patent documents in detail to produce patent information.

The authors consider 'Patent Analysis' as the most effective methods to keep in touch with technology innovations and to find out the connection between technology development and economic growth. The study and analysis also helps to understand the processes of technology innovations by local and international enterprises. A few types of analysis performed by authors in this article were Technology Life Cycle Analysis, Patent/Assignee Count by Country Analysis, Company R&D Capability Comparison, Detailed R&D Capability Indicator Analysis, Inventor Analysis, Citation Analysis, IPC and UPC Analysis

The authors have concluded from their research findings that RFID is being widely applied in the industries and the future development of RFID is expected to progress toward identifications of smaller items and smarter tags. The authors recommend companies to adopt a patent application strategy that focuses on quality and quantity to supplement their technological insufficiency and to prevent their competitors from entering the market through design-around schemes.

IV. METHODOLOGY

Our methodology consisted of three main processes – Data extraction, parsing and data analysis.

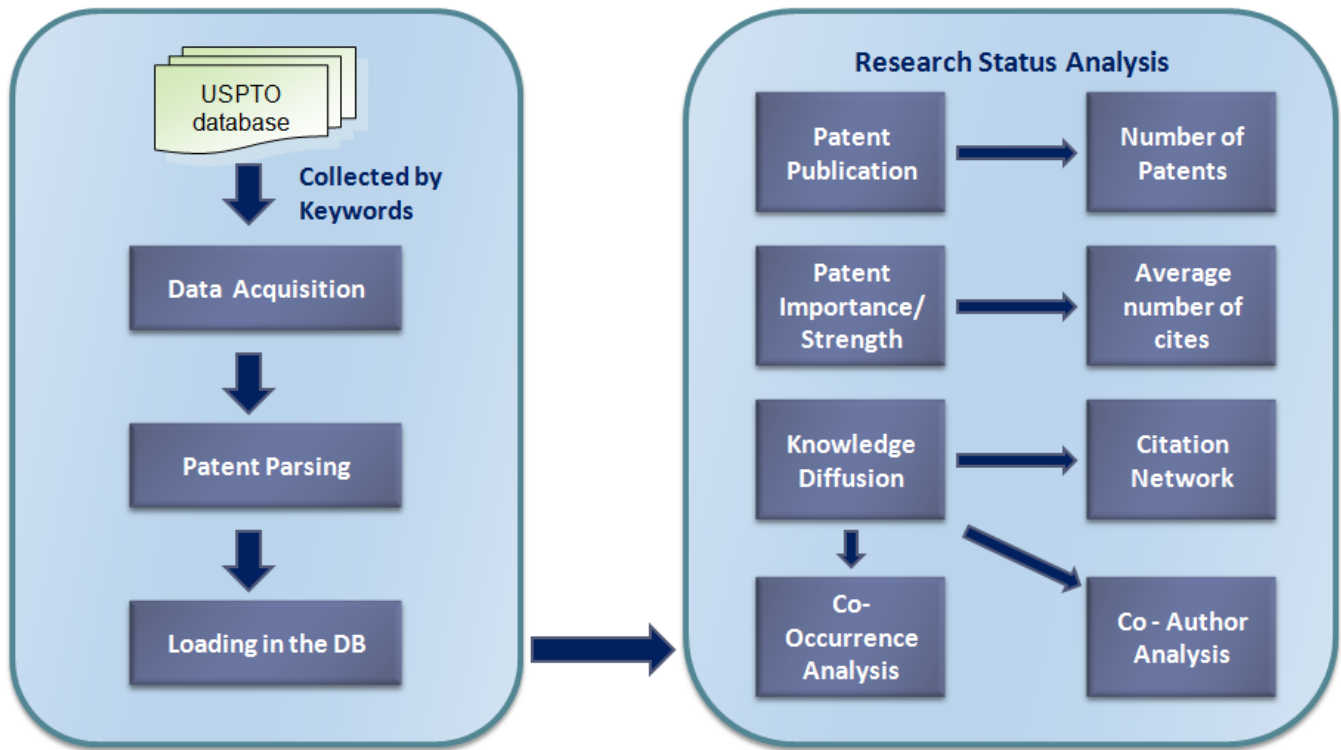


Figure 1: Research Design

I. DATA EXTRACTION

The team used the United States Patent and Trade Office (USPTO) Website to extract patent data. The analysis done in this project uses data from all “issued patents” from 1976 to February 12, 2008 containing the word ‘RFID’. There were a total of 3,952 patents during that time frame with the first RFID patent being issued in 1983.

The aim was to gather all the related patents from the USPTO database in free text format, filter and parse the data and then store the data in a structured manner for analysis.

We followed these steps:

1. Spider search results (summary pages) - A spider program written in Perl was used to spider the search result pages.
2. Spider individual patent documents (detailed pages) - This program collected all the patent ID’s related to RFID, and used these patent ID’s to download the detailed pages. The team used multiple proxies to run this program.

