



Professor Ravi Sandhu

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Executive Director and Founder, Institute for Cyber Security

Lutcher Brown Endowed Chair in Cyber Security

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Degrees

Degree	Major	University	Year
Ph.D.	Computer Science	Rutgers University, New Jersey	1983
M.S.	Computer Science	Rutgers University, New Jersey	1980
M.Tech.	Computer Technology	Indian Institute of Technology, New Delhi	1976
B.Tech.	Electrical Engineering	Indian Institute of Technology, Bombay	1974

Academic Career

- **Univ. of Texas at San Antonio, 2007 onwards:** Professor of Computer Science and Lutcher Brown Endowed Chair (Cyber Security). Executive Director, Institute for Cyber Security (2007-), Director NSF CREST Center for Security and Privacy Enhanced Cloud Computing (2017-).
- **George Mason University, 1995-2007:** Full Prof., 1989-1995: Assoc. Prof. (Info. & Software Engg.).
- **Ohio State University, 1983-1989:** Assistant Professor, 1982-1983: Instructor (Computer Science).

Career Focus and Goals

My career has focused on high impact research, practice and education in cyber security starting with my doctoral thesis. Effective cyber security requires science, engineering, business, policy and people skills. My goal has been and is to instill this culture in the discipline and provide leadership in all elements.

Professional Recognition

- **Citations and Impact.** (Based on current Google Scholar) 44,500+ citations, h-index 87.
- **Frequent Keynote and Invited Speaker.** See www.profsandhu.com for details.
- **National Academy of Inventors Fellow, 2021.**
- **IFIP TC 11 Kristian Beckman Award, 2019.** “In recognition of significant and long-term contribution to the field of information security in research, education and promotion.”
- **IEEE Innovation in Societal Infrastructure Award, 2018.** “For advancing the foundations and practice of information security through creation, development, and technology transfer of role-based access control (RBAC).”
- **IFIP WG 11.3 Outstanding Research Award, 2017.** “For outstanding research contributions to the field of data and applications security and privacy that have had lasting impact in furthering or understanding the theory or development of secure and private data applications.”
- **Society for Information Reuse and Integration Fellow, 2014:** For innovative work in computer and information security and outstanding service to SIRI.”
- **ACM SIGSAC Outstanding Innovation Award, 2012.** “For seminal contributions to the theory and practice of access control, notably including role-based access control.”
- **AAAS Fellow, 2008.** “For distinguished contributions to cyber security, including seminal role-based access control and usage control models, and for leadership in research journals and conferences.”
- **ACM SIGSAC Outstanding Contributions Award, 2008.**
- **IEEE Computer Society Technical Achievement Award, 2004.** “For outstanding and pioneering contributions to information security including innovation of the RBAC model and usage control.”

- **IEEE Fellow 2002.** “For contributions to the field of information and system security.”
- **ACM Fellow 2001.** “For technical contributions to the field of info. and system security, notably access control models and systems, and professional leadership in research journals and conferences.”
- **Best Paper Awards.** IEEE Conf. on Information Privacy, Security, Risk and Trust (PASSAT 2012). NIST/NSA National Computer Security Conference (1992 and 1998).
- **Test of Time Award.** ACM Symposium on Access Control Models and Technologies (SACMAT 2018 for SACMAT 2008 paper).

University Recognition

- **University of Texas at San Antonio, 2015.** Charter member inductee of UTSA's Academy of Distinguished Researchers.
- **University of Texas at San Antonio, 2015.** Inductee of UTSA College of Science Academy for Outstanding Teaching Scholars.
- **University of Texas at San Antonio, 2007 onwards:** Lutchter Brown Endowed Chair in Cyber Security (Computer Science).
- **George Mason University 2001.** Outstanding research award.

