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SECURE COMMUNICATIONS AT THE SPEED OF CYBER

Risk Assessment Based Access Control with Text and Behavior Analysis for Document Management

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Outline

- Motivation
  - Risk assessment based access control
- Models and Methods
  - Two risk assessment modules
- Evaluation Results
- Conclusion

Document Management

- Documents with sensitive information for business, government, and military operations must be classified and accessible only to appropriate personnel
- Example:
  - Unclassified (U), Confidential (C)
  - Secret (S) and Top Secret (TS)

Traditional Access

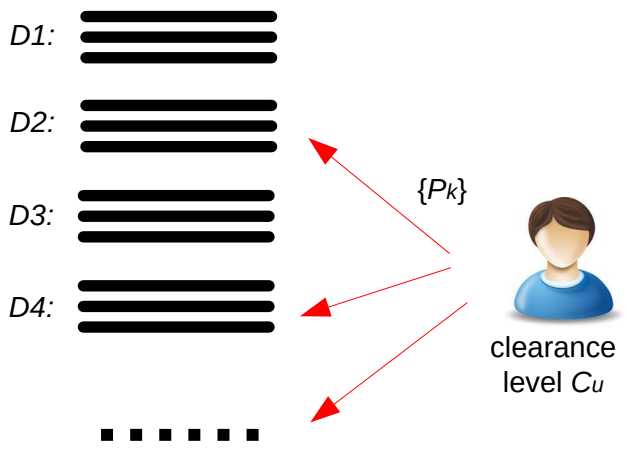
- Binary decision:
  - Alice has a ‘Secret’ level.
    - Able to access ‘Secret’ or lower level documents.
  - Potential security issues:
    - Account hacking
    - Insider threat
    - Classification error (due to human or machine errors)
    - …

Motivation

- We are motivated to design a new access control mechanism to protect sensitive information from unintentional or malicious access and disclosure
  - Traditional:
    - granting document access when a user has such access
  - Our method:
    - assess the risk of document disclosure to such a user
      - Scanning textual content and analyzing behavior

Research Question

- Research Question:
  - Given all N documents $\{D_k\}$, $k \in [1,N]$ stored in the system and a user's security clearance level C_u,
  - Determine whether to grant the user's current request to access documents $\{P_k\}$, $k \in [1,L]$, where L is the number of currently requested documents.

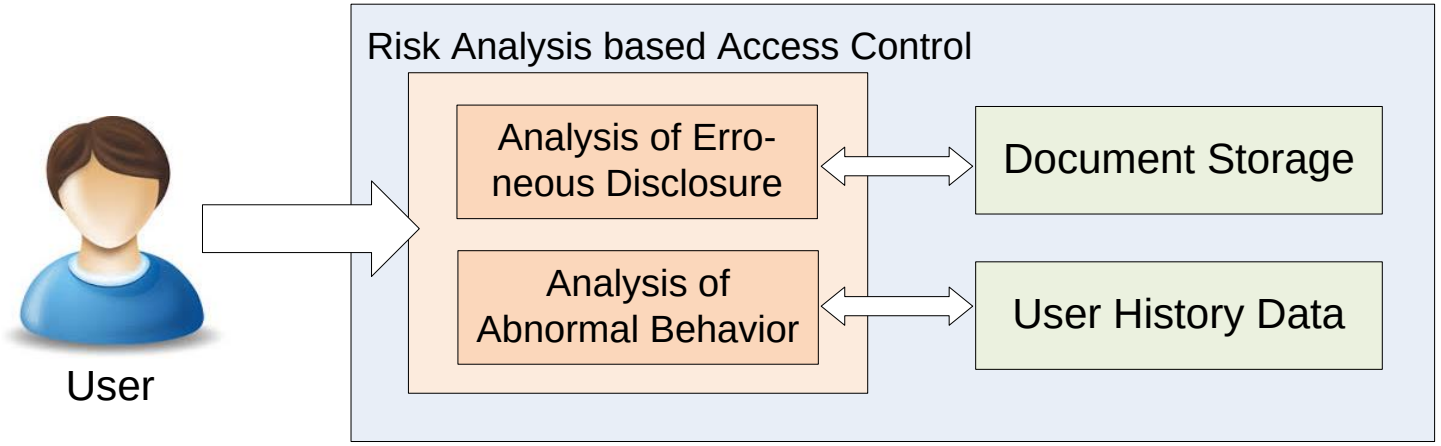


Models

- Each document can be classified into one level in an ordered set of classification levels.
  - E.g., {U, C, S, TS} with U< C < S < TS
- Classification
  - is a function, mapping from a document to a security classification level
    - either by human being or a classification algorithm.

