



## Professor Ravi Sandhu

University of Texas at San Antonio

*Executive Director and Founder, Institute for Cyber Security*

*Lutcher Brown Endowed Chair in Cyber Security*

*Professor of Computer Science, College of Sciences*

[www.profsandhu.com](http://www.profsandhu.com)

### Contact

Inst. for Cyber Security, One UTSA Circle NPB 3.122, U. of Texas-San Antonio, San Antonio, TX 78249

Voice : 210 458 6081, Cell: 210 845 3410, Email: [ravi.sandhu@utsa.edu](mailto:ravi.sandhu@utsa.edu), URL: [www.profsandhu.com](http://www.profsandhu.com)

### 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: Full Professor and Endowed Chair (Cyber Security).
- **George Mason University**, 1995-2007: Full Prof., 1989-1995: Assoc. Prof. (Information Security).
- **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 Google Scholar) 32,000+ citations. My h-index is 70 (70 papers with 70 or more citations each). Number 1 cited paper in access control with 7600+ citations. Number 1 non-cryptographer at Microsoft Academic Search in Security and Privacy, number 5 overall.
- **Frequent Keynote and Invited Speaker.** See [www.profsandhu.com](http://www.profsandhu.com) for details.
- **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).

### 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. 7600+ hits. #1 in access control.
- Proposed NIST Std. for RBAC. ACM TISSEC, 4(3):224-274, 2001. 3000+ hits.
- The NIST Model for Role-Based Access Control. 5<sup>th</sup> ACM RBAC:47-63, 2000. 1000+ hits.
- The ARBAC97 Model for Role-Based Admin. of Roles. ACM TISSEC, 2(1):105-135, 1999. 700+ hits.
- Configuring RBAC to Enforce MAC and DAC. ACM TISSEC, 3(2):85-106, 2000. 700+ hits.
- Role-Based Authorization Constraints Specification. ACM TISSEC, 3(4):207-226, 2000. 500+ hits
- Total 25+ RBAC papers with 100+ hits.

## Usage Control

- The UCON<sub>ABC</sub> Usage Control Model, ACM TISSEC, 7(1):128-174, 2004. 900+ hits.
- Towards Usage Control Models: Beyond Traditional Access Control. ACM SACMAT 2002. 400+ hits.
- Usage Control: A Vision for Next Generation Access Control, MMM-ACNS 2003. 200+ hits.

## Access Control Tutorials

- Access Control: Principles and Practice. IEEE Communications, 32(9): 40-48, 1994. 1200+ hits.
- Lattice-Based Access Control Models. IEEE Computer, 26(11): 9-19, 1993. 800+ hits.
- Database Security: Concepts, Approaches and Challenges. IEEE TDSC, 2(1): 2-19, 2005. 400+ hits.

## Access Control Other Models

- Task-based Authorization Controls. 11<sup>th</sup> IFIP 11.3 Data and Application Sec.:262-275, 1997. 600+ hits.
- The Typed Access Matrix Model. 13<sup>th</sup> IEEE Security and Privacy (Oakland):122-136, 1992. 300+ hits.
- Toward a Multilevel Secure Relational Data Model, SIGMOD:50-59, 1991. 250+ hits.
- Transaction Control Expressions for Separation of Duties. 4<sup>th</sup> ACSAC:282-286, 1988. 200+ hits.
- Crypto. Implementation of a Tree Hierarchy for Access Control. IPL, 27(2):95-98, 1988. 200+ hits.
- The Schematic Protection Model, Journal of the ACM, 35(2):404-432, 1988. 150+ hits.

## Research Highlights

- **Statistics:** 250+ papers (with 100+ co-authors), 30 USA patents, 22 PhD graduates, 45+ 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 initiatives include:** Access Control and Authorization Foundations, Attribute-Based Access Control, Relationship-Based Access Control, Security and Privacy in Cloud Computing, Internet of Things, Big Data and Secure Information Sharing Applications.
- **Earlier research:** My research on RBAC has been instrumental in establishing it as the preferred form of access control, including its acceptance as an ANSI/NIST standard in 2004. My earlier research on numerous access control models remains influential and state-of-the-art. My newer models such as UCON, group-centric secure information sharing and ABAC are gaining strong influence.

## 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), IEEE CSF (1992-2008 Member), ACM CODASPY (2010 onwards Chair).

- 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).
- 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).
- 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**

- Teach highly popular advanced graduate courses on Cyber Security Models and Systems at University of Texas at San Antonio
- I was the principal architect for 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.
- I have presented short courses, tutorials and invited lectures all over the world including Asia, Australia, Europe, North America and South America.

