Technology Monitoring and Forecasting for Cyberdefense: a Scientometric Approach

Tugrul U Daim and Haydar Yalcin

EGE UNIVERSITY, IZMIR TURKEY

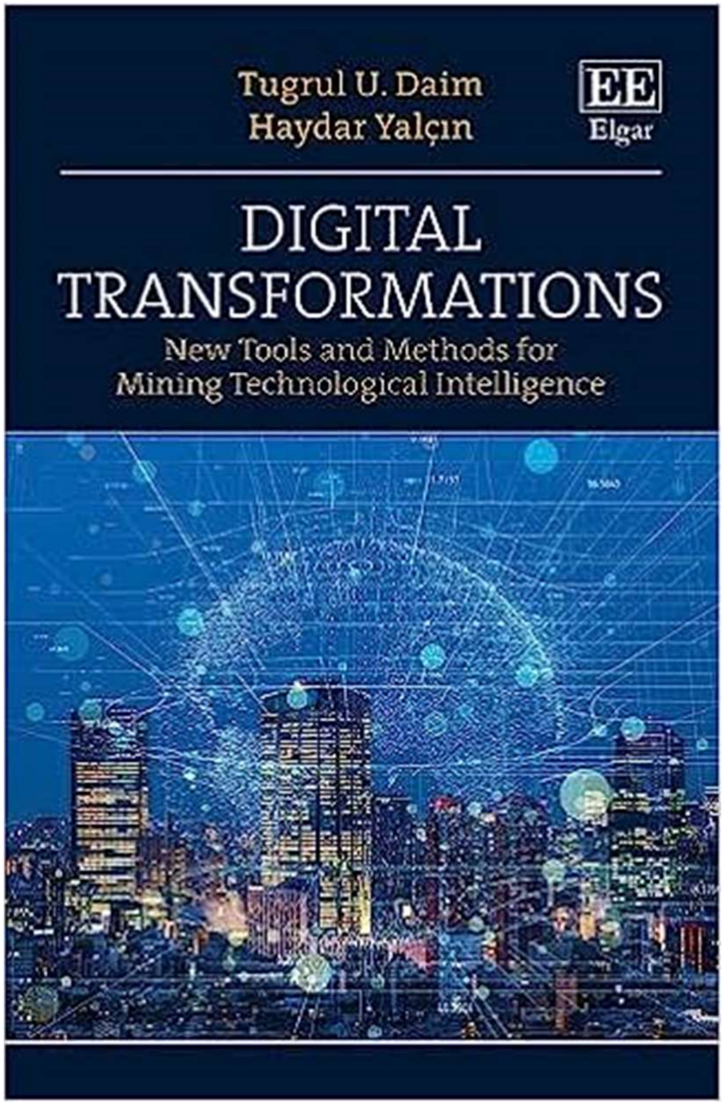
AGENDA

- Introduction to the team
- Project Objectives
- Methods
- Results

THE TEAM

Tugrul Daim

Haydar Yalcin

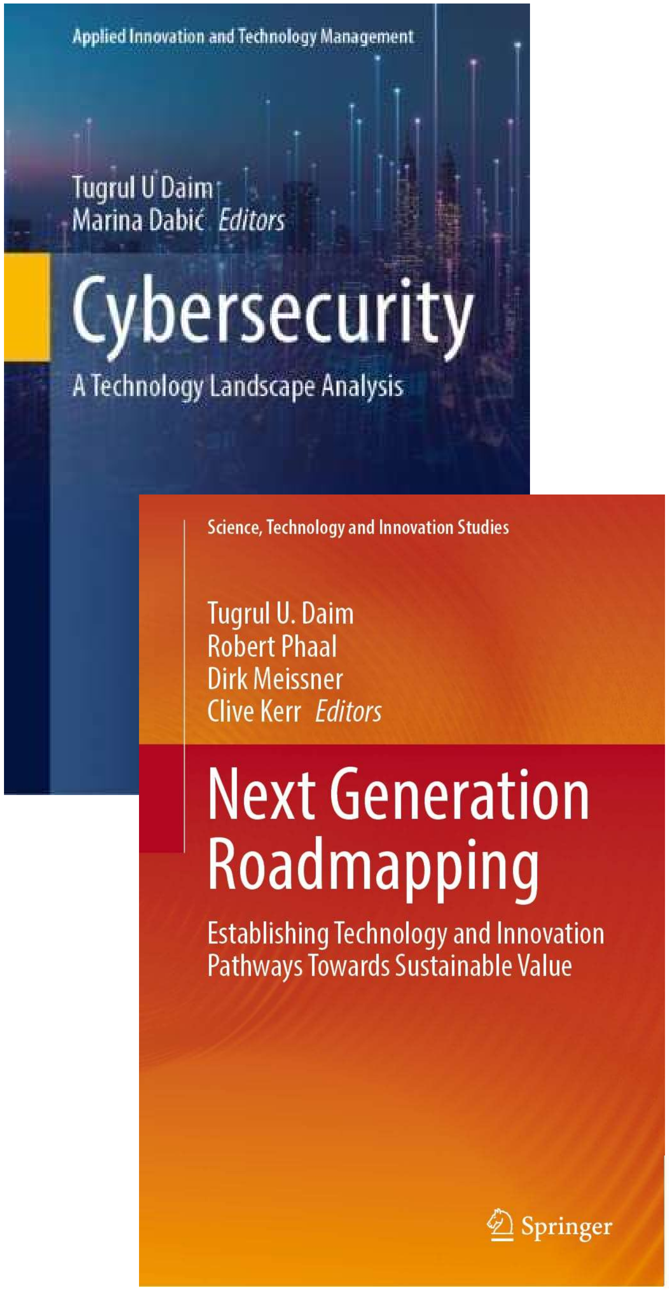


Tugrul U. Daim
Haydar Yalçın

EE
Elgar

DIGITAL TRANSFORMATIONS

New Tools and Methods for Mining Technological Intelligence



Applied Innovation and Technology Management

Tugrul U Daim
Marina Dabić *Editors*

Cybersecurity

A Technology Landscape Analysis

Science, Technology and Innovation Studies

Tugrul U. Daim
Robert Phaal
Dirk Meissner
Clive Kerr *Editors*

Next Generation Roadmapping

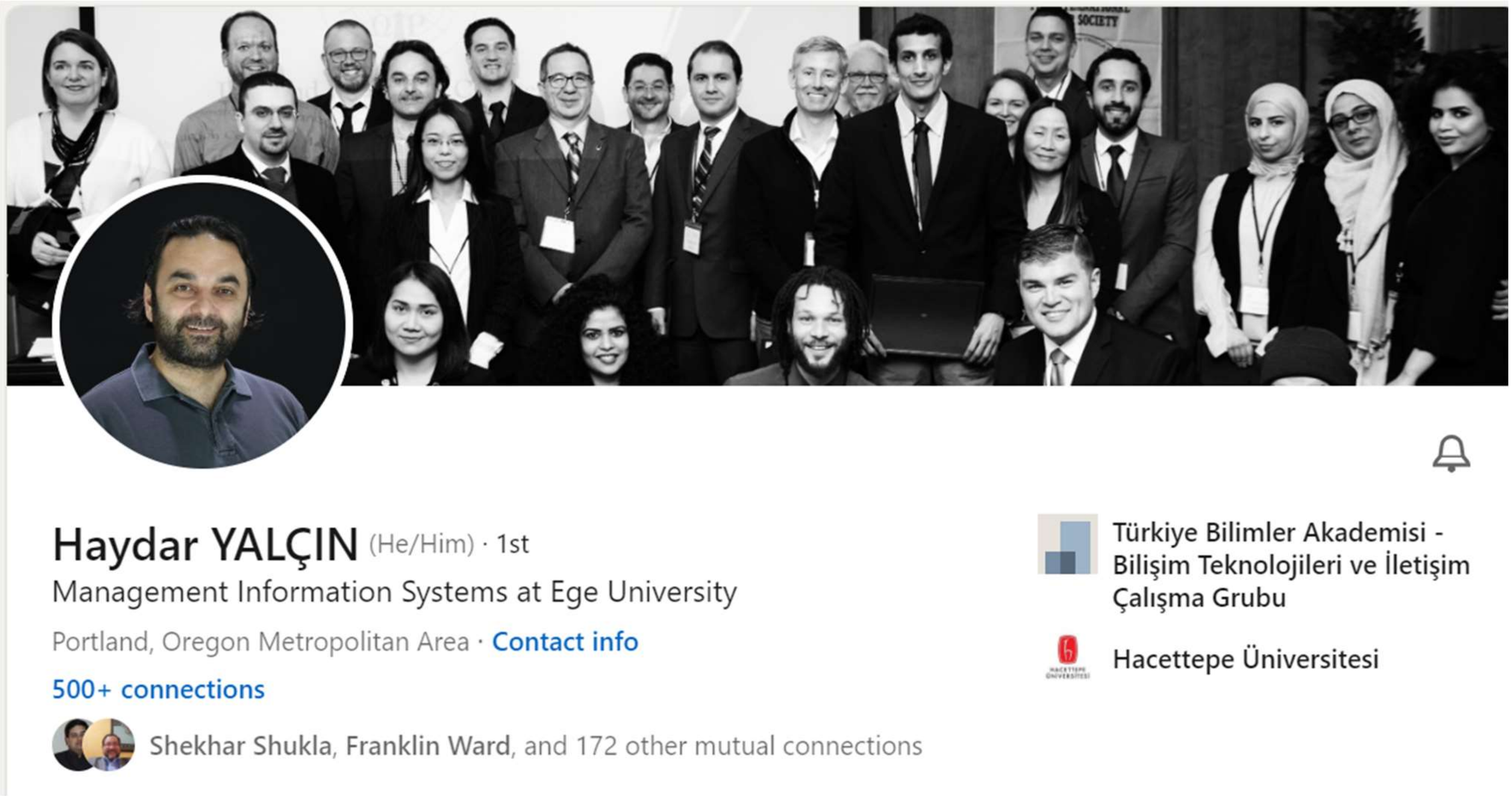
Establishing Technology and Innovation Pathways Towards Sustainable Value

Springer

Tugrul U Daim

- Professor of Engineering and Technology Management
- Associate Director for Research, National Center of Academic Excellence in Cybersecurity
- Editor in Chief of IEEE Transactions on Engineering Management
- Fulbright Scholar

Haydar Yalcin



Haydar YALÇIN (He/Him) · 1st

Management Information Systems at Ege University

Portland, Oregon Metropolitan Area · Contact info

500+ connections

Shekhar Shukla, Franklin Ward, and 172 other mutual connections

Türkiye Bilimler Akademisi - Bilişim Teknolojileri ve İletişim Çalışma Grubu

Hacettepe Üniversitesi

Transportation Research Part E 168 (2022) 102943

Contents lists available at ScienceDirect

Transportation Research Part E

journal homepage: www.elsevier.com/locate/tre

ELSEVIER

Logistics, supply chain management and technology research: An analysis on the axis of technology mining

Haydar Yalcin[a], Tugrul U. Daim[b,c,*]

[a] Ege University Izmir, Turkiye
[b] Portland State University, United States
[c] Chaoyang University of Technology, Taiwan

ARTICLE INFO

Keywords
Logistics
Supply chain management
Social network analysis
Structural hole analysis
Techmining
Patent analysis

ABSTRACT

In this study, it is aimed to explore the technology research and development processes in the field of logistics and supply chain management according to scientific publications and patent data. For this purpose, important research focuses on the field were revealed, authors, institutions and countries leading the field were determined, and sub-technology areas for technologies in the field of logistics and supply chain management were determined by patent analysis. In our research, in which technology mining method was used, patent analysis and bibliometrics were handled together. Our research also aimed to determine the important research focuses for the field. Accordingly, with the pandemic, in scientific studies in the field of logistics and supply chain management, it has been seen that connected ecosystem components such as bitcoin, Internet of Things (IoT), and smart contracts stand out as open and relatively untouched areas. On the other hand, it has been observed that the USA, the United Kingdom, China and India have come to the fore as the leading countries in the field, and the tendency towards research on data flow and sharing has increased in patent analysis.