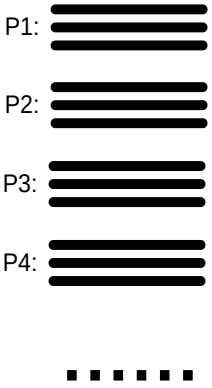
Risk Assessment based Access Control

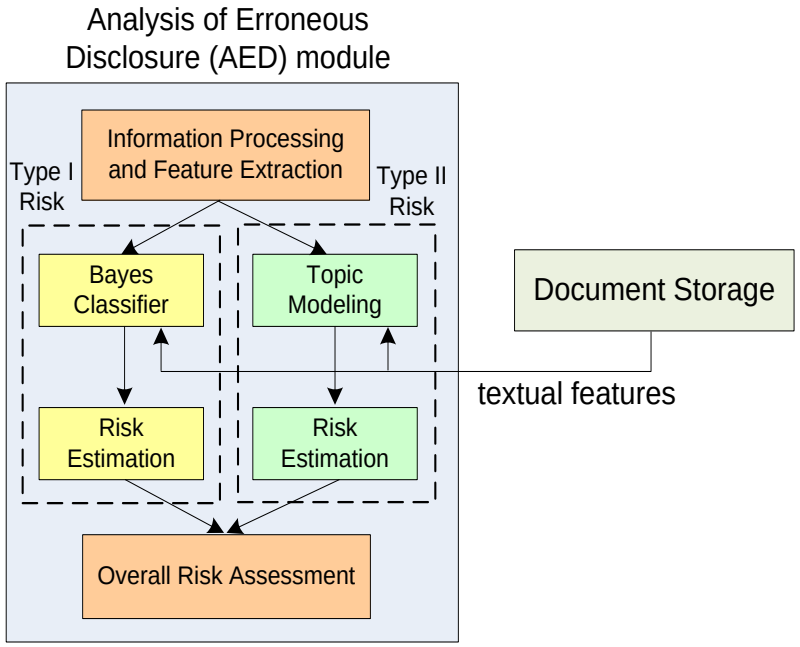
- Two key components:
  - Analysis of Erroneous Disclosure (AED)
  - Analysis of Abnormal Behavior (AAB)



Analysis of Erroneous Disclosure (AED)

- The role of the AED module is to determine the risk of these documents being erroneously classified.
- Such a risk contains two major factors:
  - Risk due to classification errors/mismatch, called Type I risk.
  - Risk due to information similarity, called Type II risk.

