



**INSTITUTE OF COMPUTER SCIENCES AND INFORMATION TECHNOLOGY (ICS/IT)  
FACULTY OF MANAGEMENT AND COMPUTER SCIENCES  
THE UNIVERSITY OF AGRICULTURE, PESHAWAR  
KHYBER PAKHTUNKHWA PAKISTAN**

Phone: +92-91-9221323, Ext: 3214, Email: [dicsit@aup.edu.pk](mailto:dicsit@aup.edu.pk), Web: [www.aup.edu.pk](http://www.aup.edu.pk)

<b>Program:</b>	<b>PhD-Computer Science</b>
<b>Course Title:</b>	<b>Private Information Retrieval</b>
<b>Course Code:</b>	<b>CS-782</b>
<b>Course Hours:</b>	<b>03</b>
<b>Total Weeks:</b>	<b>16</b>
<b>Total Credit Hours:</b>	<b>48</b>

**Course Objective**

Online users' privacy is a delicate issue that has been unfortunately overlooked mainly by technology corporations and especially the general public since the birth of the Internet. Many online businesses and services such as web search engines (WSE), online retailers, and social networks keep their users' history and exploit it for profit. This course explores the tools and techniques for privacy preserved information retrieval from web search engines. This course also explores the adversarial models, privacy attacks and metrics used for privacy exposure calculation. So this course will help to retrieve information from adverse web search engines while the users' privacy remains intact.

**Learning Outcome**

The successful student will have an advanced understanding of the theoretical underpinnings of WSE user privacy. They will be able to relate this understanding to areas ranging from the philosophical, political, organizational, and technical aspects. In particular, they will know privacy as a process of adapting to a changing circumstance and understand the significance of randomness in protecting privacy and quantifying risk, and be able to operationalize this understanding.

**Skills:**

- Identify web user privacy-related aspects of information retrieval from the public server.
- Evaluate proposed technical mechanisms for privacy preserved Information Retrieval.
- Apply differentially private information retrieval mechanisms when the sensitivity to requested information to changes in data is readily available.

**General Competence:**

- Acquisition of new knowledge and skills from the research literature.
- Quantitative and qualitative analysis of problems.
- Relating technology and society.

**Course Prerequisites:**

The prerequisites for this course are:

- Data Communication/Computer Networks



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- Calculus
- Basic Probability Theory and Statistics

**Week Wise Course Content Distribution:**

**Week-1**

- Introduction to Information Retrieval
- Private Information Retrieval
- Difference between Privacy and Security
- Anonymity

**Week-2**

- Data Usability Laws and Breaches
- AOL and Google's Incidents
- Web Browser
- Browser User Profile

**Week-3**

- Web Search Engine (WSE)
- WSE Browsing History
- WSE Cookies and Trackers

**Week-4**

- Private Information Retrieval Solutions
  - Private Information Retrieval Protocols
    - Crowds
    - Useless User Profile (UUP)
    - User Private Information Retrieval Protocol (UPIR)
    - Poshidah I-II

**Week-5**

- Private Information Retrieval Solutions
  - Private Information Retrieval Protocols
    - Obscure Logging (OSLo)
    - Multi-Group (MG)- Obscure Logging (OSLo)
    - Profile Aware (PA)- Obscure Logging (OSLo)

**Week-6**

- Private Information Retrieval Solutions
  - Unlinkability Solutions



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- Proxy Service
- Virtual Private Networks
- Mixed Network
- Web Mixes
- TOR (The Onion Router)
- RAC (Resilient Anonymous Communication)

**Week-7**

- Private Information Retrieval Solutions
  - Indistinguishability Solutions
    - Fake Query Mechanisms
    - Query Transformation Mechanisms
    - Profile Obfuscation Mechanism
  - Hybrid Solutions
    - PEAS
    - X-Search

**Week-8**

- WSE User Privacy Attacks (Part I)
  - Active Attacks
    - Timing Attacks
    - Congestion Attacks
    - Predecessor Attack
    - Flooding Attacks

**Week-9**

- WSE User Privacy Attacks (Part II)
  - Passive Attacks
    - Machine Learning-Based Attacks
    - Machine Learning Algorithms

**Week-10**

- WSE User Privacy Evaluation Mechanisms (Part I)
  - Entropy
  - Cross-Entropy Loss
  - Degree of Anonymity
  - Profile Exposure Level (PEL)

**Week-11**

- WSE User Privacy Evaluation Mechanisms (Part II)
  - Kullback-Leibler (KL) Divergence
  - Search Engines Results Assessment



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- Precision, Recall and F-Measure

**Week-12**

- Adverse Evaluation Models
  - Peddinti and Saxena Model
  - Balsa's Model
  - Gervais Model
  - Sim-Attack

**Week-13**

- Adverse Evaluation Models
  - QuPiD Attack
  - NN-QuPiD Attack

**Week-14**

- WSE User Privacy Preservation Techniques
  - Profile Exposure Measure (PEM)
    - Maximum Privacy Exposure (mpeT) Value
    - Profile Similarity
  - ProQSim Effect

**Week-15**

- Query Categorization Techniques
  - Query Categorization using Open Directory Project (ODP)
  - Query Categorization using Wikipedia
  - Query Categorization using uClassify

**Week-16**

- Web User Location Privacy
- AOL Web User Dataset
  - User Profile
  - WEKA Tool

**Total Marks: 100**

**Recommended Books and Materials:**

1. Khan, Rafi Ullah, editor. Protecting User Privacy in Web Search Utilization. IGI Global, 2023. <https://doi.org/10.4018/978-1-6684-6914-9>
2. Kissell Joe. "Take Control of Your Online Privacy", ISBN: 978-1-947282-37-7, Publisher : Alt Concepts Inc.; 4th edition 2019.
3. Yi, Xun, Russell Paulet, and Elisa Bertino. "Private information retrieval." Synthesis Lectures on Information Security, Privacy, and Trust, 2013.



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4. Khan, Rafiullah. "On the effectiveness of private information retrieval protocols." Department of Computer Science, Capital University of Science and Technology, Islamabad, Pakistan (2020).
5. Petit, Albin. "Introducing privacy in current web search engines." Université de Lyon; Universität Passau, 2017.
6. Solove DJ. The new vulnerability: data security and personal information. Securing Privacy in the Internet Age. Radin & Chander, eds.
7. Chander A, Gelman L, Radin MJ, editors. Securing privacy in the internet age. Stanford University Press; 2008.

**Course Proposed and Designed by:**

**Dr Rafi Ullah Khan**

Institute of Computer Science and Information Technology

The University of Agriculture Peshawar

[rafiyz@aup.edu.pk](mailto:rafiyz@aup.edu.pk)

[rafiyz@gmail.com](mailto:rafiyz@gmail.com)