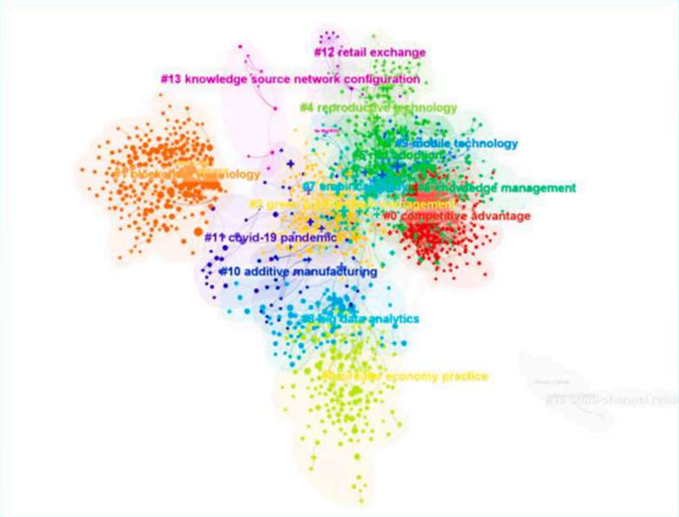
1. Introduction

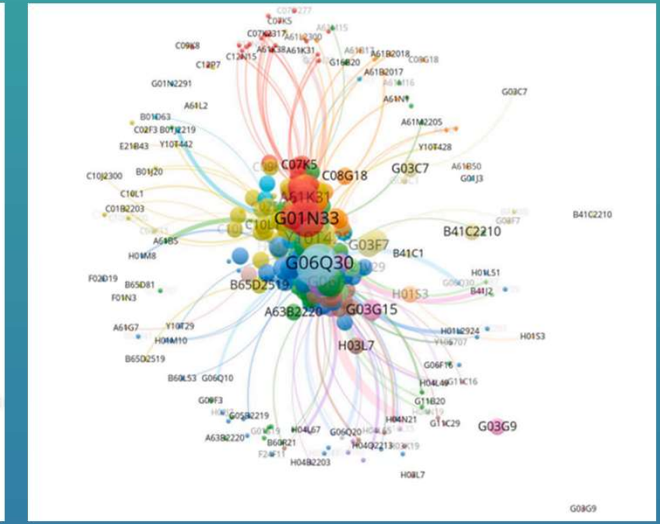
Innovation efforts in recent years have largely focused on seeking how countries and companies can improve their socio-economic and technological performance. Recognition of the close relationship between technological progress, economic growth and social welfare has managed to attract attention from both the scientific and expert communities, as well as political and business leaders around the world. After many technological waves such as Information and Communications Technology (ICT), biotechnology, nanotechnology, among others, it has been observed that some countries have significantly increased their economic and political power, while others have fallen into the position of followers of these countries or lagged behind. As a result, it is increasingly recognized that medium and long-term planning, as well as the search for long-term futures, play a critical role in ensuring successful national and business development (Miles et al., 2016).

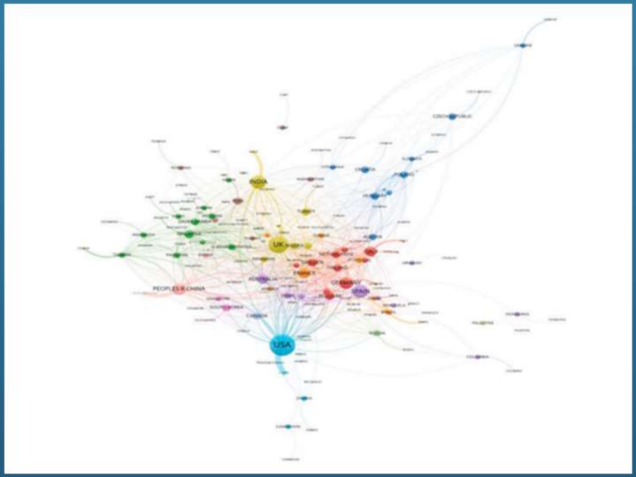
Although civilization has been the scene of developments and progress throughout history, there is a consensus that the changes and advances in the last few decades have taken place at a dizzying pace, according to different sources. The second-generation industrial period started with the advent of steam and waterpower, and a new path was opened by industrial mechanization, and mass production assembly lines that became more active with the use of electricity. While developments in electronics, information systems

* Corresponding author.
E-mail address: tugrul.u.daim@pdx.edu (T.U. Daim).

https://doi.org/10.1016/j.tre.2022.102943
Received 29 August 2022; Received in revised form 3 October 2022; Accepted 25 October 2022
1366-5545/© 2022 Elsevier Ltd. All rights reserved.

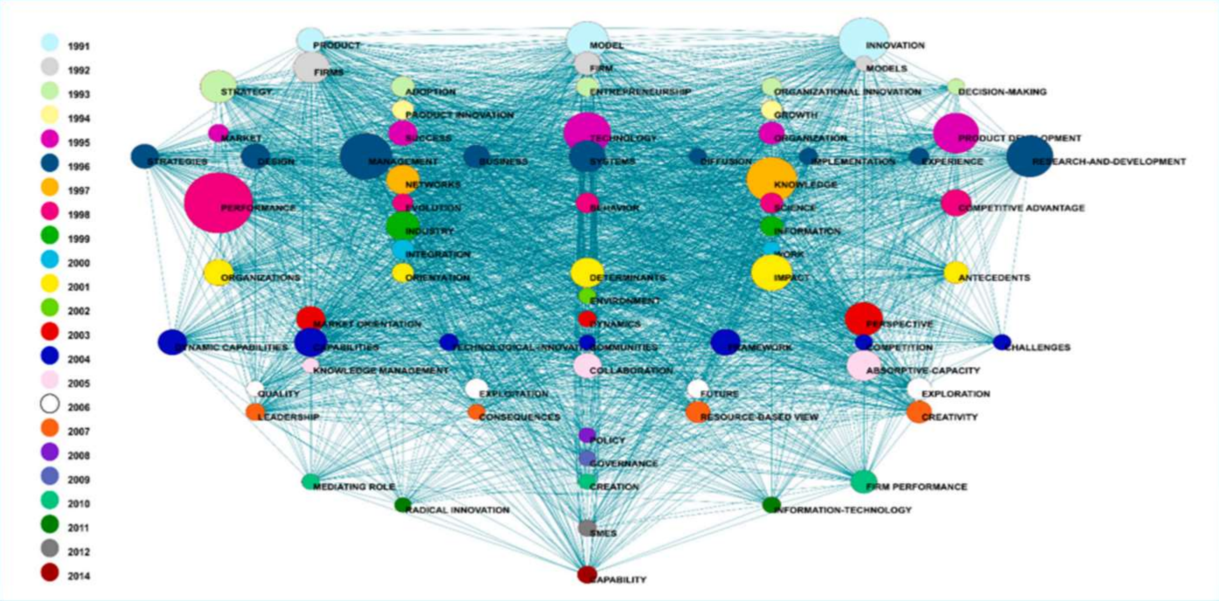






- We use NLP techniques to extract topics and clusters;
- Patent Class
- Patent Landscape Analysis

- We use SNA to see patents evolutions over time
- We use multi layer map to visualize the patents and their class over time
- In this way we can see patent evolution dynamics over time



Technological Forecasting & Social Change 185 (2022) 122052

Contents lists available at ScienceDirect

Technological Forecasting & Social Change

journal homepage: www.elsevier.com/locate/techfore

Conceptual structure and perspectives on "innovation management": A bibliometric review

Ali Bonyadi Naeini[a], Mehdi Zamani[a], Tugrul U. Daim[b,e,*], Mahak Sharma[c], Haydar Yalcin[d]

[a] Progress Engineering Department, Iran University of Science and Technology (IUST), Tehran, Iran
[b] Portland State University, Portland, OR, USA
[c] Birla Institute of Management Technology (BIMTECH), India
[d] Ege University, Turkey
[e] Chaoyang University of Technology, Taiwan

ARTICLE INFO

Keywords:
Bibliometric analysis
Innovation management
Emerging technologies
Patent analysis
Strategic diagram
Thematic evolution map

ABSTRACT

The present study aims to analyze "Innovation Management" using a bibliometric technique. To this aim, Web of Science (WOS) citation database was used to extract the articles. Then, the received files were combined and integrated using Bibexcel. In the next step, the data were illustrated and analyzed by R Studio and R package. The results identified well-cited articles, active, and influential journals, and authors in the field. In addition, investigating the strategic diagrams and thematic evolution maps revealed basic, developed, emerging, and obsolete issues in "Innovation Management". During the recent years, many researchers have focused on some issues with a forward-looking approach such as "Emerging Technologies", "Patent Analysis", as well as "Nanotechnology", "Service Innovation", and "Technology Transfer". The results represent a comprehensive understanding of the evolutionary process of each field and are considered as a coherent instrument for research policy.

1. Introduction

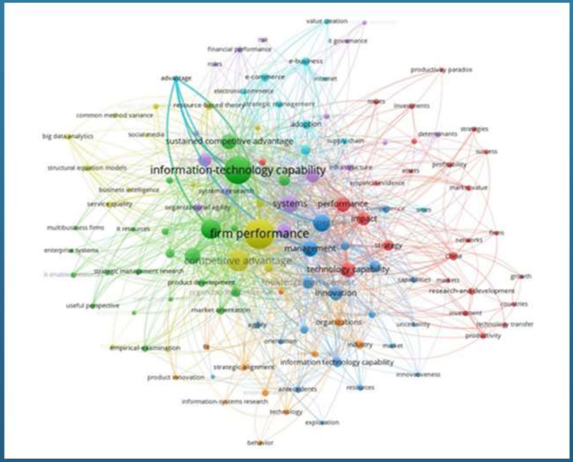
Innovation management is considered as a set of measures that formalize the innovation process and facilitate systematizing new methods, ideas, and products. In addition, this mechanism plays a significant role in the performance of small, medium, and large companies (Melendez et al., 2019). Therefore, it should be impactful in implementing the innovation management process when the objective of any company is to achieve a competitive advantage through developing the innovation, which requires defining the strategies and adopting an appropriate administrative structure to support innovation (Melendez et al., 2019). Many studies have been conducted in the field of innovation management, and one of the most widely used is qualitative studies. A qualitative approach provides accurate and desirable insight by investigating the articles carefully, while requiring considerable time and effort. Thus, this type of study is conducted on issues with limited data (Huang et al., 2019). During the recent years, various studies have been conducted on innovation management with a qualitative approach. For example, Szutowski et al. investigated confirming the conceptual representation of the innovation process, in which they examined the relationship between designing the innovation processes and performance of the company (Szutowski et al., 2019). Marrone and Ferris provided a conceptual framework for innovation management and emphasized the importance of brokers in the process (Marrone and Ferris, 2017). Serpell and Alvarez described a quantitative-qualitative approach to innovation management, which included a system for assessing the state of innovation management in construction companies (Serpell and Alvarez, 2014). In another study, Frank et al. identified the principles of successful innovation behavior and management in cognate companies (Frank, 2019). The researchers studied other issues in this regard such as the relationship between innovation management and culture (Meissner and Sprenger, 2010), the effect of strategic knowledge management on innovation (Marques et al., 2016), social processes occurring during implementing the radical organizational innovation (Carrero et al., 2000), and identifying the required organizational methods for generating the innovation in a company (Vargas et al., 2017).