II. DATA PARSING

The data collected was parsed based on key words such as Abstract, Title, Inventors, Assignee, Cited References etc. The entire parsed data set was loaded and stored in Microsoft SQL database in table formats. All tables were linked using patent ID.

III. DATA ANALYSIS

The following analyses were conducted on the collected data.

Bibliometric Analysis	Patent publication <ul style="list-style-type: none">• Number of patents by country in each year• Number of patents by continent• Number of patents by assignee in each year• Number of patents by technology field in each year• Patents most cited• Inventors with most patents
	Patent importance and strength <ul style="list-style-type: none">• Average number of cites by country• Average number of cites by assignee• Average number of cites by technology fields
Knowledge Diffusion	<ul style="list-style-type: none">• Country citation network analysis• Institution citation network analysis• Technology citation network analysis
Co-author analysis	<ul style="list-style-type: none">• Co-author network analysis
Co-word occurrence analysis	<ul style="list-style-type: none">• Patent title co-occurrence analysis• Patent abstract co-occurrence analysis

V. ANALYSIS

Bibliometric Analysis

Bibliometric analysis is a type of research method used in library and information science. It utilizes quantitative analysis and statistics to describe patterns of publication within a given field or body of literature. Researchers may use bibliometric methods of evaluation to determine the influence of a single writer, for example, or to describe the relationship between two or more writers or works.

I. PATENT PUBLICATION ANALYSIS

The 3,935 patents came from by 1,209 assignees, 5,843 inventors and 2,391 primary inventors. A total of 32 countries received RFID patents from the USPTO.

A. PATENT PUBLICATION ANALYSIS BASED ON COUNTRIES/ COUNTRIES

From figures 2 – 5 it can be concluded that United States has the maximum patents issued in the field of RFID, with more 78.3% of all patents issued in the last decade. Some of the other leading countries in RFID are Germany and Japan. Although the first RFID patent was issued in 1987, it took some time for this technology field to gain importance and popularity. Analysis shows that RFID started to gain momentum only in the late 1990's and saw a significant increase in 2005 – 2006.