Highly Cited Papers at Google Scholar Include: Role-Based Access Control (RBAC)

- Role-Based Access Control Models, IEEE Comp., 29(2):38-47, 1996. 9500+ hits. #1 in access control.
- Proposed NIST Std. for RBAC. ACM TISSEC, 4(3):224-274, 2001. 3700+ hits. #2 in access control.
- The NIST Model for Role-Based Access Control. 5th ACM RBAC:47-63, 2000. 1300+ hits.
- The ARBAC97 Model for Role-Based Admin. of Roles. ACM TISSEC, 2(1):105-135, 1999. 900+ hits.
- Configuring RBAC to Enforce MAC and DAC. ACM TISSEC, 3(2):85-106, 2000. 900+ hits.
- Role-Based Authorization Constraints Specification. ACM TISSEC, 3(4):207-226, 2000. 600+ hits
- Framework for Role-Based Delegation Models. IEEE ACSAC:168-176, 2000. 400+ hits

Usage Control

- The UCON_{ABC} Usage Control Model, ACM TISSEC, 7(1):128-174, 2004. 1300+ hits.
- Towards Usage Control Models: Beyond Traditional Access Control. ACM SACMAT 2002. 550+ hits.

Access Control Tutorials

- Access Control: Principles and Practice. IEEE Communications, 32(9): 40-48, 1994. 1750+ hits.
- Lattice-Based Access Control Models. IEEE Computer, 26(11): 9-19, 1993. 1000+ hits.
- Database Security: Concepts, Approaches and Challenges. IEEE TDSC, 2(1): 2-19, 2005. 550+ hits.

Access Control Other Models

- A Unified Attribute-Based Access Control Model ... 26th IFIP Data/App. Sec.:262-275, 2012. 450+ hits
- Task-based Authorization Controls. 11th IFIP 11.3 Data and Application Sec.:262-275, 1997. 700+ hits.
- The Typed Access Matrix Model. 13th IEEE Security and Privacy (Oakland):122-136, 1992. 400+ hits.
- Toward a Multilevel Secure Relational Data Model, SIGMOD:50-59, 1991. 250+ hits.
- Transaction Control Expressions for Separation of Duties. 4th ACSAC:282-286, 1988. 200+ hits.
- Crypto. Implementation of a Tree Hierarchy for Access Control. IPL, 27(2):95-98, 1988. 300+ hits.
- The Schematic Protection Model, Journal of the ACM, 35(2):404-432, 1988. 200+ hits.

Research Highlights

- **Statistics:** 300+ papers (with 100+ co-authors), 31 USA patents, 32 PhD graduates, 50+ research grants.
- **Sponsors:** include NSF, NSA, NRO, NRL, AFOSR, NIST, DARPA, ARDA, AFOSR, Sandia, State Dept., DOE, IRS, RADC, FAA, Intel, Northrop Grumman, Lockheed Martin, ITT, Verizon.
- **Ongoing research agenda:** Pursue world-leading research in both the scientific foundations of cyber security and their convergent applications in diverse 21st century cyber technology domains, including cloud computing, internet of things, autonomous vehicles, big data and blockchain. Current focus is on foundations and technology of convergent access control models that synergistically bring together attribute, role and relationship based approaches.
- **Research impact:** My seminal research on role-based access control has been instrumental in establishing it as the currently dominant form of access control, including acceptance as an ANSI/NIST

standard in 2004. My research on numerous access control models remains influential and state-of-the-art. Newer models such as UCON, group-centric sharing and ABAC are gaining strong influence. I expect my ongoing work on convergence of access control models and security technologies to have considerable impact on researchers and practitioners in the 2020s.

Professional Leadership Includes

- Editor-in-Chief, IEEE Transactions on Dependable and Secure Computing (TDSC), 2010-2013.
- Founding General Chair, ACM Conf. on Data and Applications Security and Privacy (CODASPY), 2011.
- Founding Editor-in-Chief, ACM Transactions on Information & Systems Security (TISSEC), 1997-2004.
- Chairman, ACM Special Interest Group on Security Audit and Control (SIGSAC), 1995-2003. Security Editor, IEEE Internet Computing, 1998-2004.
- Conference Founder: ACM CCS (1993), ACM SACMAT (1995), ACM CODASPY (2011).
- Conference Steering Committees: ACM CCS (1993-2003 Chair, 2003-2007 Member), ACM SACMAT (1995-2008 Chair, 2017 onwards member), IEEE CSF (1992-2008 Member), ACM CODASPY (2010 onwards member).
- Conference Program Chair: IEEE CSF (1991, 1992), ACM CCS (1993, 1994, 2002), ACM SACMAT (1995, 2017), ACSAC (1996), IFIP WG 11.3 (1996), ACM CSAW (2007), ACM AsiaCCS (2011), ACM CODASPY (2012), NSS (2013), ARES (2013), CRISIS (2013), IEEE IRI (2016).
- Conference Gen. Chair: IEEE: CSF (1993, 1994), ACM: CCS (1996), SACMAT (2001, 2002), CODASPY (2011, 2012, 2013, 2014).