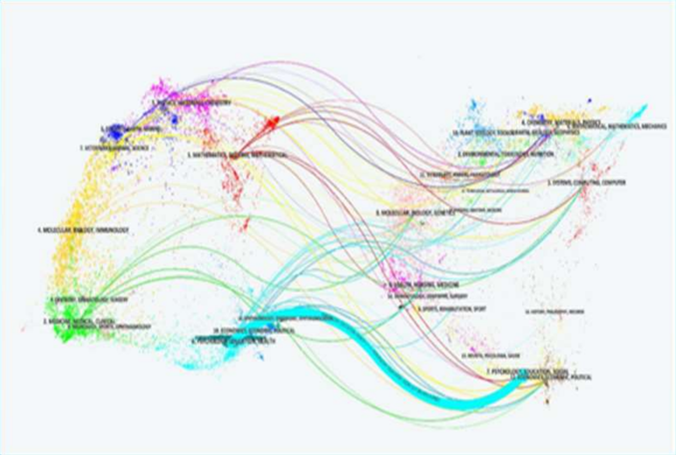
"Bibliometric Analysis" was first used by Prichard, and which can include documents, authors, research groups, countries, and any other collections (Caya and Neto, 2018). In fact, this type of study has a

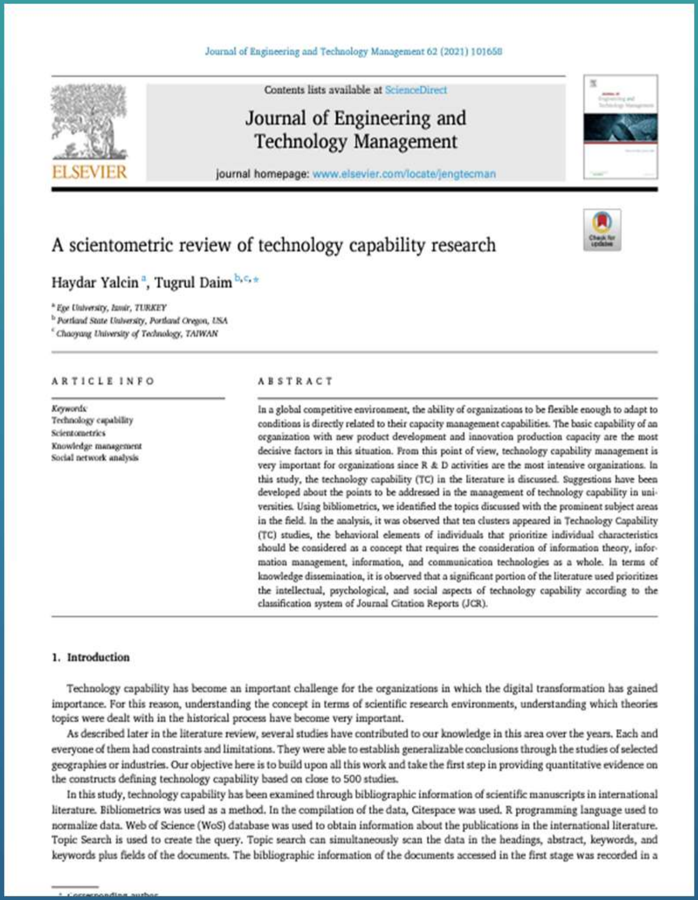
[*] Corresponding author.
E-mail addresses: bonyadi@iust.ac.ir (A.B. Naeini), tugrul.u.daim@pdx.edu (T.U. Daim).

https://doi.org/10.1016/j.techfore.2022.122052
Received 20 December 2020; Received in revised form 13 June 2022; Accepted 14 September 2022
Available online 19 October 2022

- We use double layer maps to understand knowledge diffusion among scientific disciplines




4. MOLECULAR, BIOLOGY, IMMUNOLOGY
1. MATHEMATICS, SYSTEMS, MATHEMATICAL
8. MOLECULAR, BIOLOGY, GENETICS
3. SYSTEMS, COMPUTING, COMPUTER
7. PSYCHOLOGY, EDUCATION, SOCIAL


Journal of Engineering and Technology Management 62 (2021) 101658

Contents lists available at ScienceDirect

Journal of Engineering and Technology Management

journal homepage: www.elsevier.com/locate/jengtecman

ELSEVIER

A scientometric review of technology capability research

Haydar Yalcin [a], Tugrul Daim [b,c,*]

[a] Ege University, Izmir, TURKEY
[b] Portland State University, Portland Oregon, USA
[c] Chaoyang University of Technology, TAIWAN

ARTICLE INFO

Keywords:
Technology capability
Scientometrics
Knowledge management
Social network analysis

ABSTRACT

In a global competitive environment, the ability of organizations to be flexible enough to adapt to conditions is directly related to their capacity management capabilities. The basic capability of an organization with new product development and innovation production capacity are the most decisive factors in this situation. From this point of view, technology capability management is very important for organizations since R & D activities are the most intensive organizations. In this study, the technology capability (TC) in the literature is discussed. Suggestions have been developed about the points to be addressed in the management of technology capability in universities. Using bibliometrics, we identified the topics discussed with the prominent subject areas in the field. In the analysis, it was observed that ten clusters appeared in Technology Capability (TC) studies, the behavioral elements of individuals that prioritize individual characteristics should be considered as a concept that requires the consideration of information theory, information management, information, and communication technologies as a whole. In terms of knowledge dissemination, it is observed that a significant portion of the literature used prioritizes the intellectual, psychological, and social aspects of technology capability according to the classification system of Journal Citation Reports (JCR).

1. Introduction

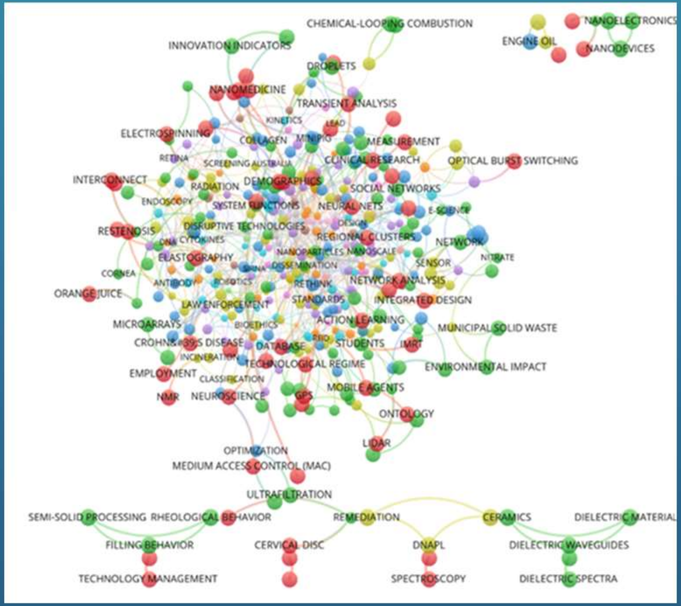
Technology capability has become an important challenge for the organizations in which the digital transformation has gained importance. For this reason, understanding the concept in terms of scientific research environments, understanding which theories topics were dealt with in the historical process have become very important.

As described later in the literature review, several studies have contributed to our knowledge in this area over the years. Each and everyone of them had constraints and limitations. They were able to establish generalizable conclusions through the studies of selected geographies or industries. Our objective here is to build upon all this work and take the first step in providing quantitative evidence on the constructs defining technology capability based on close to 500 studies.

In this study, technology capability has been examined through bibliographic information of scientific manuscripts in international literature. Bibliometrics was used as a method. In the compilation of the data, Citespace was used. R programming language used to normalize data. Web of Science (WoS) database was used to obtain information about the publications in the international literature. Topic Search is used to create the query. Topic search can simultaneously scan the data in the headings, abstract, keywords, and keywords plus fields of the documents. The bibliographic information of the documents accessed in the first stage was recorded in a

* Corresponding author

- We use SNA to understand topic relations



Technological Forecasting & Social Change 176 (2022) 121456

Contents lists available at ScienceDirect

Technological Forecasting & Social Change

journal homepage: www.elsevier.com/locate/techfore

Developing metrics for emerging technologies: identification and assessment

Mehdi Zamani[a], Haydar Yalcin[b], Ali Bonyadi Naeini[a], Gordana Zeba[c], Tugrul U Daim[d,e,*]

[a] Iran University of Science & Technology, Tehran, Iran
[b] Ege University, Izmir, Turkey
[c] University of Slavonski Brod, Slavonski Brod, Croatia
[d] Portland State University, Portland, OR, USA
[e] Chaoyang University of Technology, Taiwan

A R T I C L E I N F O

Keywords:
Bibliometric analysis
Emerging technologies
Strategic diagrams
Thematic evolution maps
Future studies
Structural hole analysis

A B S T R A C T

We analyze the field of emerging technologies using bibliographic techniques. The Web of Science (WoS) citation database was used as an article retrieval tool in this study. To analyze the studies, first the files received from the mentioned database were integrated by Bibexcel software. Then, the process of "current technologies" was studied from 1969 to 2020 by the Bibliometrix package from Bibliometrics and SciMat software, as well as thematic evolution maps and strategic diagrams. To identify the main actors and resources in these areas, the results obtained from the analysis indicated highly cited articles, journals, and influential authors in this field. In addition, the results of evaluating strategic diagrams and thematic evolution maps revealed the topics of emerging technologies. In general, the topics and technologies such as "Internet of Things (IoT)", "Intelligent Transportation Systems (ITS)", "Ultrasound", are among the emerging areas and technologies being considered during the last decade as the most central topics. Structural hole analysis has been applied to determine the sub-technologies of these technologies that have begun to mature. Furthermore, the trend of research focus on these topics has been increasing. For this reason, to determine the sub-subject areas that are open to improvement, they are handled with low aggregate constraints values.

1. Introduction

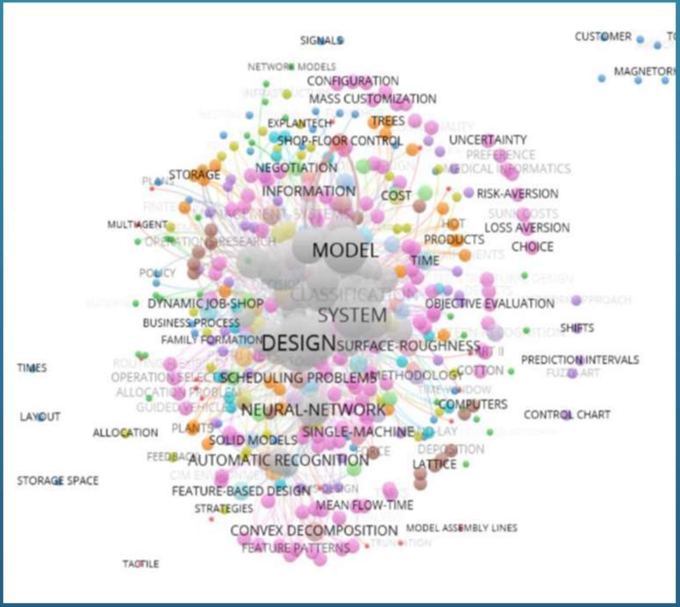
In today's world of turbulent change, the rapid development of new innovative technologies on an unprecedented scale has reached a turning point in the industrial sense and in the direction of development of industry, economy and society in general. The 4th industrial revolution is underway, in the context of which new technologies must be used to ensure the competitiveness of enterprises and entire national industries. Well-known cutting-edge technologies such as cloud computing, mobile computing, the Internet of Things, the Internet of Services, data collection, Big Data analytics, artificial intelligence, augmented reality, 3D printing and others have experienced rapid development and application. Research related to these technologies and the resulting new innovative emerging technologies have a significant impact on competitiveness. Competitiveness in emerging technologies can take the lead in the market. Given the rapid pace of technological progress, it is necessary to provide a good metric framework to facilitate decisions about future scientific research and development. It is crucial to provide insight into trends in future research and emerging technologies. For this reason, the authors decided to focus on emerging technologies and metrics for their identification and assessment in this study.

Globalization and increasing competition in the present as well as in the future, have led to the growing interest of individuals at the micro and macro levels in emerging technologies. There has been exponentially increasing publications on emerging technologies in the recent decade. However, different definitions of emerging technologies have been proposed, some of which overlap but point to different dimensions and features of this phenomenon. Rotolo et al. listed five fundamental features of emerging technologies as a novelty, relatively rapid growth, coherence, prominence, and uncertainty (Rotolo et al., 2015). In this study, the authors provide an overview of research on emerging

[*] Corresponding author.
E-mail addresses: M.zamani1990@yahoo.com (M. Zamani), haydar.yalcin@gmail.com (H. Yalcin), Bonyadi@iust.ac.ir (A.B. Naeini), tugrul.u.daim@pdx.edu, ji2td@pdx.edu (T.U. Daim).

https://doi.org/10.1016/j.techfore.2021.121456

- We use SNA to see topics and institutions relations



Technological Forecasting & Social Change 171 (2021) 120971

Contents lists available at ScienceDirect

Technological Forecasting & Social Change

journal homepage: www.elsevier.com/locate/techfore

Technology mining: Artificial intelligence in manufacturing

Gordana Zeba[a], Marina Dabić[b,c], Mirjana Čičak[a], Tugrul Daim[d,e,f,*], Haydar Yalcin[g]

[a] University of Slavonski Brod, Slavonski Brod, Croatia
[b] University of Zagreb, Faculty of Economics and Business, 10 000 Zagreb, Croatia
[c] Nottingham Trent University, Nottingham, United Kingdom
[d] Chaoyang University of Technology, Taiwan
[e] Department of Engineering and Technology Management, Portland State University, Oregon, USA
[f] HSE University, Moscow, Russian Federation
[g] Division of Management Information Systems - Department of Business Administration, Ege University, Izmir, Turkey

ARTICLE INFO

Keywords:
Artificial intelligence
Bibliometric
Content analysis
Industry 4.0
Manufacturing

ABSTRACT

The period of the fourth industrial revolution, called Industry 4.0, is characterized by new, innovative technologies such as: Cloud Computing; the Internet of Things; the Industrial Internet of Things; Big Data; Blockchain; Cyber-Physical Systems; Artificial Intelligence, and so on. Artificial Intelligence technology plays a significant role in modern manufacturing, particularly in the context of the Industry 4.0 paradigm. This article offers a visual and a comprehensive study of the application of Artificial Intelligence in manufacturing. Existing scholarly literature on Artificial Intelligence in manufacturing, within the Web of Science Core Collection databases, is examined in two periods: 1979-2010 and 2011-2019. These periods are viewed, respectively, as before and after the emergence of the term Industry 4.0. Bibliometric and content analysis of relevant literature is conducted and key findings are subsequently identified. The results indicate that the most important topics today are: cyber-physical systems and smart manufacturing; deep learning and big data; and real-time scheduling algorithms.