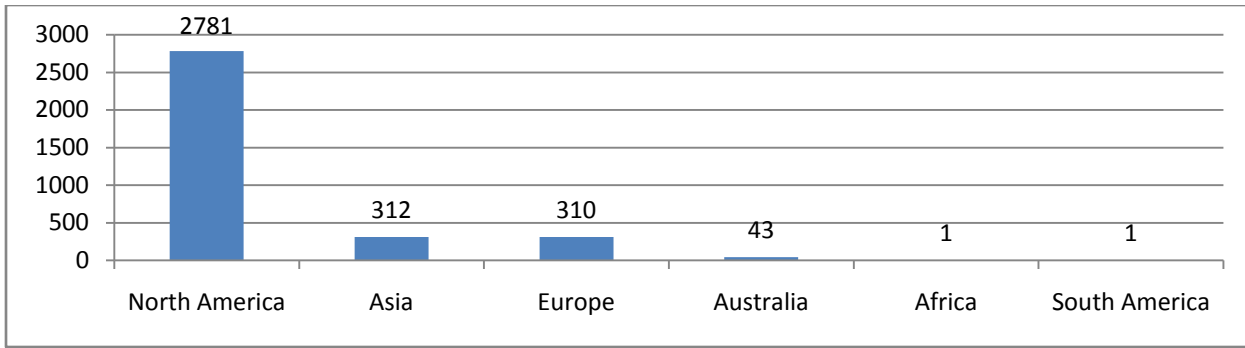


Figure 2: Patents Issued by Continent -1987 - 2007

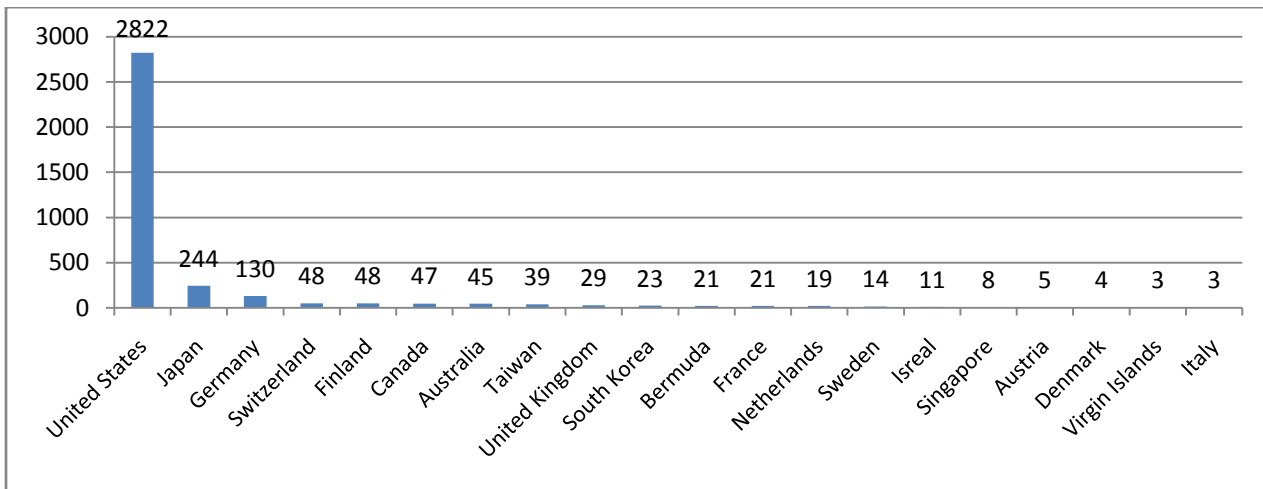


Figure 3: Top 20 Countries by Patents Issued - 1976-2008

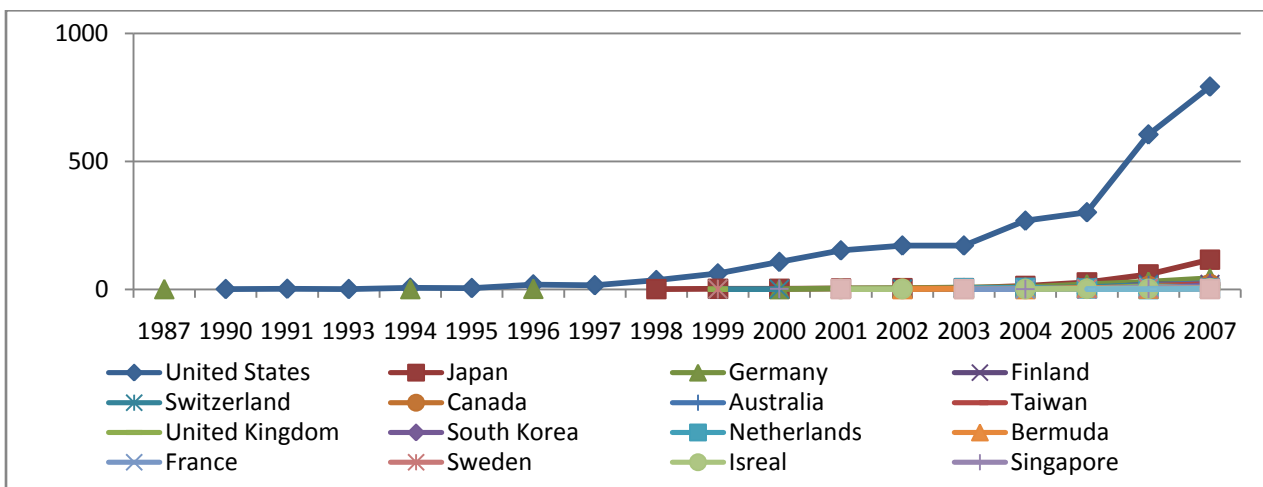


Figure 4: Top 20 Countries in Patents Issued in each year - 1987 - 2007

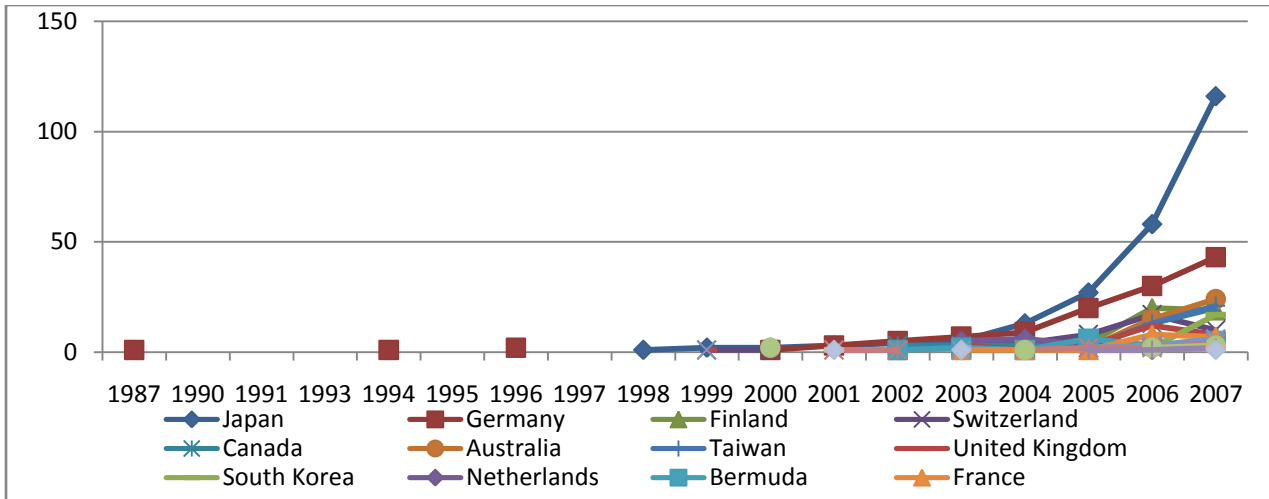


Figure 5: Top 20 Countries excluding USA in Patents Issued in each year - 1987 - 2007

B. PATENT PUBLICATION ANALYSIS BASED ON ASSIGNEE

The analysis from figure 6 and figure 7 shows that Micron Technologies, IBM and Symbol (which was recently acquired by Motorola) are the companies with the most patents in the RFID field. Other companies such as HP, Intermec IP and 3M Innovative Properties have also made significant contribution in RFID technology.