Entrepreneurial and Consulting Career

- TriCipher Inc., 2000-2010, Chief Scientist and Co-Founder (Acquired by VMware in 2010). Principal inventor on 28 issued patents that were vital to the valuation and viability of multiple VC deals through eventual acquisition.
- Consultant to numerous organizations including: McAfee, Trusted Information Systems, National Institute of Standards and Technology, Verizon, SETA Corporation, Argonne National Laboratory, Singapore Management University, Northrop Grumman, Integris Health.

Teaching Career

- Currently teach popular advanced courses on “Cyber Security Foundations and Practice” at University of Texas at San Antonio.
- Major contributor to MS in Cyber Security Sciences degree at University of Texas at San Antonio.
- Principal architect of the MS and PhD in Information Security and Assurance at George Mason University, where I personally developed and taught the core courses and multiple electives.
- Presented short courses, tutorials and invited lectures all over the world including Asia, Australia, Europe, North America and South America.
- As part of the NSF Center for Security and Privacy Enhanced Cloud Computing, I am pursuing a sustained partnership with the Northside Independent School District, largest in San Antonio, to develop high-school curriculum for cyber security and recruit students to UTSA.

Personal

- US Citizen, 1997. Born in India. Schooled at Doon School, IITs (Bombay and Delhi) and Rutgers University. Married with two sons.
- Fond of travel, diverse cultures, books and movies. Avid spectator of sports and current affairs.

Detailed Enumeration

The rest of my CV gives a detailed enumeration of the following items: Sponsored Research Grants, PhD Advisees Completed, USA Patents and Refereed Publications. Additional information, copies of publications, patents and dissertations, various presentations, course syllabi and full CV are available at www.profsandhu.com.

Sponsored Research Grants

Currently Active

1. CREST Center for Security and Privacy Enhanced Cloud Computing (C-SPECC)
Principal Investigator and Center Director: Ravi Sandhu
Co-Principal Investigators: Nicole Beebe, Guadalupe Carmona, Ram Krishnan, Jeff Prevost
Sponsor: *National Science Foundation*, 2017-2023

Completed

2. Planning Grant: Engineering Research Center for Sustainable Urban Ecosystems
Principal Investigator: Adolfo Matamoros
Co-Principal Investigators: Ravi Sandhu, David Akopian, Krystel Castillo, Christopher Reddick
Sponsor: *National Science Foundation*, 2019-2020
3. Robust Machine Learning for Cyber Operations
Principal Investigator: Ravi Sandhu
Co-Principal Investigator: Jianwei Niu
Sponsor: National Security Agency, 2018-2019
4. Fine-Grained, Dynamic Virtual Resource Separation in Cloud Platforms for Assured Delivery of Cloud Based Services
Principal Investigator: Ram Krishnan
Co-Principal Investigator: Ravi Sandhu
Sponsor: *Army Research Office*, 2015-2019
5. Towards Agile and Privacy-Preserving Cloud Computing
Principal Investigator: Ravi Sandhu
Former Principal Investigator: Meng Yu
Sponsor: *National Science Foundation*, 2015-2019
6. Attribute Based Access Control for Cloud Infrastructure as a Service
Principal Investigator: Ram Krishnan
Co-Principal Investigator: Ravi Sandhu
Sponsor: *National Science Foundation*, 2014-2018
7. Supply Chain Security and Quality Control in Business and Social Context
Principal Investigator: Wei-Ming Lin
Co-Principal Investigators: Ravi Sandhu, Kefeng Xu, Yao Zhao
Sponsor: *National Science Foundation*, 2015-2018
Partners: Rutgers University
8. Privacy-Enhanced Secure Data Provenance
Lead Principal Investigator: Ravi Sandhu
Principal Investigators: Elisa Bertino, Murat Kantarcioglu
Co-PIs: Alain Bensoussan, Gabriel Ghinita, Bhavani Thuraisingham, Greg White, Shouhuai Xu
Sponsor: *National Science Foundation*, 2011-2017
Partners: Purdue U., UT Dallas, U. Mass. Boston
9. Identity and Access Control in the Physical and Virtual Internet of Things
Principal Investigator: Ravi Sandhu
Co-Principal Investigators: Ram Krishnan
Sponsor: Mitre Corporation, 2016