1. Introduction

Increasing globalization has had a huge impact on economic, social, and political changes. Many technologies are in the process of emerging, such as: Cloud Computing, the Internet of Things (IoT), Internet of Services (IoS), Big Data analytics, and Artificial Intelligence (AI). These technologies are the foundation of Industry 4.0 and they ensure that the manufacturing industry is smart and able to meet current challenges, such as: adapting to individual customer requirements, improving quality, and responding more quickly to market demands (Zheng et al., 2018). Industry 4.0 has had a significant impact on global manufacturing and industrial development, using the aforementioned technologies to optimize production in real-time and facilitate vertical, horizontal, and end-to-end integration (Xu et al., 2018; Obradović et al., 2021). The Cyber-Physical System (CPS) is in the process of gaining recognition within the manufacturing industry and it enables the physical and virtual worlds that characterize Industry 4.0 to coalesce. AI is increasingly present today in various fields of human activity. It is an integral part of the digitalization of business. It has entered the Industry 4.0 era and has found a place in the manufacturing industry as well. Manufacturing is undergoing a transformation from intelligent manufacturing, which is knowledge-based, to smart manufacturing, which is knowledge-enabled and data-driven (Zhong et al., 2017). Smart manufacturing is based on innovative information and communication technologies, particularly those involving AI (Choen et al., 2019; Zhang et al., 2019). AI is considered to be one of the key technologies for Industry 4.0 and smart manufacturing (Zheng et al., 2018; Mao et al., 2019). Due to the increasing amount of information processed in post-millennial culture, systems that use AI are becoming increasingly important. Irregularities and faults are inevitable in mass production and so companies that do not use AI spend more time detecting faults by browsing through thousands of product images. AI software needs several product images to detect imperfections in a very short time-frame. Companies collect huge amounts of unstructured data from different sources, such as: sensors in machines, production lines, manufacturing execution systems, enterprise resource planning systems,

All authors contributed equally

[*] Corresponding author.
E-mail addresses: gzeba@unisb.hr (G. Zeba), mdabic@efzg.hr, marina.dabic@ntu.ac.uk (M. Dabić), mcicak@unisb.hr (M. Čičak), ji2td@pdx.edu (T. Daim).

PROJECT OBJECTIVES

- We aim to identify concepts and technologies that will gain importance and lose their importance in the short-medium and long-term on cybersecurity technologies through basic research documents conducted in the world.
- In this context, it will be possible to identify researchers, countries and organizations that shape the field, as well as identifying research teams on cybersecurity and identifying the leaders of these teams.
- In our study, the status of cybersecurity research, frequently discussed topics, and the social and intellectual structure of cybersecurity technologies research will be investigated

METHODS

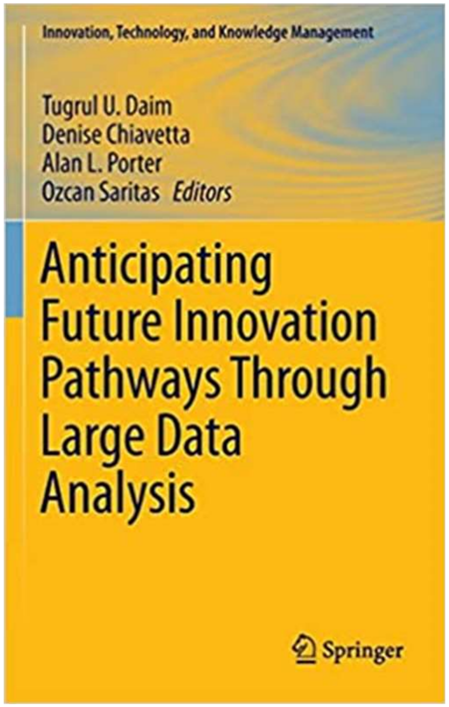
SERIES ON TECHNOLOGY MANAGEMENT – VOL. 30

Innovation Discovery

Network Analysis of Research and Invention Activity for Technology Management

Tugrul Daim • Alan Pilkington
editors

World Scientific



Innovation, Technology, and Knowledge Management

Tugrul U. Daim
Denise Chiavetta
Alan L. Porter
Ozcan Saritas *Editors*

Anticipating Future Innovation Pathways Through Large Data Analysis

Springer

METHODS: *Bibliometrics, Patent Search and Social Network Analysis*

- Betweenness centrality is a way of detecting the amount of influence a node has over the flow of information in a graph. It is often used to find nodes that serve as a bridge from one part of a graph to another. The algorithm calculates unweighted shortest paths between all pairs of nodes in a graph.
- Closeness centrality is a measure of the average shortest distance from each vertex to each other vertex. Specifically, it is the inverse of the average shortest distance between the vertex and all other vertices in the network.

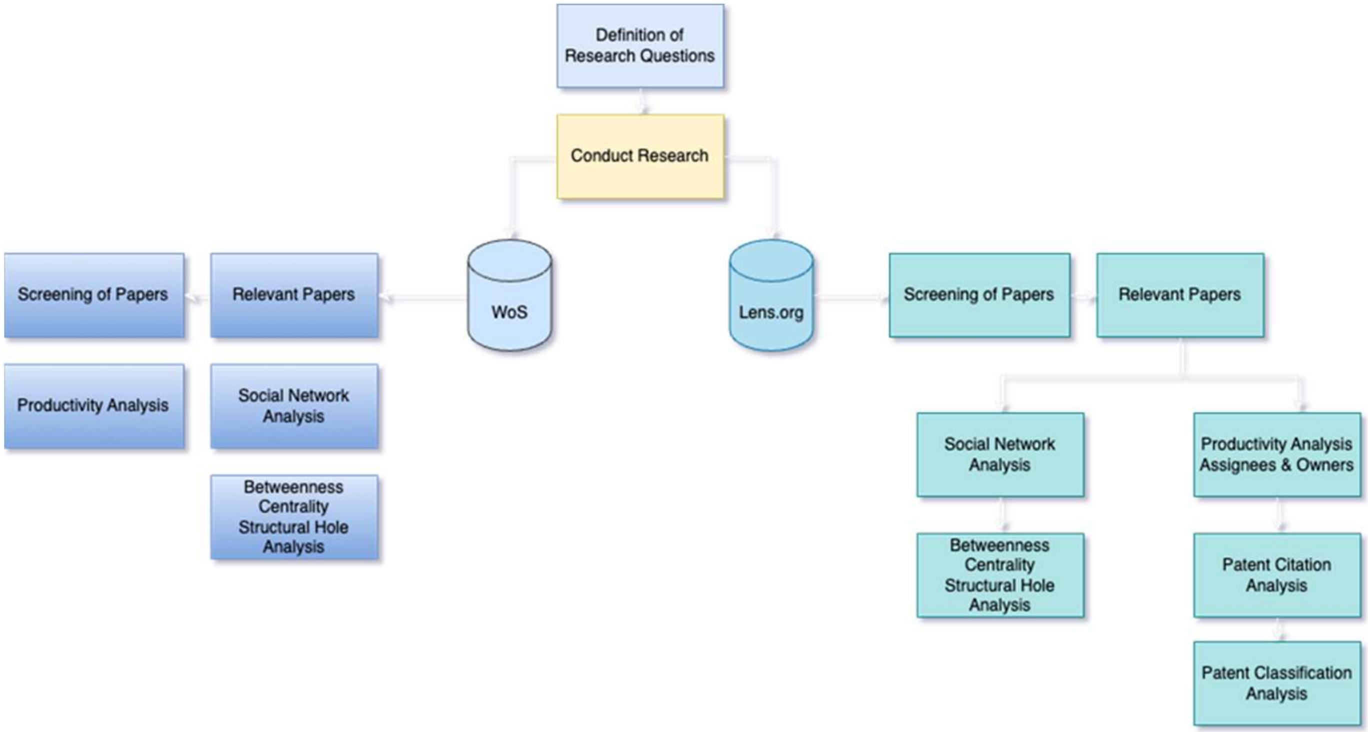
METHODS: *Bibliometrics, Patent Search and Social Network Analysis*

- Authority and hub values are defined in terms of one another in a mutual recursion. An authority value is computed as the sum of the scaled hub values that point to that page. A hub value is the sum of the scaled authority values of the pages it points to.
- A structural hole refers to an “empty space” between contacts in a person's network. It means that these contacts do not interact closely (though they may be aware of one another). Actors on either side of the structural hole have access to different flows of information.

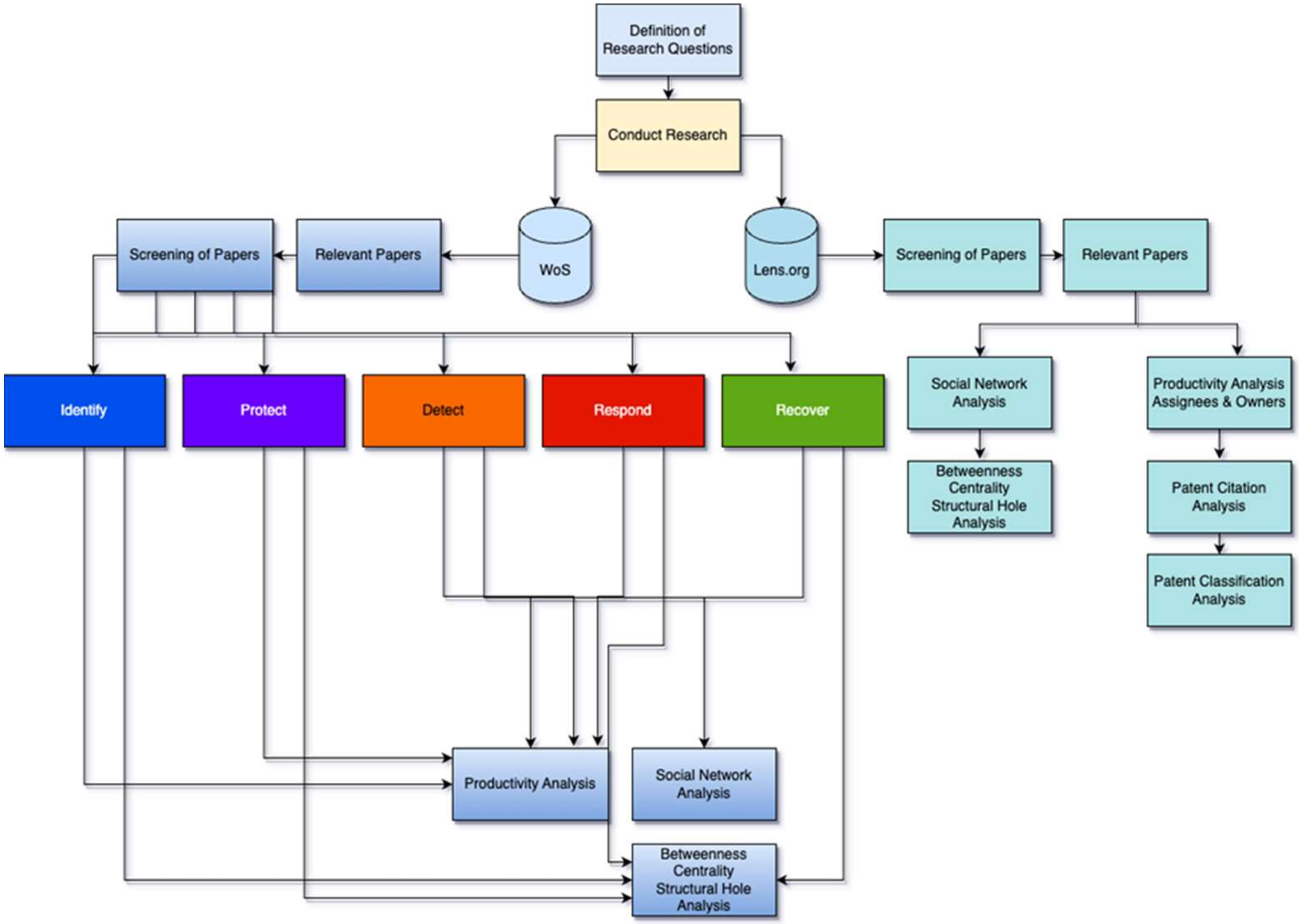
METHODS: *NLP and LDA*

- In Natural Language Processing (NLP), Latent Dirichlet Allocation (LDA) is a generative statistical model that explains a set of observations through unobserved groups, and each group explains why some parts of the data are similar.
- The LDA is an example of a topic model. In this, observations (e.g., words) are collected into documents, and each word's presence is attributable to one of the document's topics.