### **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 and Bridge. Avid spectator of sports and current affairs.

### **Detailed Enumeration**

The rest of my CV (available at [www.profsandhu.com](http://www.profsandhu.com)) gives a detailed enumeration of the following items.

- Sponsored Research Grants
- PhD Advisees Completed
- USA Patents
- Publications

Additional information, copies of publications, patents and dissertations, various PowerPoint presentations and course syllabi can be found at [www.profsandhu.com](http://www.profsandhu.com).

## Sponsored Research Grants

### Currently Active

1. 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*, 2015-2018
2. Attribute Based Access Control for Cloud Infrastructure as a Service  
Principal Investigator: Ram Krishnan  
Co-Principal Investigator: Ravi Sandhu  
Sponsor: *National Science Foundation*, 2014-2017
3. 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*, 2015-2017  
Partners: Rutgers University
4. 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*, 2011-2016  
Partners: Purdue U., UT Dallas, U. Mass. Boston

### Completed

5. 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
6. 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
7. 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
8. Secure Information Sharing Models for Cyber Response Teams  
Principal Investigator: Ram Krishnan  
Co-Principal Investigators: Ravi Sandhu  
Sponsor: *LMI Research Institute*, 2013-2014
9. Securing Named Data Networking with Lightweight Integrity Verification  
Principal Investigator: Ravi Sandhu  
Sponsor: *Cisco Research Center*, 2013-2014
10. 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

11. 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
12. 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
13. 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
14. Army STTR Phase I: Parallel Random Number Generators  
Principal Investigator: Raj Boppana  
Co-Principal Investigators: Ravi Sandhu, Ram Tripathi  
Sponsor: *Silicon Informatics*, 2010-2011
15. 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.
16. 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.
17. 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
18. Deploying Secure Distributed Systems using LaGrande Technology: Models, Architectures and Protocols  
Principal Investigator: Ravi Sandhu  
Sponsor: *Intel Research Council*, 2004-2009
19. Secure Knowledge Management: Models and Mechanisms  
Principal Investigator: Ravi Sandhu  
Sponsor: *National Science Foundation*, 2005-2009
20. Information Operations Across Infospheres  
Principal Investigator: Ravi Sandhu  
Sponsor: *Air Force Office of Scientific Research*, 2006-2008  
Partner: UT Dallas

21. 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.
22. Next Generation Authentication and Access Control for the FAA  
Principal Investigator: Ravi Sandhu  
Sponsor: *Federal Aviation Administration*, 2004-2005
23. 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
24. Scalable Authorization in Distributed Systems  
Principal Investigator: Ravi Sandhu  
Sponsor: *National Science Foundation*, 1999-2002
25. Sonora: Secure Metadata Models and Architectures  
Principal Investigator: Ravi Sandhu  
Co-Investigator: Larry Kerschberg  
Sponsor: *Northrop Grumman*, 2001-2002
26. Secure Objects  
Principal Investigator: Ravi Sandhu  
Co-Investigators: Larry Kerschberg and Edgar Sibley  
Sponsor: *National Reconnaissance Office and National Security Agency*, 2000-2001
27. Security and Containment Policy for the Attack Sensing, Warning and Response Laboratory  
Principal Investigator: Ravi Sandhu  
Sponsor: *National Security Agency*, 1999-2000
28. Secure Role-Based Workflow Systems  
Principal Investigator: Ravi Sandhu  
Sponsor: *Naval Research Laboratory*, 1999
29. Control and Tracking of Information Dissemination  
Principal Investigator: Ravi Sandhu  
Sponsor: *Lockheed Martin*, 1999
30. Distributed Role-Based Access Control Models and Architectures  
Principal Investigator: Ravi Sandhu  
Sponsor: *Sandia National Laboratories*, 1999
31. Role-Based Access Control on the Web  
Principal Investigator: Ravi Sandhu  
Sponsor: *National Security Agency*, 1998-99
32. Secure Remote Access  
Principal Investigator: Ravi Sandhu  
Sponsor: *National Security Agency*, 1998
33. Agent-Based Systems  
Principal Investigators: Ravi Sandhu, Prasanta Bose, Elizabeth White  
Sponsor: *National Security Agency*, 1998

34. Multi-Layered Countermeasures to Vulnerabilities in Networked Systems  
Principal Investigator: Ravi Sandhu  
Sponsor: *National Security Agency*, 1996-97
  
35. 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
  
36. 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
  
37. A Pragmatic Approach to the Design and Analysis of Composite Secure Systems  
Principal Investigator: Ravi Sandhu  
Sponsor: *National Security Agency*, 1994-97
  
38. Design of Multilevel Secure Relational Databases  
Principal Investigator: Ravi Sandhu  
Sponsor: *National Security Agency*, 1994-96
  
39. 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.
  