10. Design and Implementation of Cybersecurity Risk Metrics for Cloud Based IT Infrastructure
Principal Investigator: Ram Krishnan
Co-Principal Investigators: Ravi Sandhu
Sponsor: LMI Research Institute, 2015-2016
11. Army STTR Phase II: Random Number Generation for High Performance Computing
Principal Investigator: Raj Boppana
Co-Principal Investigators: Ravi Sandhu, Ram Tripathi
Sponsor: *Silicon Informatics*, 2012-2014
12. Secure Information Sharing Models for Cyber Response Teams
Principal Investigator: Ram Krishnan
Co-Principal Investigators: Ravi Sandhu
Sponsor: *LMI Research Institute*, 2013-2014
13. Securing Named Data Networking with Lightweight Integrity Verification
Principal Investigator: Ravi Sandhu
Sponsor: *Cisco Research Center*, 2013-2014
14. Design of a Curriculum on Building Security Services in the Cloud
Principal Investigator: Ram Krishnan
Co-Principal Investigator: Ravi Sandhu
Sponsor: *Intel Corporation*, 2013-2014
15. Managing the Assured Information Sharing Life Cycle (AISL)
Principal Investigator: Ravi Sandhu
Co-Principal Investigator: Shouhuai Xu
Sponsor: *Air Force Office of Scientific Research, MURI*, 2008-2013
Partners: U. of Maryland-BC, U. of Michigan, U. of Illinois-UC, Purdue U., UT Dallas
16. SNGuard: Securing Dynamic Online Social Networks
Principal Investigator: Ravi Sandhu
Sponsor: *National Science Foundation*, 2008-2012
Partners: Penn. State Univ., Arizona State Univ., Univ. of North Carolina-Charlotte
17. IAPD: A Framework for Integrated Adaptive and Proactive Defenses against Stealthy Botnets
Principal Investigators: Shouhuai Xu
Co-Principal Investigator: Ravi Sandhu
Sponsor: *Air Force Office of Scientific Research*, 2009-2012
Partners: Georgia Tech
18. Army STTR Phase I: Parallel Random Number Generators
Principal Investigator: Raj Boppana
Co-Principal Investigators: Ravi Sandhu, Ram Tripathi
Sponsor: *Silicon Informatics*, 2010-2011
19. Institute for Cyber Security Research Superiority Grant
Principal Investigator: Ravi Sandhu
Sponsor: *State of Texas Emerging Technology Fund*, 2007-2011
The grant that founded the Institute for Cyber Security and brought me to UTSA.
20. STARS Grant for Establishing Institute for Cyber Security Laboratory
Principal Investigator: Ravi Sandhu
Sponsor: *University of Texas System*, 2007-2011
Another grant as incentive for my move to UTSA.