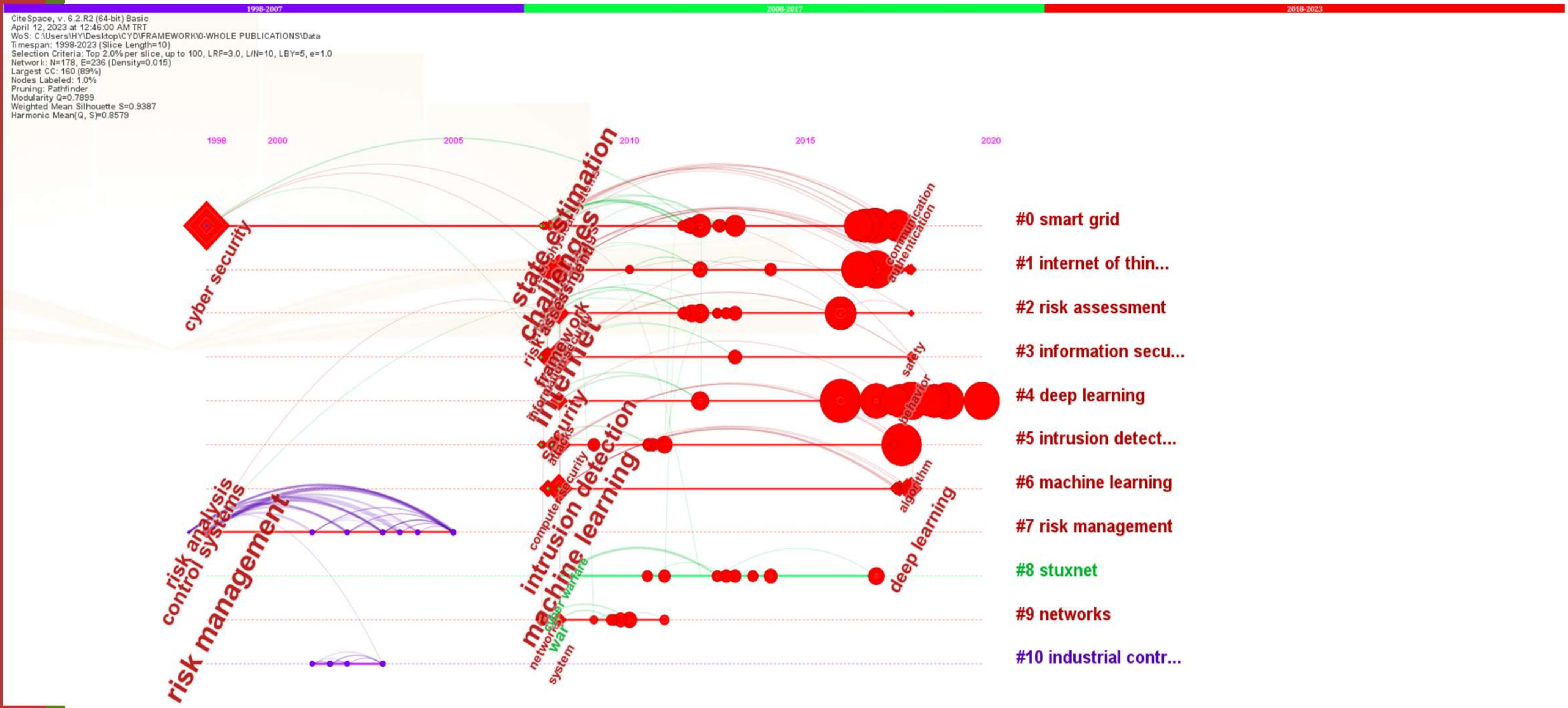
METHODS


Definition of Research Questions
Conduct Research
WoS
Lens.org
Screening of Papers
Relevant Papers
Productivity Analysis
Social Network Analysis
Betweenness Centrality Structural Hole Analysis
Screening of Papers
Relevant Papers
Social Network Analysis
Productivity Analysis Assignees & Owners
Betweenness Centrality Structural Hole Analysis
Patent Citation Analysis
Patent Classification Analysis

METHODS


Definition of Research Questions
Conduct Research
WoS
Lens.org
Relevant Papers
Screening of Papers
Screening of Papers
Relevant Papers
Identify
Protect
Detect
Respond
Recover
Social Network Analysis
Productivity Analysis Assignees & Owners
Betweenness Centrality Structural Hole Analysis
Patent Citation Analysis
Patent Classification Analysis
Productivity Analysis
Social Network Analysis
Betweenness Centrality Structural Hole Analysis

RESULTS



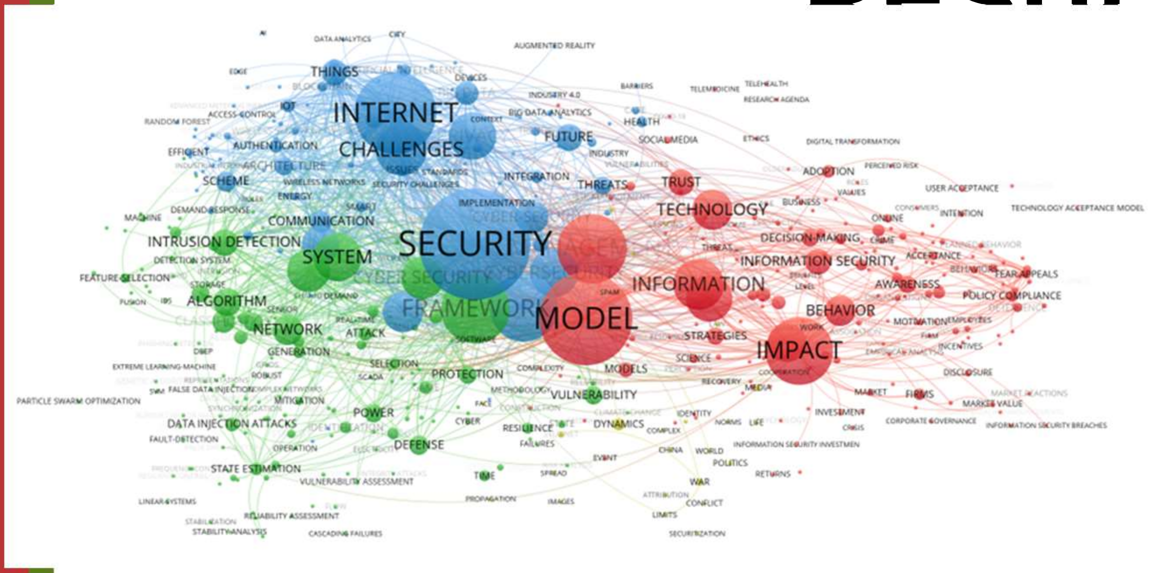
```
CiteSpace, v. 6.2.R2 (64-bit) Basic
April 12, 2023 at 12:46:00 AM TRT
WoS: C:\Users\HY\Desktop\CYD\FRAMEWORK\0-WHOLE PUBLICATIONS\Data
Timespan: 1998-2023 (Slice Length=10)
Selection Criteria: Top 2.0% per slice, up to 100, LRF=3.0, L/N=10, LBY=5, e=1.0
Network: N=178, E=236 (Density=0.015)
Largest CC: 160 (89%)
Nodes Labeled: 1.0%
Pruning: Pathfinder
Modularity Q=0.7899
Weighted Mean Silhouette S=0.9387
Harmonic Mean(Q, S)=0.8579
```

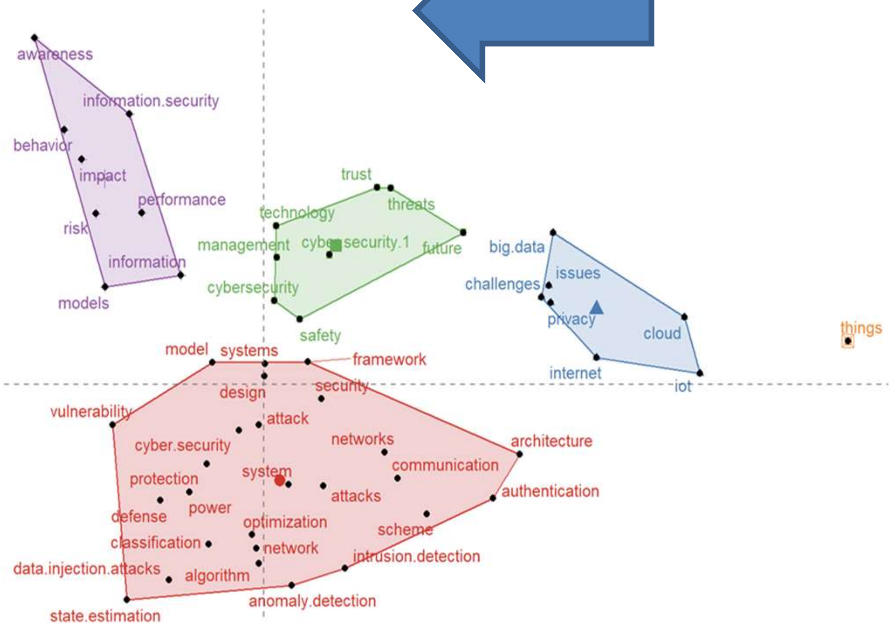
Timeline Analysis >> state estimation.

Early Rise then Fall >> internet of things, risk management, and information security

Rising >> deep learning cluster. along with machine learning, intrusion detection and stuxnet