40. Architectures for Type-Based Distributed Access Control  
Principal Investigator: Ravi Sandhu  
Sponsor: *National Security Agency*, 1993-96
  
41. 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
  
42. Derivation, Modeling, and Analysis of Access Control Systems  
Principal Investigators: Ravi Sandhu and Paul Ammann  
Sponsor: *National Science Foundation*, 1992-95
  
43. Unified Security Models for Confidentiality and Integrity  
Principal Investigator: Ravi Sandhu  
Sponsor: *National Security Agency*, 1992-94
  
44. Foundations of Multilevel Secure Object-Oriented Databases  
Principal Investigator: Ravi Sandhu  
Sponsor: *National Security Agency*, 1992-94
  
45. Polyinstantiation in Multilevel Relations  
Principal Investigator: Sushil Jajodia  
Co-Principal Investigator: Ravi Sandhu  
Sponsor: *Rome Air Development Center*, Department of Defense, 1992
  
46. 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

47. 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. Navid Pustchi, *Authorization Federation in Multi-Tenant Multi-Cloud IaaS*, UTSA, Spring 2016.
2. Khalid Bijon, *Constraints for Attribute Based Access Control with Application in Cloud IaaS*, UTSA, Spring 2015.
3. Dang Nguyen, *Provenance-Based Access Control Models*, UTSA, Summer 2014.
4. Bo Tang, *Multi-Tenant Access Control for Cloud Services*, UTSA, Summer 2014.
5. Xin Jin, *Attribute-Based Access Control Models and Implementation in Cloud Infrastructure as a Service*, UTSA, Spring 2014.
6. Yuan Cheng, *Access Control for Online Social Networks Using Relationship Type Patterns*, UTSA, Spring 2014.
7. Ram Krishnan, *Group-Centric Secure Information Sharing Models*, GMU, Fall 2009. (Co-advisor: Daniel Menasce.)
8. David A. Wheeler, *Fully Countering Trusting Trust through Diverse Double-Compiling*, GMU, Fall 2009. (Co-advisor: Daniel Menasce.)
9. Venkata Bhamidipati, *Architectures and Models for Administration of User-Role Assignment in Role Based Access Control*, GMU, Fall 2008. (Co-advisor: Daniel Menasce.)
10. Zhixiong Zhang, *Scalable Role and Organization Based Access Control and Its Administration*, GMU, Spring 2008. (Co-advisor: Daniel Menasce.)
11. Xinwen Zhang, *Formal Model and Analysis of Usage Control*, GMU, Summer 2006. (Co-advisor: Francesco Parisi-Presicce.)
12. Mohammad Abdullah Al-Kahtani, *A Family of Models for Rule-Based User-Role Assignment*, GMU, Spring 2004.
13. Jaehong Park, *Usage Control: A Unified Framework for Next Generation Access Control*, GMU, Summer 2003.
14. Ezedin Barka, *Framework for Role-Based Delegation Models*, GMU, Summer 2002.
15. Pete Epstein, *Engineering of Role/Permission Assignments*, GMU, Spring 2002.
16. Qamar Munawar, *Administrative Models for Role-Based Access Control*, GMU, Spring 2000.
17. Gail-Joon Ahn, *The RCL 2000 Language for Role-Based Authorization Constraints*, GMU, Fall 1999.
18. Joon Park, *Secure Attribute Services on the Web*, GMU, Summer 1999.



19. Phillip Hyland, *Concentric Supervision of Security Applications: An Assurance Methodology*, GMU, Spring 1999.
20. Tarik Himdi, *A Scalable Extended DGSA Scheme for Confidential Data Sharing in Multi-Domain Organizations*, GMU, Spring 1998.
21. Srinivas Ganta, *Expressive Power of Access Control Models Based on Propagation of Rights*, GMU, Summer 1996.
22. Roshan Thomas, *Supporting Secure and Efficient Write-Up in High-Assurance Multilevel Object-Based Computing*, GMU, Summer 1994.