21. A Systematic Defensive Framework for Combating Botnets
Principal Investigator: Ravi Sandhu
Co-Principal Investigator: Shouhuai Xu
Sponsor: *Office of Naval Research*, 2009-2010
Partners: Purdue U., UT Dallas, Texas A&M, U. of Wisconsin
22. Deploying Secure Distributed Systems using LaGrande Technology: Models, Architectures and Protocols
Principal Investigator: Ravi Sandhu
Sponsor: *Intel Research Council*, 2004-2009
23. Secure Knowledge Management: Models and Mechanisms
Principal Investigator: Ravi Sandhu
Sponsor: *National Science Foundation*, 2005-2009
24. Information Operations Across Infospheres
Principal Investigator: Ravi Sandhu
Sponsor: *Air Force Office of Scientific Research*, 2006-2008
Partner: UT Dallas
25. Usage Control Models, Architectures and Mechanisms Based on Integrating Authorizations, Obligations and Conditions
Principal Investigator: Ravi Sandhu
Sponsor: *National Science Foundation*, 2003-2006
The grant that produced the UCON model and paper.
26. Next Generation Authentication and Access Control for the FAA
Principal Investigator: Ravi Sandhu
Sponsor: *Federal Aviation Administration*, 2004-2005
27. Flexible Policy Models and Architectures for Client and Server-assured Document Access Controls
Principal Investigator: Roshan Thomas, McAfee Research, Network Associates
Investigator: Ravi Sandhu
Sponsor: *Advanced Research and Development Agency*, 2003-2005
28. Scalable Authorization in Distributed Systems
Principal Investigator: Ravi Sandhu
Sponsor: *National Science Foundation*, 1999-2002
29. Sonora: Secure Metadata Models and Architectures
Principal Investigator: Ravi Sandhu
Co-Investigator: Larry Kerschberg
Sponsor: *Northrop Grumman*, 2001-2002
30. Secure Objects
Principal Investigator: Ravi Sandhu
Co-Investigators: Larry Kerschberg and Edgar Sibley
Sponsor: *National Reconnaissance Office and National Security Agency*, 2000-2001
31. Security and Containment Policy for the Attack Sensing, Warning and Response Laboratory
Principal Investigator: Ravi Sandhu
Sponsor: *National Security Agency*, 1999-2000
32. Secure Role-Based Workflow Systems
Principal Investigator: Ravi Sandhu
Sponsor: *Naval Research Laboratory*, 1999

33. Control and Tracking of Information Dissemination
Principal Investigator: Ravi Sandhu
Sponsor: *Lockheed Martin*, 1999
34. Distributed Role-Based Access Control Models and Architectures
Principal Investigator: Ravi Sandhu
Sponsor: *Sandia National Laboratories*, 1999
35. Role-Based Access Control on the Web
Principal Investigator: Ravi Sandhu
Sponsor: *National Security Agency*, 1998-99
36. Secure Remote Access
Principal Investigator: Ravi Sandhu
Sponsor: *National Security Agency*, 1998
37. Agent-Based Systems
Principal Investigators: Ravi Sandhu, Prasanta Bose, Elizabeth White
Sponsor: *National Security Agency*, 1998
38. Multi-Layered Countermeasures to Vulnerabilities in Networked Systems
Principal Investigator: Ravi Sandhu
Sponsor: *National Security Agency*, 1996-97
39. Role-Based Access Control: Phase II
Principal Investigator: Ed Coyne, SETA Corporation
Investigators: Ravi Sandhu, Charles Youman (SETA)
Sponsor: *National Institute of Standards and Technology*, 1995-97
40. Task-based Authorizations: A New Paradigm for Access Control
Principal Investigator: Roshan Thomas, Odyssey Research Associates
Investigator: Ravi Sandhu
Sponsor: *Defense Advanced Research Projects Agency*, 1995-97
41. A Pragmatic Approach to the Design and Analysis of Composite Secure Systems
Principal Investigator: Ravi Sandhu
Sponsor: *National Security Agency*, 1994-97
42. Design of Multilevel Secure Relational Databases
Principal Investigator: Ravi Sandhu
Sponsor: *National Security Agency*, 1994-96
43. Role-Based Access Control: Phase I
Principal Investigator: Hal Feinstein, SETA Corporation
Investigators: Ravi Sandhu, Ed Coyne (SETA), Charles Youman (SETA)
Sponsor: *National Institute of Standards and Technology*, 1994
The grant that produced the seminal RBAC96 model and paper.
44. Architectures for Type-Based Distributed Access Control
Principal Investigator: Ravi Sandhu
Sponsor: *National Security Agency*, 1993-96
45. Privacy Models and Policies
Principal Investigator: Andrew Sage, George Mason University
Investigators: Ravi Sandhu, Sushil Jajodia and Paul Lehner