It is interesting to note that while Micron had a huge spike in the number of patents issued in 2000 - 2001, jumping from five in 1999 to forty in 2001, the number of patents fell drastically after 2001. IBM has shown gradual progress, with a constant increase in the number of patents assigned to it from 1996 – 2005. From 2005, IBM has seen a sudden increase from ten to thirty-two patents issued.

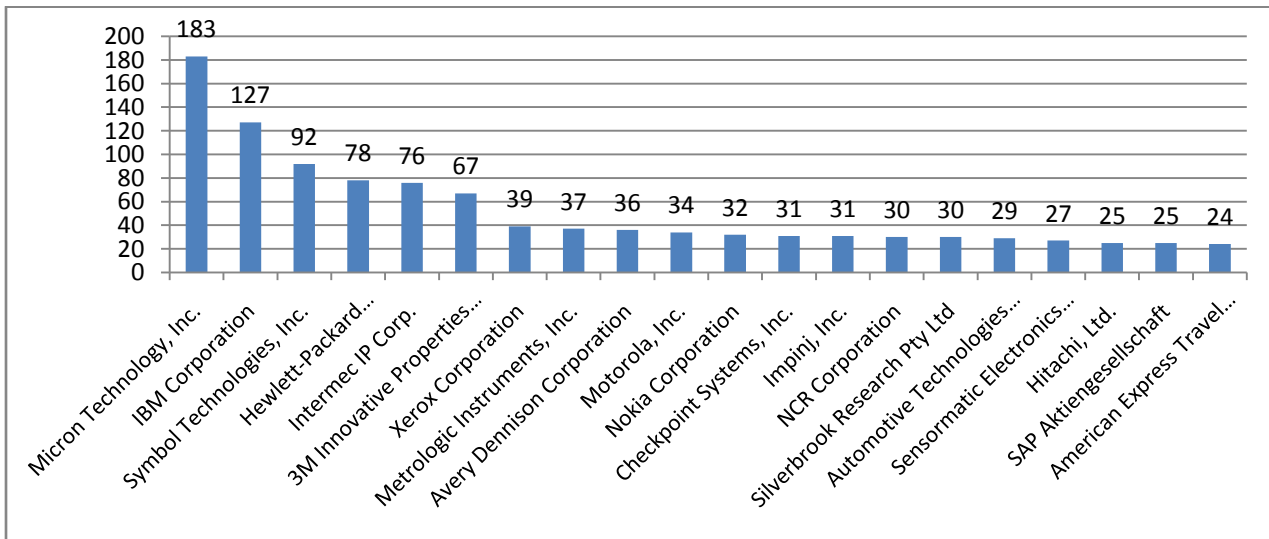


Figure 6: Top 20 Assignees by Patents Issued - 1977 – 2008

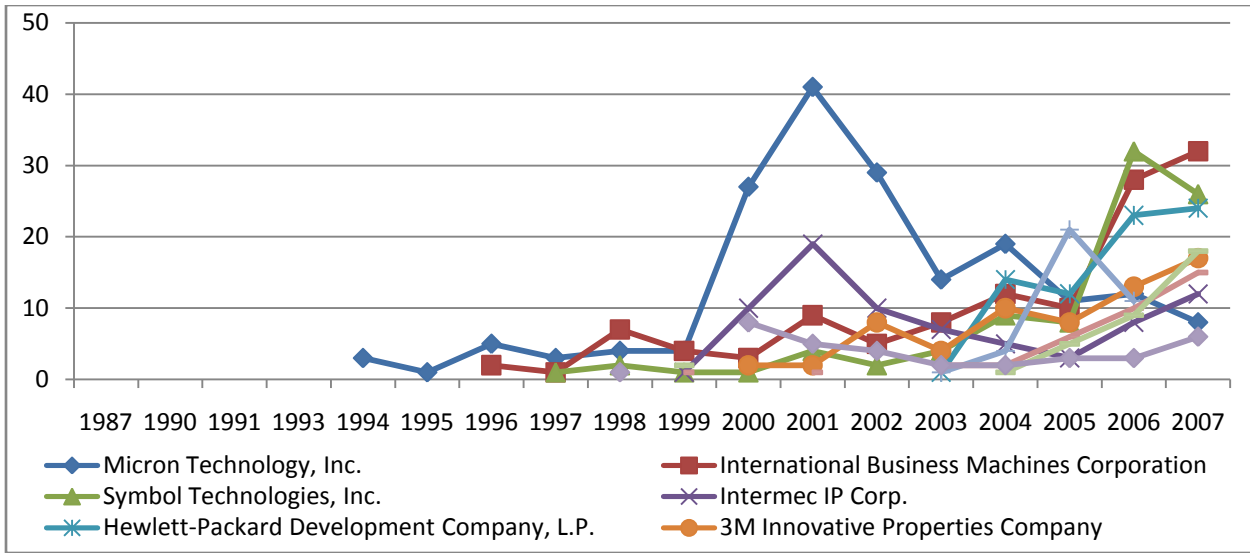


Figure 7: Top 10 Assignees by Patents Issued each year - 1976-2007

C. PATENT PUBLICATION ANALYSIS BASED ON TECHNOLOGY FIELD

'Communications, Electrical' and 'Registers' are the classes under which most of the patents have been filed. The number of patents that have been issued in the 'Communications, Electrical' field rose significantly from 100 in 2005 to 300 in 2006, and 360 in 2007. It can be inferred from this analysis that there are several innovations being made in this technology field. The same can be said for Registers.

ClassName	Field Names	Number of Patents
340	Communications, Electrical	1,243
235	Registers	635
455	Telecommunications	151
343	Communications: Radio Wave Antennas	129
700	Data Processing: Generic Control Systems or Specific Applications	109
705	Data Processing: Financial, Business Practice, Management or Cost/Price Determination	73
342	Communications: Directive Radio Wave Systems and Devices	65
701	Data Processing: Vehicles, Navigation and Relative Location	64
702	Data Processing: Measuring, Calibrating or Testing	63
257	Active Solid-State Devices	52