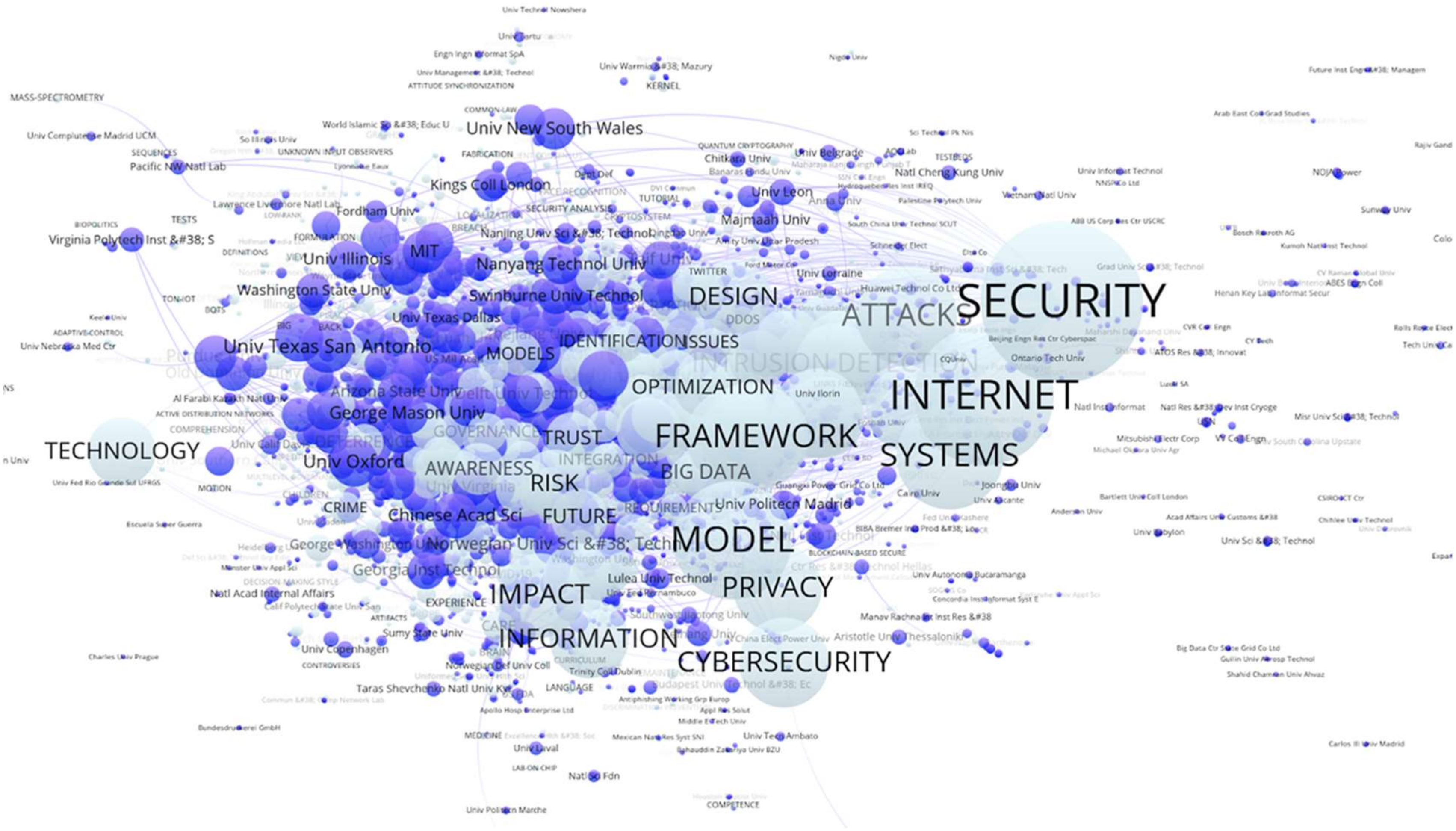
RESULTS





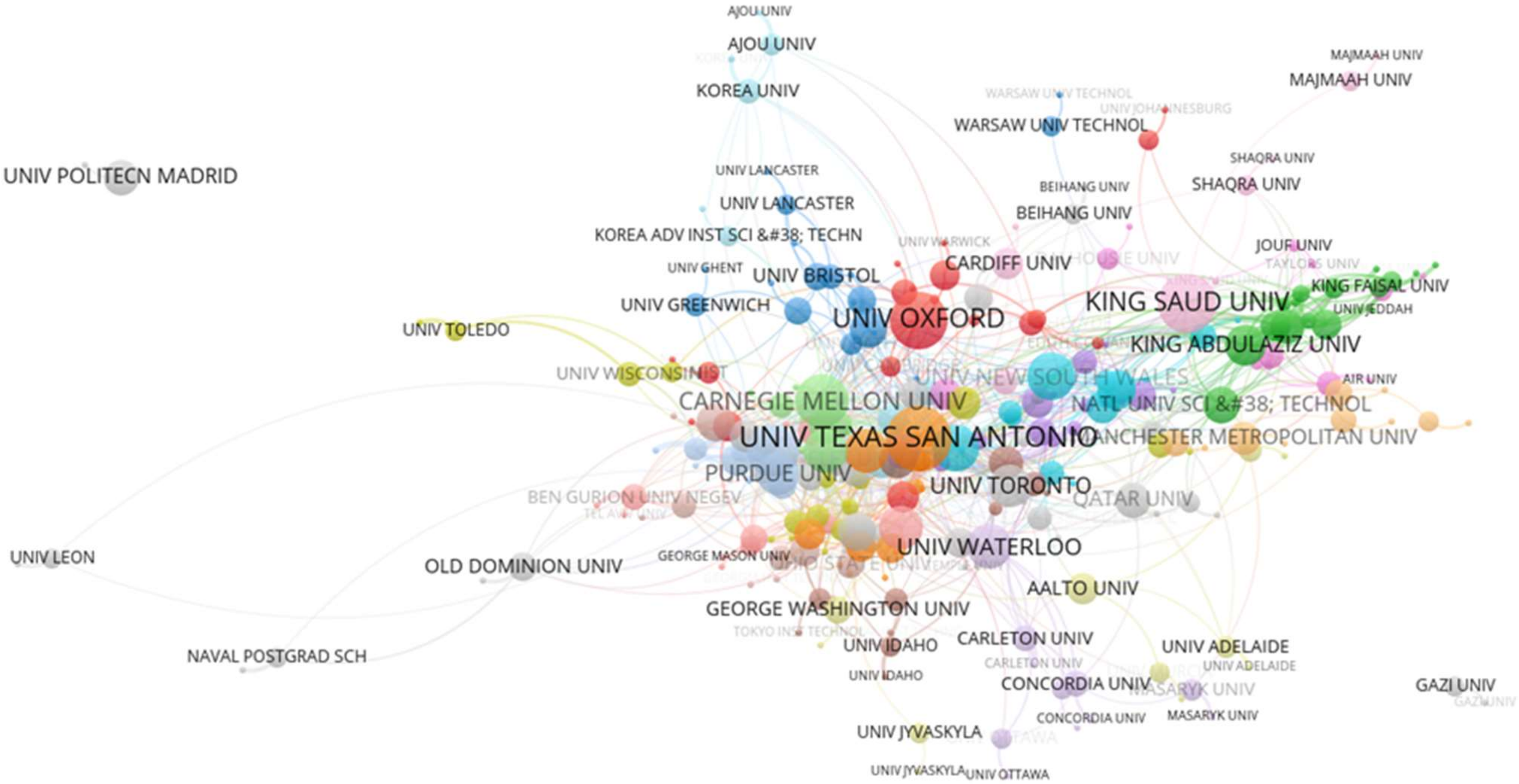
Synonym Analysis >> internet and infrastructure (security, challenge, internet and communication); behavioral dimension of information technologies (information technology, impact, model, and information technology); infrastructure and methodological (system algorithm, infiltration detection)

RESULTS



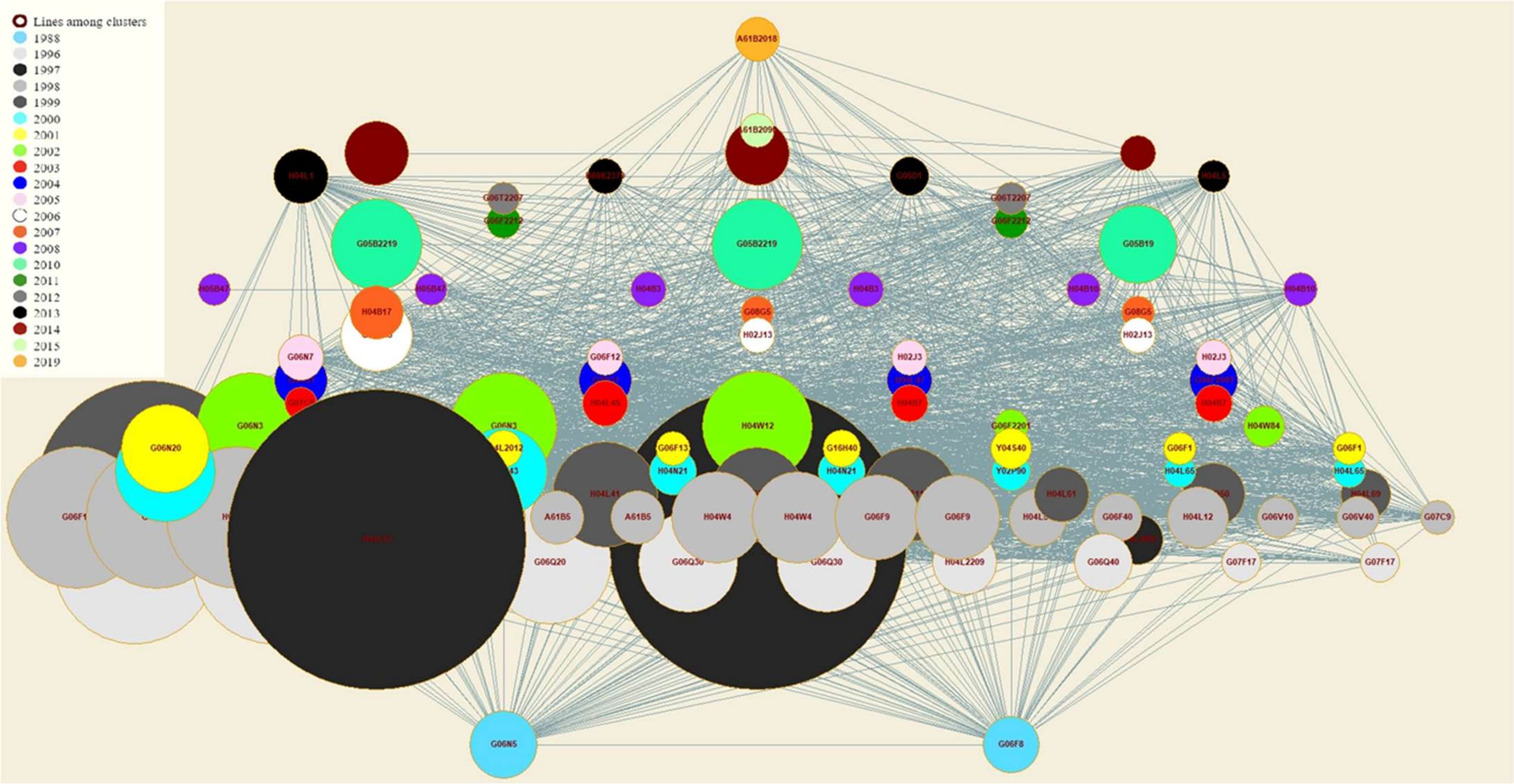
Active research institutions >> blue institutions, light blue keywords, fields of expertise and competence