## USA Patents

1. *Method and System for Verifying User Instructions*. Ravi Sandhu and Ravi Ganesan. USA Patent 8,800,018, August 5, 2014.
2. *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.
3. *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.
4. *Enhanced Security for User Instructions*. Ravi Sandhu and Ravi Ganesan. USA Patent 8,332,921. December 11, 2012.
5. *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.
6. *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.
7. *Secure Cookies*. Ravi Sandhu and Joon Park. USA Patent 8,019,881. September 13, 2011.
8. *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.
9. *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.
10. *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.
11. *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.
12. *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.
13. *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.
14. *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.

15. *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.
16. *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.
17. *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.
18. *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.
19. *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.)
20. *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.
21. *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.)
22. *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.
23. *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.
24. *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.
25. *One Time Password Entry to Access Multiple Network Sites*. Ravi Sandhu, Colin deSa and Karuna Ganesan. USA Patent 7,055,032. May 30, 2006.
26. *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.
27. *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.
28. *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.
29. *High Security Cryptosystem*. Ravi Sandhu, Colin deSa and Karuna Ganesan. USA Patent 6,940,980. September 6, 2005.
30. *A System and Method for Password Throttling*. Ravi Sandhu, Colin deSa and Karuna Ganesan. USA Patent 6,883,095. April 19, 2005.

## PUBLICATIONS

### Journal Publications: Early Access

1. Qi Li, Ravi Sandhu, Xinwen Zhang and Mingwei Xu, Mandatory Content Access Control for Privacy Protection in Information Centric Networks. *IEEE Transactions on Dependable and Secure Computing*. Published on-line 2015.

### Journal Publications

2. Rajkumar P.V. and Ravi Sandhu, Safety Decidability for Pre-Authorization Usage Control with Finite Attribute Domains. *IEEE Transactions on Dependable and Secure Computing*, Volume 13, Number 5, Sept./Oct. 2016, pages 582-590.
3. Yuan Cheng, Jae Park and Ravi Sandhu. "An Access Control Model for Online Social Networks Using User-to-User Relationships." *IEEE Transactions on Dependable and Secure Computing*, Volume 13, Number 4, July/August 2016, pages 424-436.
4. Lianshan Sun, Jaehong Park, Dang Nguyen and Ravi Sandhu. "A Provenance-Aware Access Control Framework with Typed Provenance." *IEEE Transactions on Dependable and Secure Computing*, Volume 13, Number 4, July/August 2016, pages 411-423.
5. Bao Liu and Ravi Sandhu. "Fingerprint-Based Detection and Diagnosis of Malicious Programs in Hardware." *IEEE Transactions on Reliability*, Volume 64, Number 3, September 2015, pages 1068-1077.
6. Bo Tang, Ravi Sandhu and Qi Li. "Multi-Tenancy Authorization Models for Collaborative Cloud Services." *Concurrency and Computation: Practice and Experience*, Volume 27, Number 11, August 2015, pages 2851-2868.
7. Qi Li, Xinwen Zhang, Qingji Zheng, Ravi Sandhu and Xiaoming Fu. "LIVE: Lightweight Integrity Verification and Content Access Control for Named Data Networking." *IEEE Transactions on Information Forensics and Security*, Volume 10, Number 2, February 2015, pages 308-320.
8. Elisa Bertino, Gabriel Ghinita, Murat Kantarcioglu, Dang Nguyen, Jae Park, Ravi Sandhu, Salmin Sultana, Bhavani Thuraisingham and Shouhuai Xu. "A Roadmap for Privacy-Enhanced Secure Data Provenance." *Journal of Intelligent Information Systems*, Volume 43, Number 3, May 2014, pages 481-501.
9. Khalid Bijon, Ram Krishnan and Ravi Sandhu, "Constraints Specification in Attribute Based Access Control." *ASE Science Journal*, Volume 2, Number 3, 14 pages.
10. Mukesh Singhal, Santosh Chandrasekhar, Tingjian Ge, Ravi Sandhu, Ram Krishnan, Gail-Joon Ahn and Elisa Bertino, "Collaboration in Multicloud Computing Environments: Framework and Security Issues." *IEEE Computer*, Volume 46, Number 2, February 2013, pages 76-84.
11. Ravi Sandhu, "Speculations on the Science of Web User Security." *Computer Networks*, Volume 56, Number 18, December 2012, pages 3891-3895.
12. Ram Krishnan, Jianwei Niu, Ravi Sandhu and William H. Winsborough, "Group-Centric Secure Information-Sharing Models for Isolated Groups." *ACM Transactions on Information and System Security*, Volume 14, Number 3, November 2011, Article 23, 29 pages.

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