Figure 8: Patents by Technology Field

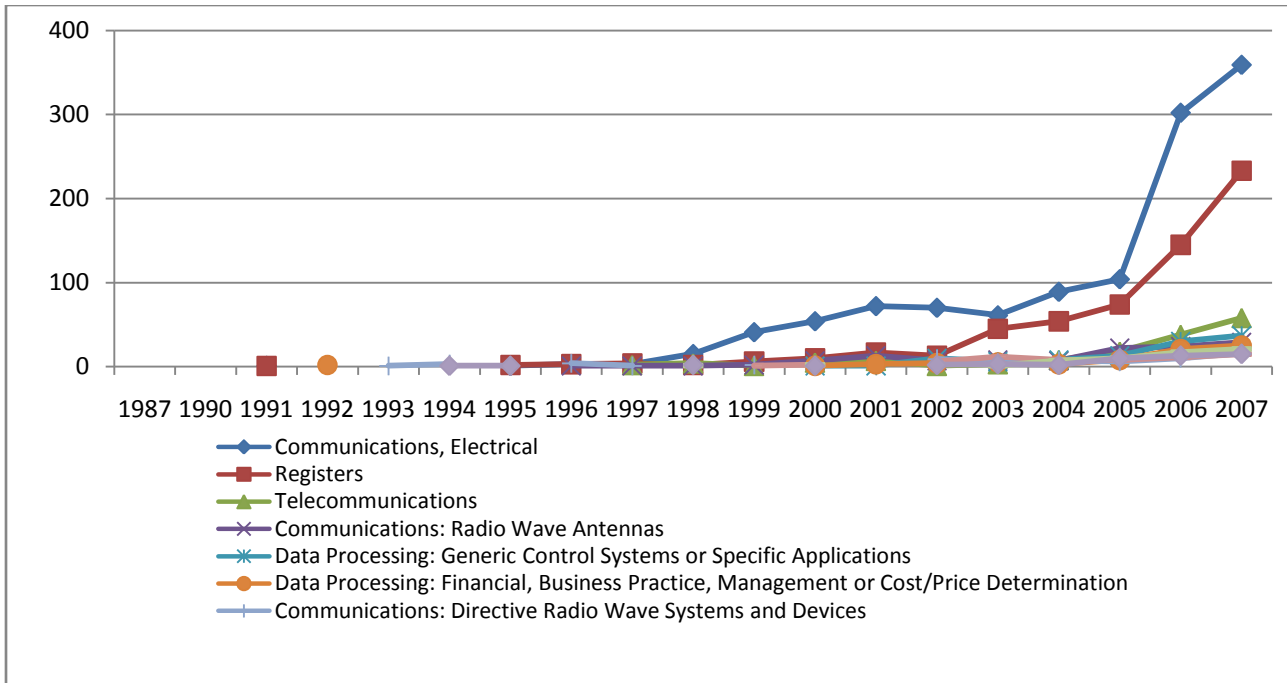


Figure 9: Top 10 Technology Fields by Patents Issued Each Year - 1983- 2007

D. INVENTORS WITH MOST PATENTS

Inventor	Patents	Assignee(s)
John R. Tuttle	78	Micron Technology, Inc. and Micron Communications, Inc.
Mark E. Tuttle	68	Micron Technology, Inc. and Micron Communications, Inc.
Ian J. Forster	48	Avery Dennison, Marconi Communications, and Mineral Lassen
David S. Breed	47	Automotive Technologies Internation and Intelligent Technologies International
Rickie C. Lake	42	Micron Technology, Inc. and Micron Communications, Inc.
David K. Ovard	41	Micron Technology, Inc. and Micron Communications, Inc.
Harry C. Knowles	37	Metrologic Intruments, Inc.
George E. Pax	36	Micron Technology, Inc. and Micron Communications, Inc.
Robert R. Rotzoll	35	Micron Technology, Inc., Micron Communications, Inc., and OrganicID Inc.
Wendell C. Johnson	32	Automotive Technologies Internation and Intelligent Technologies International

Figure 10: Top 10 inventors with the most patents

John R Tuttle - Founder and former President of Micron Communications. Mr. Tuttle developed the first commercial active microwave tag systems for Micron Technology in the early 1990's. He has provided theoretical, practical and inventive design in UHF and microwave systems. John's experience in RFID includes technology development, product design and development, and management strategy. John Tuttle has been granted over 70 patents, with more pending.

Mark E Tuttle - Associate Professor of Mechanical Engineering at the University of Washington. He joined the University of Washington in 1985. Professor Tuttle's research interests involve polymeric composite materials, composite structural design philosophies, viscoelasticity, and adhesion mechanics. Professor Tuttle is an active member of several professional societies, including the Society for Experimental Mechanics (SEM). During 1995-96 he served as SEM President, and in 2005 he was elected an SEM Fellow.

Ian Forster – Technical Director in the RFID Division of Avery Dennison. Mr. Forster has worked in RFID for over 20 years and has been involved in a broad range of projects. At Avery, he is responsible for the work of the UK based design group and all aspects of RFID technology used worldwide, with a particular focus on innovation. Avery Dennison is a Fortune 500

company, based in Pasadena, California, USA, with sales of US\$5.3 billion in 2004. The company is a global leader in pressure-sensitive technology and an innovator in self-adhesive solutions for consumer products and label materials.

E. PATENTS MOST CITED

Interestingly, patent 5649296 is the most cited RFID patent, yet its inventor and assignee are not among the top 20.

PatentID	Citations	Year	Patent Title	Assignee	Inventor
5649296	138	7/15/97	Full duplex modulated backscatter system	Lucent Technologies Inc.	John Austin - MacLellan
5448110	130	9/5/95	Enclosed transceiver	Micron communications, Inc.	John R. Tuttle
5963134	125	10/5/99	Inventory system using articles with RFID tags	Checkpoint Systems, Inc.	John H. Bowers
5629981	109	5/13/97	Information management and security system	Texas Instruments Incorporated	Virupax M. Nerlikar
5550547	96	8/27/96	Multiple item radio frequency tag identification protocol	International Business Machines Corporation	Shun S. Chan
5936527	92	8/10/99	Method and apparatus for locating and tracking documents and other objects	E-Tag Systems, Inc.	Marvin - Isaacman
5682143	91	10/28/97	Radio frequency identification tag	International Business Machines Corporation	Michael John - Brady
6100804	86	8/8/00	Radio frequency identification system	Intecmec IP Corp.	Michael J. Brady
5497140	83	3/5/96	Electrically powered postage stamp or mailing or shipping label operative with radio frequency (RF) communication	Micron Technology, Inc.	John R. Tuttle
5365551	80	11/15/94	Data communication transceiver using identification protocol	Micron Technology, Inc.	Charles K. Snodgrass

Figure 11: 10 Most Cited Patents

II. ANALYSIS ON PATENT IMPORTANCE AND STRENGTH

The 3,935 RFID patents that were used for analysis cited a total of 126,359 patents of which 113,917 citations were to non-RFID patents and 12,442 citations were to previously issued RFID Patents. For the citation network analysis we have taken into consideration only the citations to other RFID patents.

A. PATENT CITATION ANALYSIS BASED ON COUNTRIES

For this analysis, the team considered the number of distinct patents that have been issued for a country and the number of times these patents have been cited by other issued RFID patents. The average of these two has been taken. For example, the United States has 2,822 RFID patents issued by the USPTO, and they have been cited in other RFID patents 10,876 times, yielding an average of 3.85 cites per US patent.

The United States has the highest number of patents and the highest number of average citations with 3.85 citations for each patent issued. Japan has the second highest number of patents but has been cited only 0.64 times on an average. This shows that the innovations that Japan has patented have not contributed as much to the growth of this field. Canada has only 47 patents but has been cited an average of 2.49 times.