RESULTS



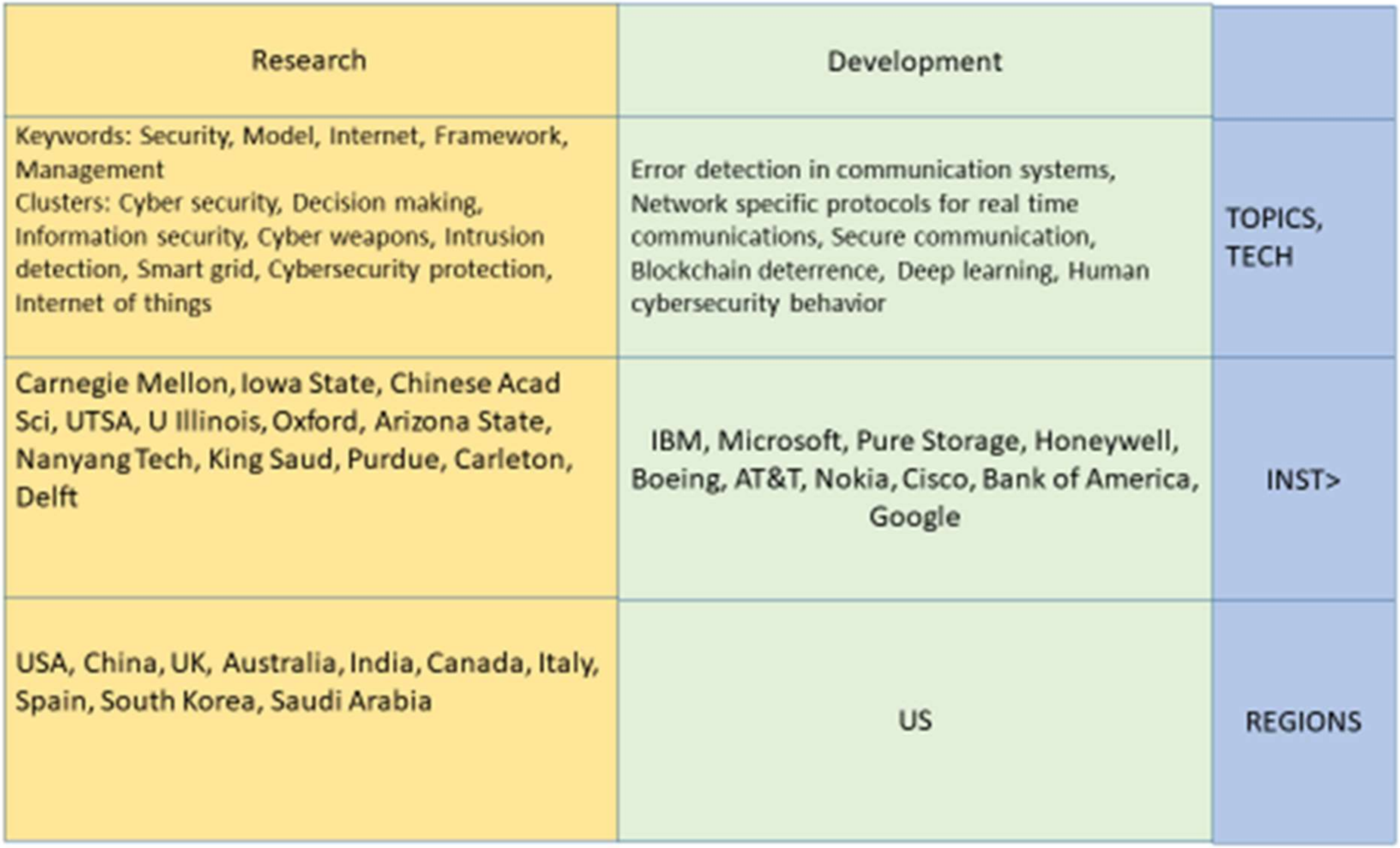
Many countries are active in research

RESULTS



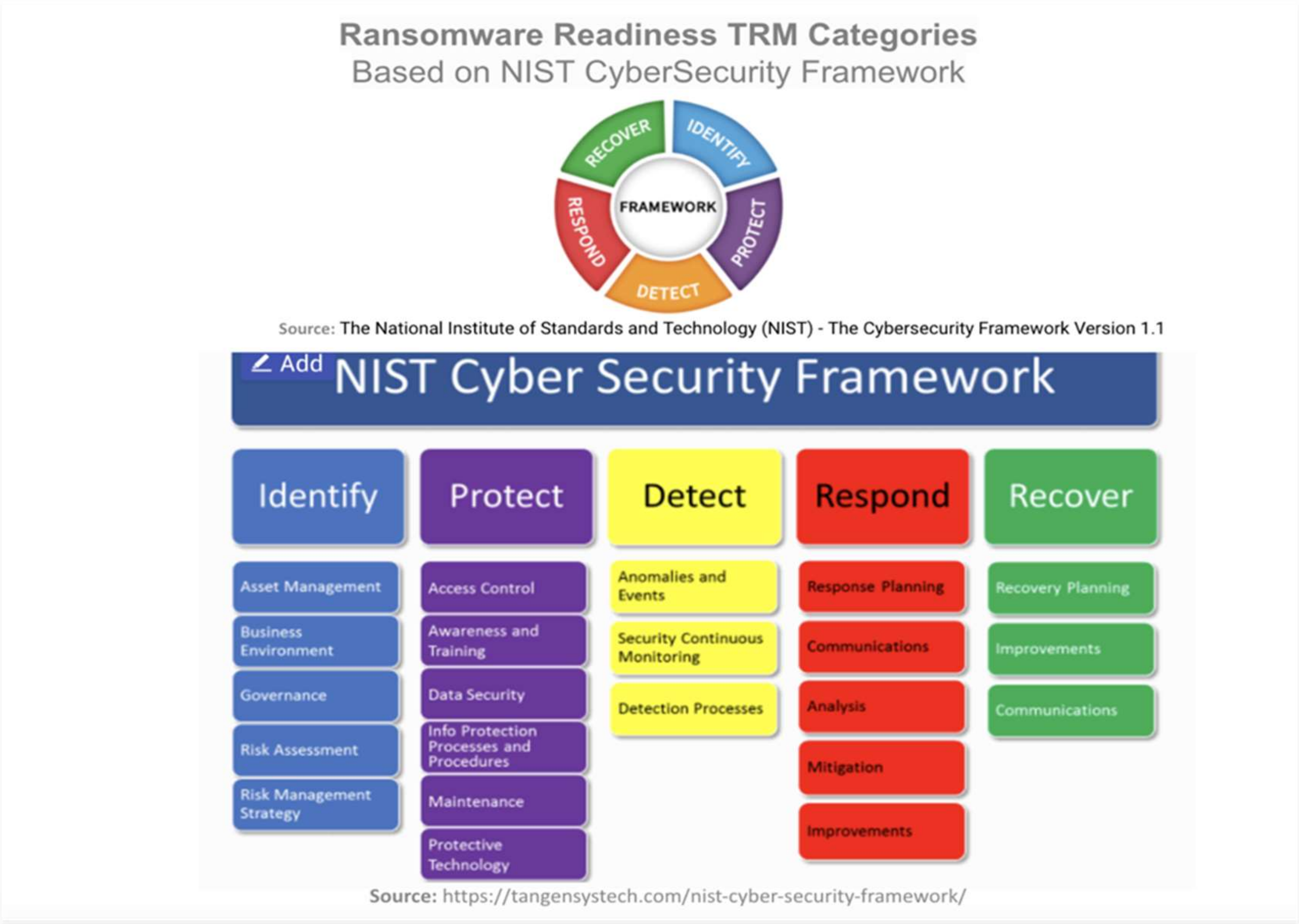
Patent classification codes in the context of the year axis and their mutual relations

RESULTS



Research	Development	
Keywords: Security, Model, Internet, Framework, Management Clusters: Cyber security, Decision making, Information security, Cyber weapons, Intrusion detection, Smart grid, Cybersecurity protection, Internet of things	Error detection in communication systems, Network specific protocols for real time communications, Secure communication, Blockchain deterrence, Deep learning, Human cybersecurity behavior	TOPICS, TECH
Carnegie Mellon, Iowa State, Chinese Acad Sci, UTSA, U Illinois, Oxford, Arizona State, Nanyang Tech, King Saud, Purdue, Carleton, Delft	IBM, Microsoft, Pure Storage, Honeywell, Boeing, AT&T, Nokia, Cisco, Bank of America, Google	INST>
USA, China, UK, Australia, India, Canada, Italy, Spain, South Korea, Saudi Arabia	US	REGIONS

RESULTS



Ransomware Readiness TRM Categories

Based on NIST CyberSecurity Framework

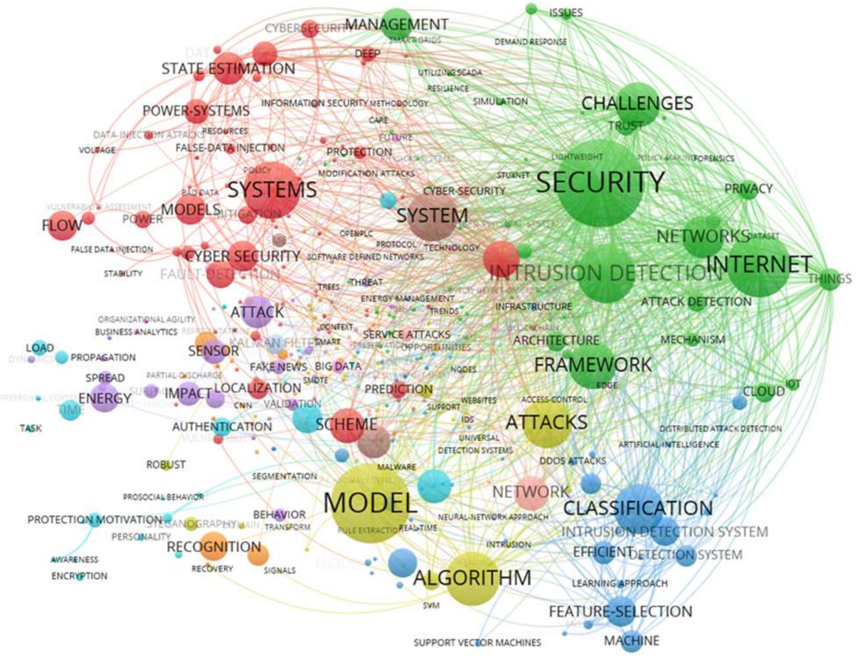
Source: The National Institute of Standards and Technology (NIST) - The Cybersecurity Framework Version 1.1

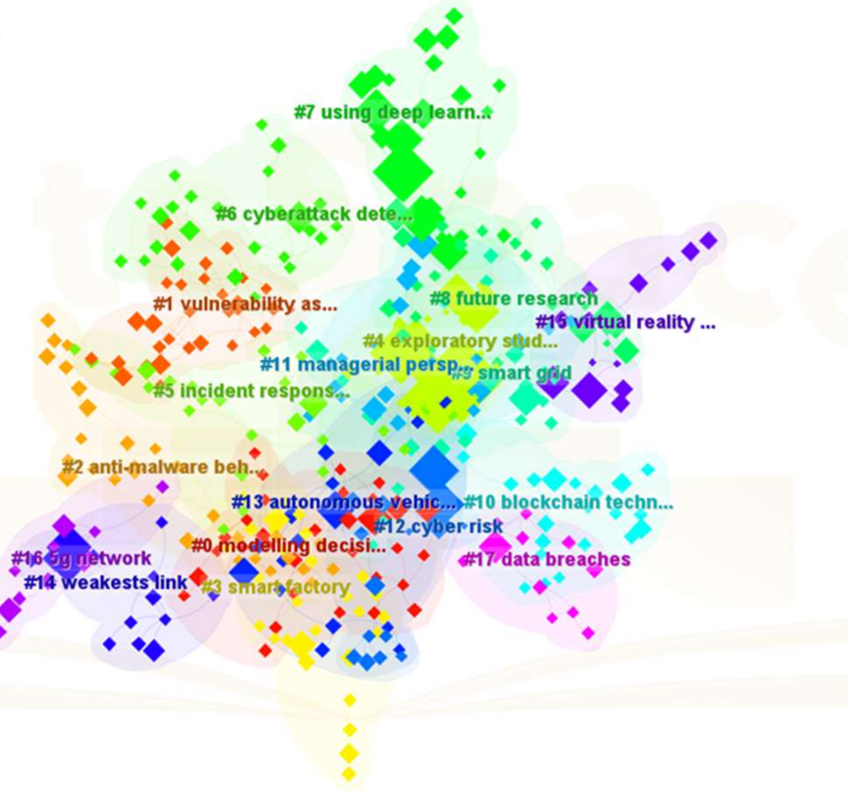
NIST Cyber Security Framework

Identify	Protect	Detect	Respond	Recover
Asset Management	Access Control	Anomalies and Events	Response Planning	Recovery Planning
Business Environment	Awareness and Training	Security Continuous Monitoring	Communications	Improvements
Governance	Data Security	Detection Processes	Analysis	Communications
Risk Assessment	Info Protection Processes and Procedures		Mitigation	
Risk Management Strategy	Maintenance		Improvements	
	Protective Technology			