Sponsor: *Internal Revenue Service*, Tax Systems Modernization Institute, 1995

46. Derivation, Modeling, and Analysis of Access Control Systems
Principal Investigators: Ravi Sandhu and Paul Ammann
Sponsor: *National Science Foundation*, 1992-95
47. Unified Security Models for Confidentiality and Integrity
Principal Investigator: Ravi Sandhu
Sponsor: *National Security Agency*, 1992-94
48. Foundations of Multilevel Secure Object-Oriented Databases
Principal Investigator: Ravi Sandhu
Sponsor: *National Security Agency*, 1992-94
49. Polyinstantiation in Multilevel Relations
Principal Investigator: Sushil Jajodia
Co-Principal Investigator: Ravi Sandhu
Sponsor: *Rome Air Development Center*, Department of Defense, 1992
50. Models, Mechanisms and Methods for Integrity Policies
Principal Investigator: Ravi Sandhu
Sponsor: *National Security Agency*, 1989-92
The grant that produced the TAM model and paper
51. Analysis of Updates of Multilevel Relations
Principal Investigator: Sushil Jajodia
Co-Principal Investigator: Ravi Sandhu
Sponsor: *Rome Air Development Center*, Department of Defense, 1990-91

PhD Advisees Completed

1. Naiwei Liu, *Cache-Based Attack and Defense on ARM Platform*, Fall 2020.
2. Abdullah Al-Alaj, *Role Based Access Control for Software Defined Networking: Formal Models and Implementation*, Summer 2020.
3. Jin Han, *Enhancing Security in Cloud Computing through Virtual Machine Placement*, Fall 2019.
4. Mahmoud Abdelsalam, *Online Malware Detection in Cloud Auto-Scaling Systems using Performance Metrics*, Fall 2018.
5. Maanak Gupta, *Secure Cloud Assisted Smart Cars and Big Data: Access Control Models and Implementation*, Fall 2018.
6. Smriti Bhatt, *Attribute-Based Access and Communication Control Models for Cloud and Cloud-Enabled Internet of Things*, UTSA, Summer 2018.
7. Asma Alshehri, *Access Control Models for Cloud-Enabled Internet of Things*, UTSA, Spring 2018.
8. Tahmina Ahmed, *Expressive Power, Safety and Cloud Implementation of Attribute and Relationship Based Access Control Models*, UTSA, Fall 2017.
9. Prosunjit Biswas, *Enumerated Authorization Policy ABAC Models: Expressive Power and Enforcement*, UTSA, Spring 2017.
10. Yun Zhang, *Secure Information and Resource Sharing in Cloud IaaS*, UTSA, Fall 2016.
11. Navid Pustchi, *Authorization Federation in Multi-Tenant Multi-Cloud IaaS*, UTSA, Spring 2016.
12. Khalid Bijon, *Constraints for Attribute Based Access Control with Application in Cloud IaaS*, UTSA, Spring 2015.
13. Dang Nguyen, *Provenance-Based Access Control Models*, UTSA, Summer 2014.
14. Bo Tang, *Multi-Tenant Access Control for Cloud Services*, UTSA, Summer 2014.
15. Xin Jin, *Attribute-Based Access Control Models and Implementation in Cloud Infrastructure as a Service*, UTSA, Spring 2014.
16. Yuan Cheng, *Access Control for Online Social Networks Using Relationship Type Patterns*, UTSA, Spring 2014.
17. Ram Krishnan, *Group-Centric Secure Information Sharing Models*, GMU, Fall 2009. (Co-advisor: Daniel Menasce.)
18. David A. Wheeler, *Fully Countering Trusting Trust through Diverse Double-Compiling*, GMU, Fall 2009. (Co-advisor: Daniel Menasce.)
19. Venkata Bhamidipati, *Architectures and Models for Administration of User-Role Assignment in Role Based Access Control*, GMU, Fall 2008. (Co-advisor: Daniel Menasce.)
20. Zhixiong Zhang, *Scalable Role and Organization Based Access Control and Its Administration*, GMU, Spring 2008. (Co-advisor: Daniel Menasce.)