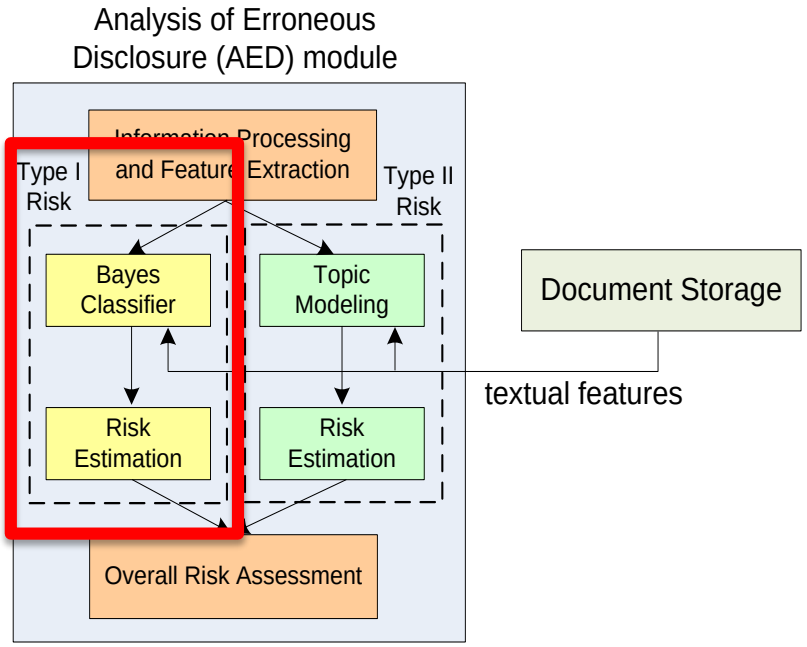




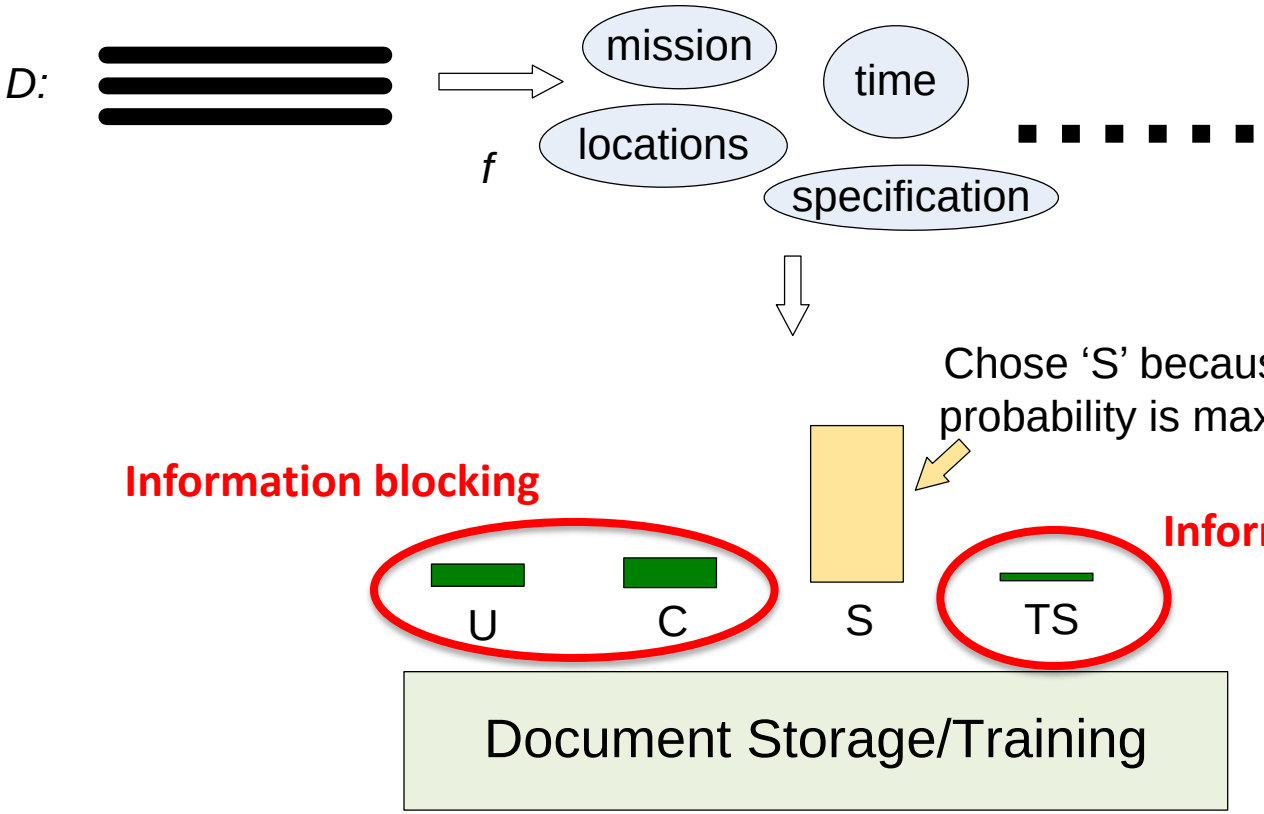
Analysis of Erroneous Disclosure (AED)

- Type I risk: Risk due to classification errors:
  - the risk of information leakage
    - A high level document is classified as a low level
  - the risk of information blocking
    - A low level document is classified as a high level

P1:
P2:
P3:
P4:
.....