Country	Patent Count	Patent Citations	Average Number of Cites
United States	2,822	10,876	3.85
Canada	47	117	2.49
Germany	130	303	2.33
United Kingdom	29	42	1.45
Switzerland	48	64	1.33
Japan	244	157	0.64
Finland	48	15	0.31
Australia	45	14	0.31
Taiwan	39	7	0.18
South Korea	23	3	0.13

Figure 12: Average Number of Cites by Country

B. PATENT CITATION ANALYSIS BASED ON ASSIGNEE

It is interesting to note that although Micron Technologies and IBM have the highest number of patents (with 183 and 127 respectively), they do not have the highest average number of citations. Motorola and Intermec IP Corp have the highest average number of citations (with 11.85 and 10.34 respectively). From this analysis we can infer the RFID innovations that Motorola and Intermec patented are the building blocks for further innovations in this field.

Assignee	Patent Count	Average Number of Cites
Motorola, Inc.	34	11.85
Intermec IP Corp.	76	10.34
Micron Technology, Inc.	183	8.20
International Business Machines Corporation	127	5.64
3M Innovative Properties Company	67	5.18
Avery Dennison Corporation	36	2.39
Symbol Technologies, Inc.	92	1.40
Xerox Corporation	39	1.28
Hewlett-Packard Development Company, L.P.	78	0.59
Metrologic Instruments, Inc.	37	0.27

Figure 13: Average Number of Cites by Assignee

C. PATENT CITATION ANALYSIS BASED ON TECHNOLOGY FIELDS

From this analysis we can see that although ‘Communications, Electrical’ has the highest patent count, these patents have not been cited the most. The 65 ‘Communications: Directive Radio Wave Systems and Devices’ patents have been cited the most with each patent being cited an average of 9.51 times.

ClassName	Field Names	Number of Patents	Average Number of Cites
342	Communications: Directive Radio Wave Systems and Devices	65	9.51
343	Communications: Radio Wave Antennas	129	5.33
257	Active Solid-State Devices	52	5.13
340	Communications, Electrical	1,243	5.13
455	Telecommunications	151	2.81
705	Data Processing: Financial, Business Practice, Management or Cost/Price Determination	73	2.71
701	Data Processing: Vehicles, Navigation and Relative Location	64	2.33
235	Registers	635	1.88
702	Data Processing: Measuring, Calibrating or Testing	63	1.27
700	Data Processing: Generic Control Systems or Specific Applications	109	0.72

Figure 14: Average Number of Cites by Technology Field

III. KNOWLEDGE DIFFUSION

The main objective of Citation Networks is to understand the knowledge transfer processes between countries, institutions, and technical fields. This analysis can be used for competitive intelligence by identifying influential players, knowledge transfer patterns and knowledge transfer efficiency. All three citation networks show a tendency to form local citation clusters.

A. COUNTRY CITATION NETWORK ANALYSIS

Figure 12 was created in GraphViz and shows only the links of 10 or greater. This graph shows how many times each country has cited the other countries and it also shows the number of times a country has cited itself. For example, as seen from the figure, The United States has cited Canada 77 times and Canada has cited US 146 times. Also, it is clear that US has cited itself 9249 times.