21. Xinwen Zhang, *Formal Model and Analysis of Usage Control*, GMU, Summer 2006. (Co-advisor: Francesco Parisi-Presicce.)
22. Mohammad Abdullah Al-Kahtani, *A Family of Models for Rule-Based User-Role Assignment*, GMU, Spring 2004.
23. Jaehong Park, *Usage Control: A Unified Framework for Next Generation Access Control*, GMU, Summer 2003.
24. Ezedin Barka, *Framework for Role-Based Delegation Models*, GMU, Summer 2002.
25. Pete Epstein, *Engineering of Role/Permission Assignments*, GMU, Spring 2002.
26. Qamar Munawer, *Administrative Models for Role-Based Access Control*, GMU, Spring 2000.
27. Gail-Joon Ahn, *The RCL 2000 Language for Role-Based Authorization Constraints*, GMU, Fall 1999.
28. Joon Park, *Secure Attribute Services on the Web*, GMU, Summer 1999.
29. Phillip Hyland, *Concentric Supervision of Security Applications: An Assurance Methodology*, GMU, Spring 1999.
30. Tarik Himdi, *A Scalable Extended DGSA Scheme for Confidential Data Sharing in Multi-Domain Organizations*, GMU, Spring 1998.
31. Srinivas Ganta, *Expressive Power of Access Control Models Based on Propagation of Rights*, GMU, Summer 1996.
32. Roshan Thomas, *Supporting Secure and Efficient Write-Up in High-Assurance Multilevel Object-Based Computing*, GMU, Summer 1994.

USA Patents

1. *Authorization Policy for Group-Centric Secure Information Sharing*. Ram Krishnan and Ravi Sandhu. USA Patent 10,116,664. October 30, 2018.
2. *Method and System for Verifying User Instructions*. Ravi Sandhu and Ravi Ganesan. USA Patent 8,800,018, August 5, 2014.
3. *Augmented Single Factor Split Key Asymmetric Cryptography-Key Generation and Distributor*. Ravi Ganesan, Ravi Sandhu, Andrew Cottrell and Kyle Austin. USA Patent 8,407,475. March 26, 2013.
4. *Securing Multifactor Split Key Asymmetric Crypto Keys*. Ravi Sandhu, Brett Schoppert, Ravi Ganesan, Mihir Bellare and Colin deSa. USA Patent 8,340,287. December 25, 2012.
5. *Enhanced Security for User Instructions*. Ravi Sandhu and Ravi Ganesan. USA Patent 8,332,921. December 11, 2012.
6. *Roaming Utilizing an Asymmetric Key Pair*. Ravi Sandhu, Brett Schoppert, Ravi Ganesan, Mihir Bellare and Colin deSa. USA Patent 8,213,608. July 3, 2012.
7. *Asymmetric Cryptography with Rolling Key Security*. Ravi Sandhu, Brett Schoppert, Ravi Ganesan, Mihir Bellare and Colin deSa. USA Patent 8,099,607. January 17, 2012.
8. *Secure Cookies*. Ravi Sandhu and Joon Park. USA Patent 8,019,881. September 13, 2011.
9. *Augmented Single Factor Split Key Asymmetric Cryptography-Key Generation and Distributor*. Ravi Ganesan, Ravi Sandhu, Andrew Cottrell and Kyle Austin. USA Patent 7,895,437. February 22, 2011.
10. *Flexible and Adjustable Authentication in Cyberspace*. Ravi Sandhu, Ravi Ganesan, Andrew Cottrell, Tim Renshaw, Brett Schoppert and Kyle Austin. USA Patent 7,886,346. February 8, 2011.
11. *Protecting One-Time-Passwords Against Man-in-the-Middle Attacks*. Ravi Ganesan, Ravi Sandhu, Andrew Cottrell, Brett Schoppert and Mihir Bellare. USA Patent 7,840,993. November 23, 2010.
12. *Secure Login Using Single Factor Split Key Asymmetric Cryptography and an Augmenting Factor*. Ravi Ganesan, Ravi Sandhu, Andrew Cottrell and Kyle Austin. USA Patent 7,734,912. June 8, 2010.
13. *Secure Login Using Augmented Single Factor Split Key Asymmetric Cryptography*. Ravi Ganesan, Ravi Sandhu, Andrew Cottrell and Kyle Austin. USA Patent 7,734,911. June 8, 2010.
14. *Multifactor Split Asymmetric Crypto-key with Persistent Key Security*. Ravi Sandhu, Brett Schoppert, Ravi Ganesan, Mihir Bellare and Colin deSa. USA Patent 7,734,045. June 8, 2010.
15. *Multiple Factor Private Portion of an Asymmetric Key*. Ravi Sandhu, Brett Schoppert, Ravi Ganesan, Mihir Bellare and Colin deSa. USA Patent 7,630,493. December 12, 2009.
16. *Asymmetric Key Pair Having a Kiosk Mode*. Ravi Sandhu, Brett Schoppert, Ravi Ganesan, Mihir Bellare and Colin deSa. USA Patent 7,599,493. October 6, 2009.
17. *Technique for Providing Multiple Levels of Security*. Ravi Sandhu, Brett Schoppert, Ravi Ganesan, Mihir Bellare and Colin deSa. USA Patent 7,596,697. September 29, 2009.
18. *Secure Login Using a Multifactor Split Asymmetric Crypto-Key with Persistent Key Security*. Ravi Sandhu, Brett Schoppert, Ravi Ganesan, Mihir Bellare and Colin deSa. USA Patent 7,571,471. August 4, 2009.