Source: https://tangensystech.com/nist-cyber-security-framework/

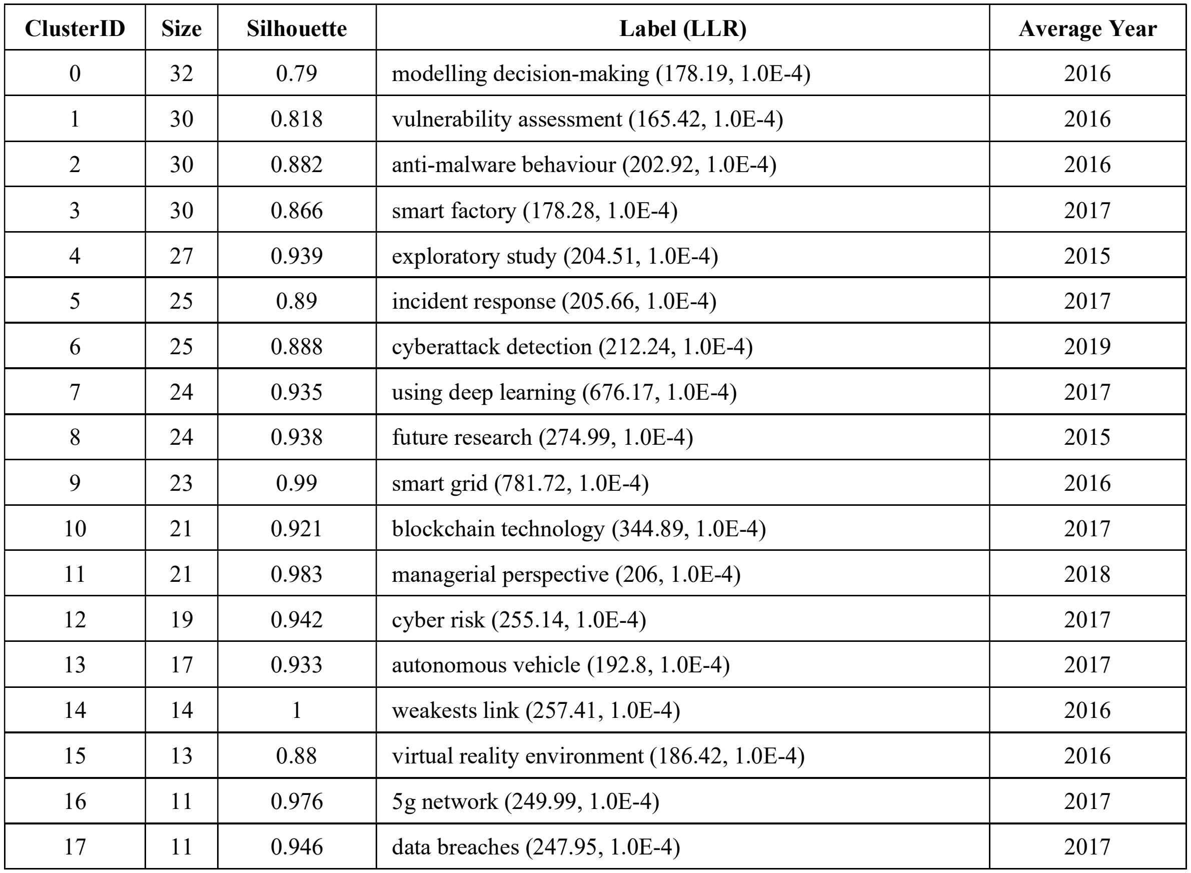
RESULTS





- NIST: Identify, Protect, Detect, Respond, Recover

RESULTS



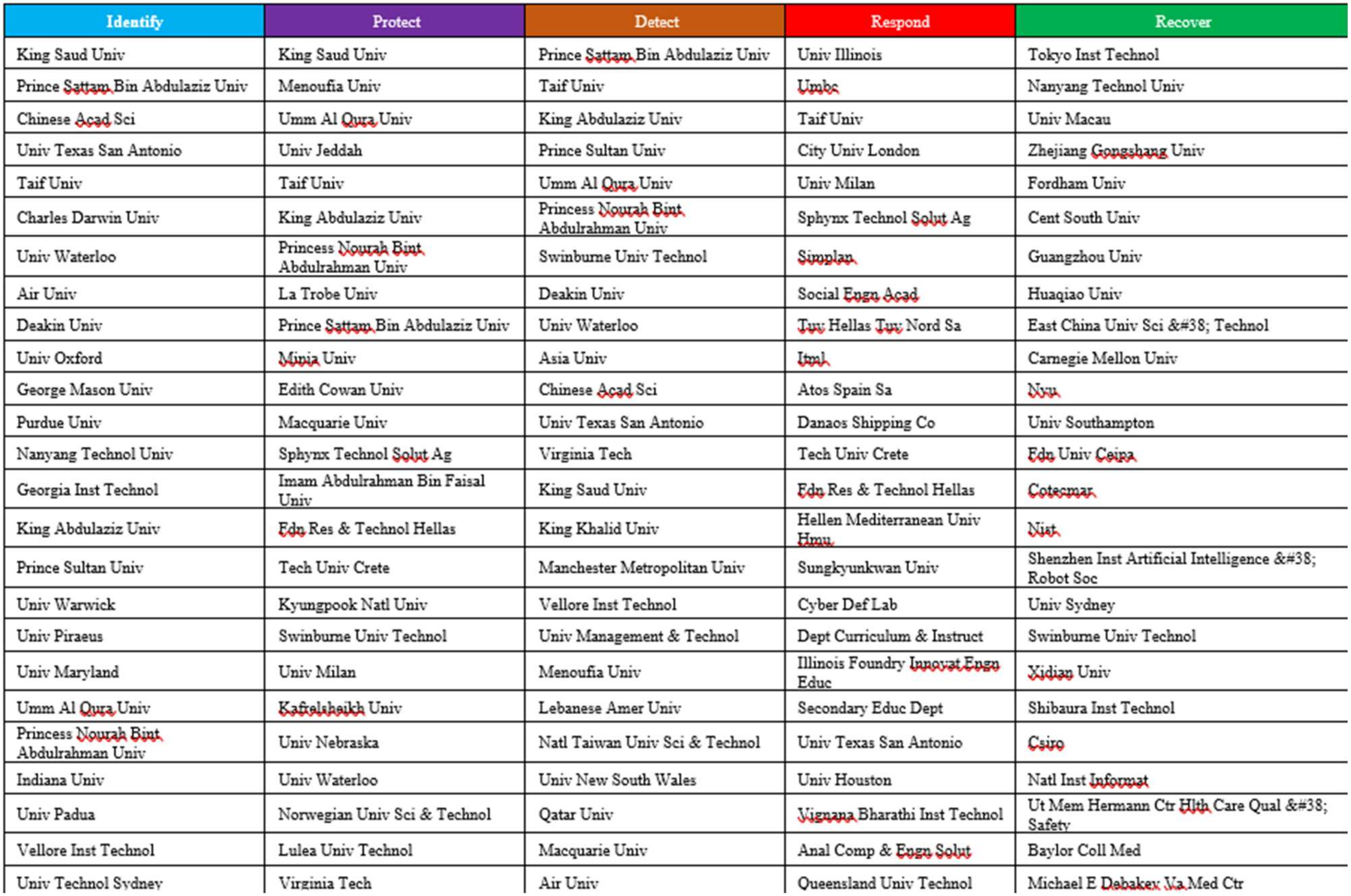
ClusterID	Size	Silhouette	Label (LLR)	Average Year
0	32	0.79	modelling decision-making (178.19, 1.0E-4)	2016
1	30	0.818	vulnerability assessment (165.42, 1.0E-4)	2016
2	30	0.882	anti-malware behaviour (202.92, 1.0E-4)	2016
3	30	0.866	smart factory (178.28, 1.0E-4)	2017
4	27	0.939	exploratory study (204.51, 1.0E-4)	2015
5	25	0.89	incident response (205.66, 1.0E-4)	2017
6	25	0.888	cyberattack detection (212.24, 1.0E-4)	2019
7	24	0.935	using deep learning (676.17, 1.0E-4)	2017
8	24	0.938	future research (274.99, 1.0E-4)	2015
9	23	0.99	smart grid (781.72, 1.0E-4)	2016
10	21	0.921	blockchain technology (344.89, 1.0E-4)	2017
11	21	0.983	managerial perspective (206, 1.0E-4)	2018
12	19	0.942	cyber risk (255.14, 1.0E-4)	2017
13	17	0.933	autonomous vehicle (192.8, 1.0E-4)	2017
14	14	1	weakests link (257.41, 1.0E-4)	2016
15	13	0.88	virtual reality environment (186.42, 1.0E-4)	2016
16	11	0.976	5g network (249.99, 1.0E-4)	2017
17	11	0.946	data breaches (247.95, 1.0E-4)	2017

The image has clustering analysis results. The identity information of each cluster, the cluster size, the sillhouette keyword that shows the separation value, and also the publication year information of that cluster is included. The largest cluster appears to be modeling decision making. According to the table, it is seen that such a critical density was formed in 2016. These analyzes provide us with very important inferences in determining the research focus and the years of critical intensity.

RESULTS

Identify	Protect	Detect	Respond	Recover
Security	Cybersecurity	Cybersecurity	Cybersecurity	Cybersecurity
Machine Learning	Security	Machine Learning	Machine Learning	Security
Internet of Things	Machine Learning	Deep Learning	Security	Machine Learning
Computer Security	Internet of Things	Intrusion Detection	Cyberattack	Computer Security
Deep Learning	Computer Security	Anomaly Detection	Phishing	Covid-19
Computer Crime	Privacy	Security	Computer Security	Smart Grid
Anomaly Detection	Deep Learning	Internet of Things	Smart Grid	Computer Crime
Artificial Intelligence	Intrusion Detection	Feature Extraction	Information Security	Cloud Computing
Intrusion Detection	Computer Crime	Malware	Feature Extraction	Phishing
Privacy	Blockchain	Cyberattack	Covid-19	Threat Analysis
Malware	Smart Grid	Computer Security	Anomaly Detection	Deep Learning
Protocols	Cyber-Security	Computer Crime	Deep Learning	Internet
Cloud Computing	Artificial Intelligence	Artificial Intelligence	Internet of Things	Feature Extraction
Feature Extraction	Malware	Data Models	Cloud Computing	Data Models
Smart Grid	Cyberattack	Cyber-Security	Computer Crime	Critical Infrastructure
Standards	Internet of Things (IoT)	Intrusion Detection System	Internet	Lawsuit
Information Security	Intrusion Detection System	State Estimation	Artificial Intelligence	Target
Blockchain	Cyber-Physical Systems	Support Vector Machines	Critical Infrastructure	Governance
Data Models	Critical Infrastructure	Smart Grid	Privacy	Anomaly Detection
Risk Management	Anomaly Detection	Protocols	Malware	Biological System Modeling
Taxonomy	Information Security	Neural Networks	Cybercrime	Privacy
Support Vector Machines	Authentication	Critical Infrastructure	Complex Systems	Data Breach
Real-Time Systems	Cryptography	Training	Data Models	Internet of Things
Safety	Network Security	Network Security	Data Mining	Decision Making
Computer Architecture	Feature Extraction	Botnet	Decision Making	Malware

RESULTS



Identify	Protect	Detect	Respond	Recover
King Saud Univ	King Saud Univ	Prince Sattam Bin Abdulaziz Univ	Univ Illinois	Tokyo Inst Technol
Prince Sattam Bin Abdulaziz Univ	Menoufia Univ	Taif Univ	Umbc	Nanyang Technol Univ
Chinese Acad Sci	Umm Al Qura Univ	King Abdulaziz Univ	Taif Univ	Univ Macau
Univ Texas San Antonio	Univ Jeddah	Prince Sultan Univ	City Univ London	Zhejiang Gongshang Univ
Taif Univ	Taif Univ	Umm Al Qura Univ	Univ Milan	Fordham Univ
Charles Darwin Univ	King Abdulaziz Univ	Princess Nourah Bint Abdulrahman Univ	Sphynx Technol Solut Ag	Cent South Univ
Univ Waterloo	Princess Nourah Bint Abdulrahman Univ	Swinburne Univ Technol	Simplan	Guangzhou Univ
Air Univ	La Trobe Univ	Deakin Univ	Social Engn Acad	Huaqiao Univ
Deakin Univ	Prince Sattam Bin Abdulaziz Univ	Univ Waterloo	Tuv Hellas Tuv Nord Sa	East China Univ Sci &#38; Technol
Univ Oxford	Minia Univ	Asia Univ	Itml	Carnegie Mellon Univ
George Mason Univ	Edith Cowan Univ	Chinese Acad Sci	Atos Spain Sa	Nyu
Purdue Univ	Macquarie Univ	Univ Texas San Antonio	Danaos Shipping Co	Univ Southampton
Nanyang Technol Univ	Sphynx Technol Solut Ag	Virginia Tech	Tech Univ Crete	Fdn Univ Ceipa
Georgia Inst Technol	Imam Abdulrahman Bin Faisal Univ	King Saud Univ	Fdn Res & Technol Hellas	Cotecmar
King Abdulaziz Univ	Fdn Res & Technol Hellas	King Khalid Univ	Hellen Mediterranean Univ Hmu	Nist
Prince Sultan Univ	Tech Univ Crete	Manchester Metropolitan Univ	Sungkyunkwan Univ	Shenzhen Inst Artificial Intelligence &#38; Robot Soc
Univ Warwick	Kyungpook Natl Univ	Vellore Inst Technol	Cyber Def Lab	Univ Sydney
Univ Piraeus	Swinburne Univ Technol	Univ Management & Technol	Dept Curriculum & Instruct	Swinburne Univ Technol
Univ Maryland	Univ Milan	Menoufia Univ	Illinois Foundry Innovat Engn Educ	Xidian Univ
Umm Al Qura Univ	Kafrelsheikh Univ	Lebanese Amer Univ	Secondary Educ Dept	Shibaura Inst Technol
Princess Nourah Bint Abdulrahman Univ	Univ Nebraska	Natl Taiwan Univ Sci & Technol	Univ Texas San Antonio	Csiro
Indiana Univ	Univ Waterloo	Univ New South Wales	Univ Houston	Natl Inst Informat
Univ Padua	Norwegian Univ Sci & Technol	Qatar Univ	Vignana Bharathi Inst Technol	Ut Mem Hermann Ctr Hlth Care Qual &#38; Safety
Vellore Inst Technol	Lulea Univ Technol	Macquarie Univ	Anal Comp & Engn Solut	Baylor Coll Med
Univ Technol Sydney	Virginia Tech	Air Univ	Queensland Univ Technol	Michael E Debakey Va Med Ctr

CONCLUSIONS AND NEXT STEPS

- We have identified leading technologies, institutes and scientists in cyber defense
- Specific analysis was made implanting US NIST framework
- Based on our analysis and consultation with ArmaSuisse, we selected key technologies to conduct future predictions