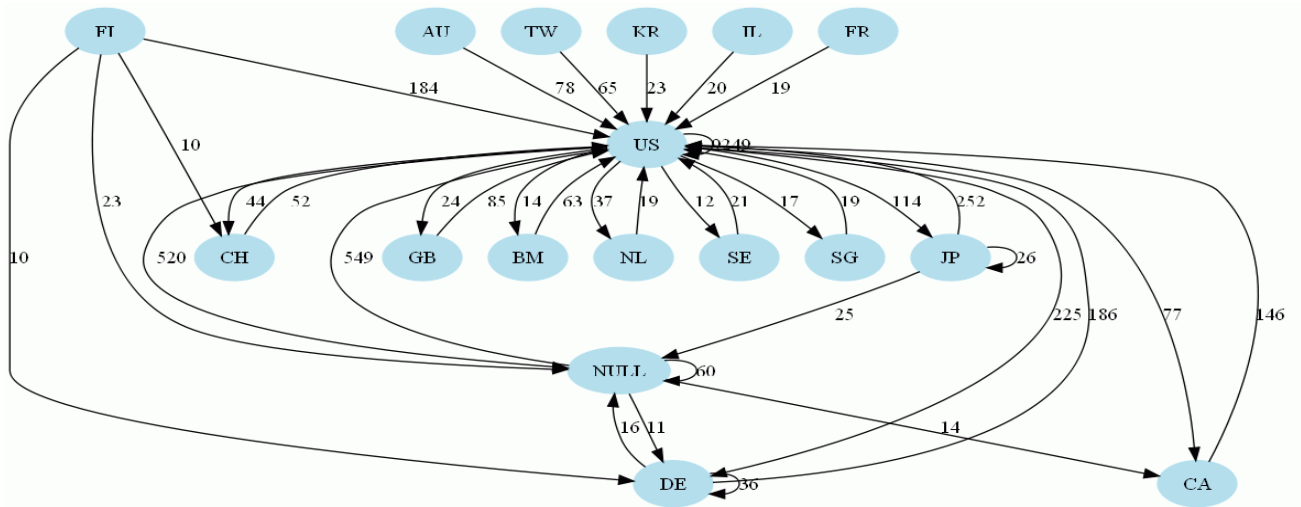


Figure 12: Country citation network analysis – links of 10 or greater

B. INSTITUTION CITATION NETWORK ANALYSIS

Figure 13 was created in NetDraw and shows all assignees with links of 15 or greater. In this figure, the node sizes are shown proportional to the citation count for each assignee. It is evident from this figure that Micron Technology, Inc has the highest number of cites as is evident from its node size.

IV. CO-AUTHOR ANALYSIS

This diagram was created in NetDraw and it identifies authors who have applied for patents with each other. In this analysis, authors with less than 20 patents have been removed and the layout used for this graph is “Spring Embedding.” This analysis reveals five different clusters of co-authorship.

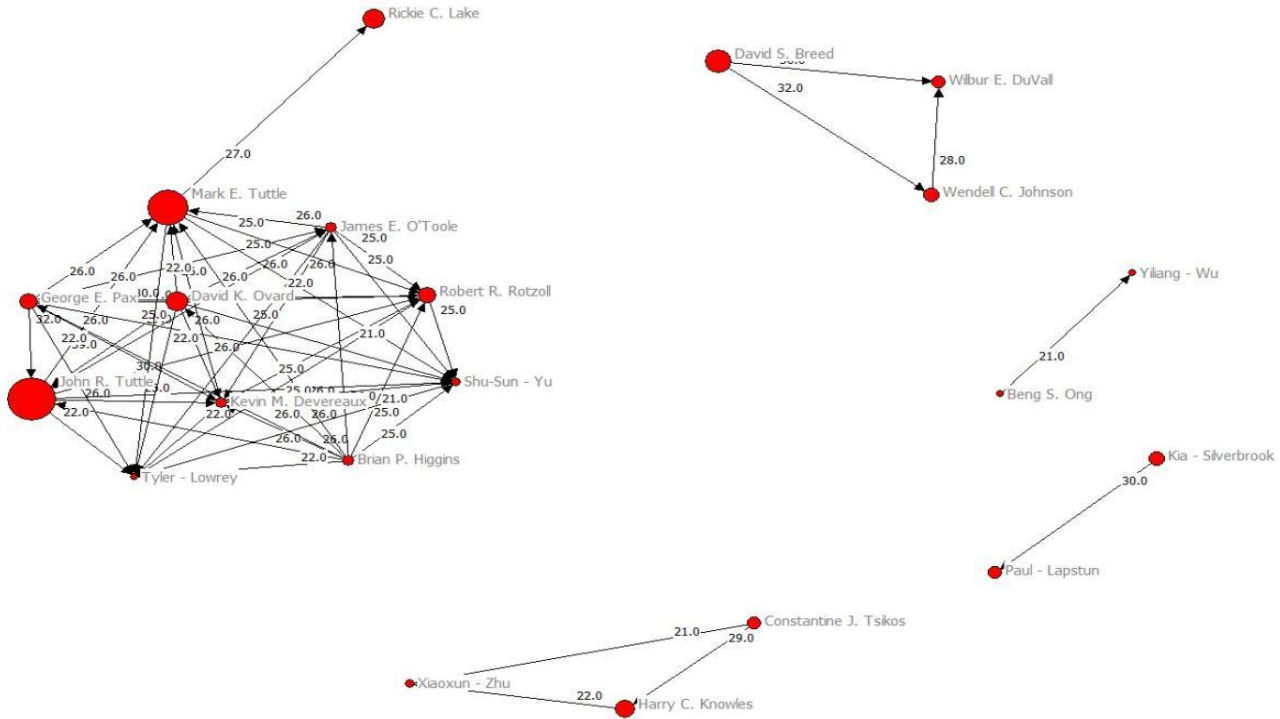


Figure 15: Co-author analysis

IV. CO-OCCURRENCE ANALYSIS

The co-occurrence analysis diagrams were generated in Pajek using the Kamada-Kawai layout.

The team followed an eight-step procedure to create the co-occurrence diagrams.

Step	Description	Tools
1	Query desired text for analysis	MS SQL
2	Build work frequency list	TextSTAT-2.exe
3	Remove stop words such as: at, be, of ,the, etc.	Stopword.exe
4	Remove very common words such as RFID	Manual
5	Remove words occurring less than 50 times	Manual
6	Generate co-occurrence matrix	Fulltext.exe
7	Generate diagram	Pajek.exe
8	Filter to remove weaker correlations	Pajek.exe

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