19. *Technique for Asymmetric Crypto-Key Generation.* Ravi Sandhu, Brett Schoppert, Ravi Ganesan, Mihir Bellare and Colin deSa. USA Patent 7,565,527. July 21, 2009.
20. *Laddered Authentication Security Using Split Key Asymmetric Cryptography.* Ravi Sandhu, Colin deSa and Karuna Ganesan. USA Patent 7,447,903. November 4, 2008. (Continuation of 7,069,435.)
21. *Authentication Protocol Using a Multi-Factor Asymmetric Key Pair.* Ravi Sandhu, Brett Schoppert, Ravi Ganesan, Mihir Bellare and Colin deSa. USA Patent 7,386,720. June 10, 2008.
22. *System and Apparatus for Storage and Transfer of Secure Data on Web.* Ravi Sandhu and Joon Park. USA Patent 7,293,098. November 6, 2007. (Continuation of 6,985,953.)
23. *Method and System for Authorizing Generation of Asymmetric Crypto-Keys.* Ravi Sandhu, Colin deSa and Karuna Ganesan. USA Patent 7,149,310. December 12, 2006.
24. *System and Method for Authentication in a Crypto-System Utilizing Symmetric and Asymmetric Crypto-Keys.* Ravi Sandhu, Colin deSa and Karuna Ganesan. USA Patent 7,069,435. June 27, 2006.
25. *System and Method for Generation and Use of Asymmetric Crypto-Keys Each Having a Public Portion and Multiple Private Portions.* Ravi Sandhu, Colin deSa and Karuna Ganesan. USA Patent 7,065,642. June 20, 2006.
26. *One Time Password Entry to Access Multiple Network Sites.* Ravi Sandhu, Colin deSa and Karuna Ganesan. USA Patent 7,055,032. May 30, 2006.
27. *Secure Communications Network With User Control of Authenticated Personal Information Provided to Network Entities.* Ravi Sandhu, Colin deSa and Karuna Ganesan. USA Patent 7,017,041. March 21, 2006.
28. *System and Apparatus for Storage and Transfer of Secure Data on Web.* Ravi Sandhu and Joon Park. USA Patent 6,985,953. January 10, 2006.
29. *A System and Method for Crypto-key Generation and Use in Cryptosystem.* Ravi Sandhu, Colin deSa and Karuna Ganesan. USA Patent 6,970,562. November 29, 2005.
30. *High Security Cryptosystem.* Ravi Sandhu, Colin deSa and Karuna Ganesan. USA Patent 6,940,980. September 6, 2005.
31. *A System and Method for Password Throttling.* Ravi Sandhu, Colin deSa and Karuna Ganesan. USA Patent 6,883,095. April 19, 2005.

REFEREED PUBLICATIONS

Journal Publications

1. Jin Han, Wanyu Zang, Meng Yu and Ravi Sandhu, "Quantify Co-Residency Risks in the Cloud through Deep Learning." *IEEE Transactions on Dependable and Secure Computing*, Early Access, October 2020, pages 12.
2. Maanak Gupta, James Benson, Farhan Patwa and Ravi Sandhu, "Secure V2V and V2I Communication in Intelligent Transportation using Cloudlets." *IEEE Transactions on Services Computing*, Early Access, September 2020, pages 12.
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