Bayes Classifier



Two Sub-Risks under Bayes Rule

- The risk of information leakage

$$R_d(P_{\text{in}}) = \sum_{s>c} \pi(s) = \sum_{s>c} \mathbb{P}(f|s),$$

- The risk of information blocking

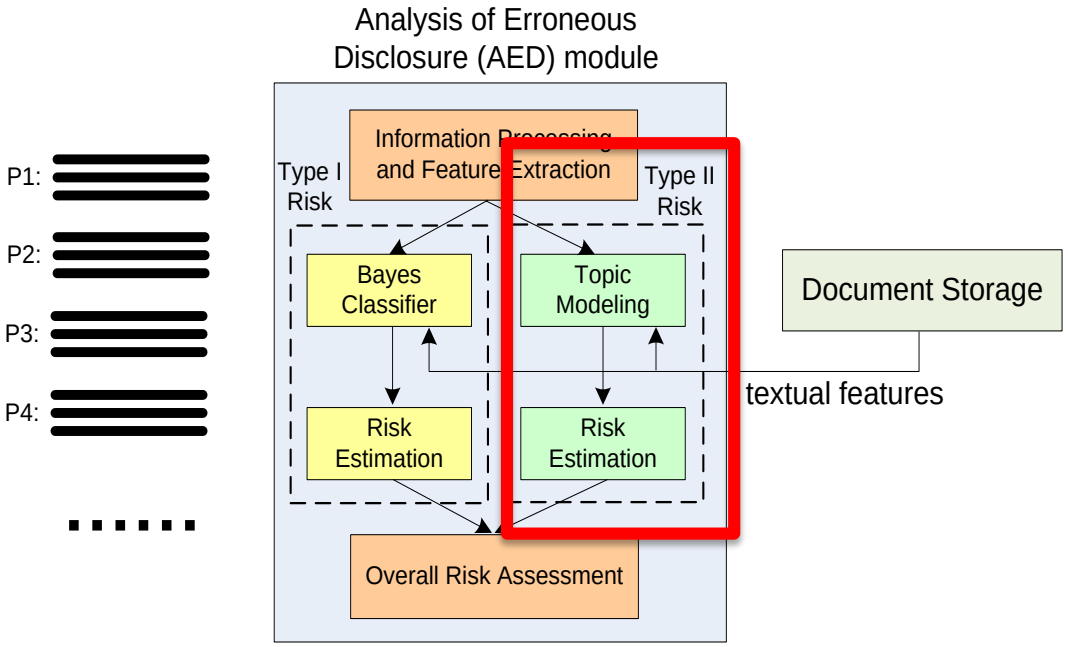
$$R_b(P_{\text{in}}) = \sum_{s<c} \pi(s) = \sum_{s<c} \mathbb{P}(f|s).$$

- Type I risk:

$$R_I(P_{\text{in}}) = R_d + R_b$$

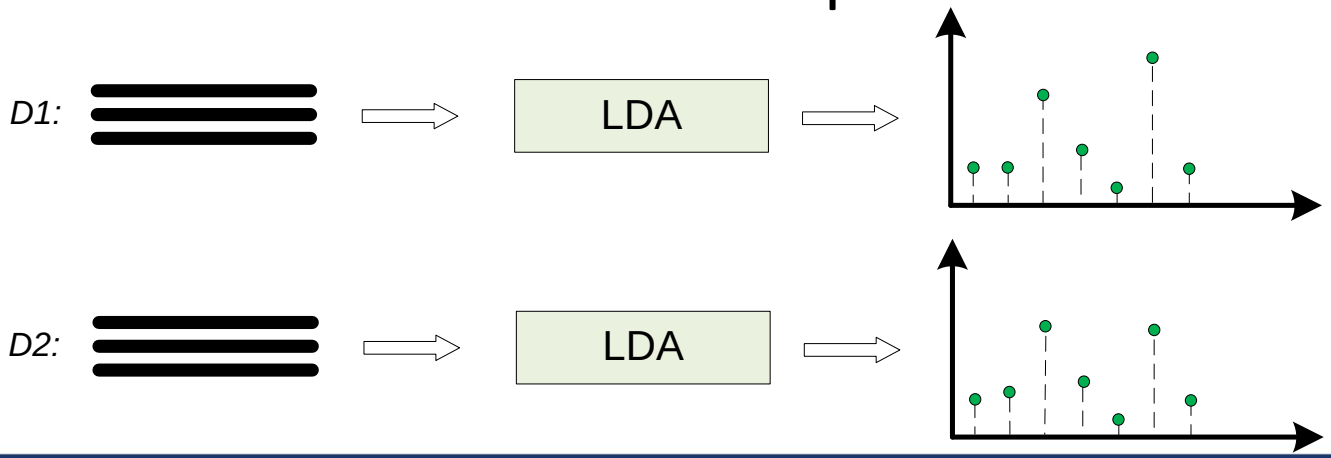
Type II Risk

- Type II risk: Risk due to information similarity:
  - similar content between documents with different classification levels



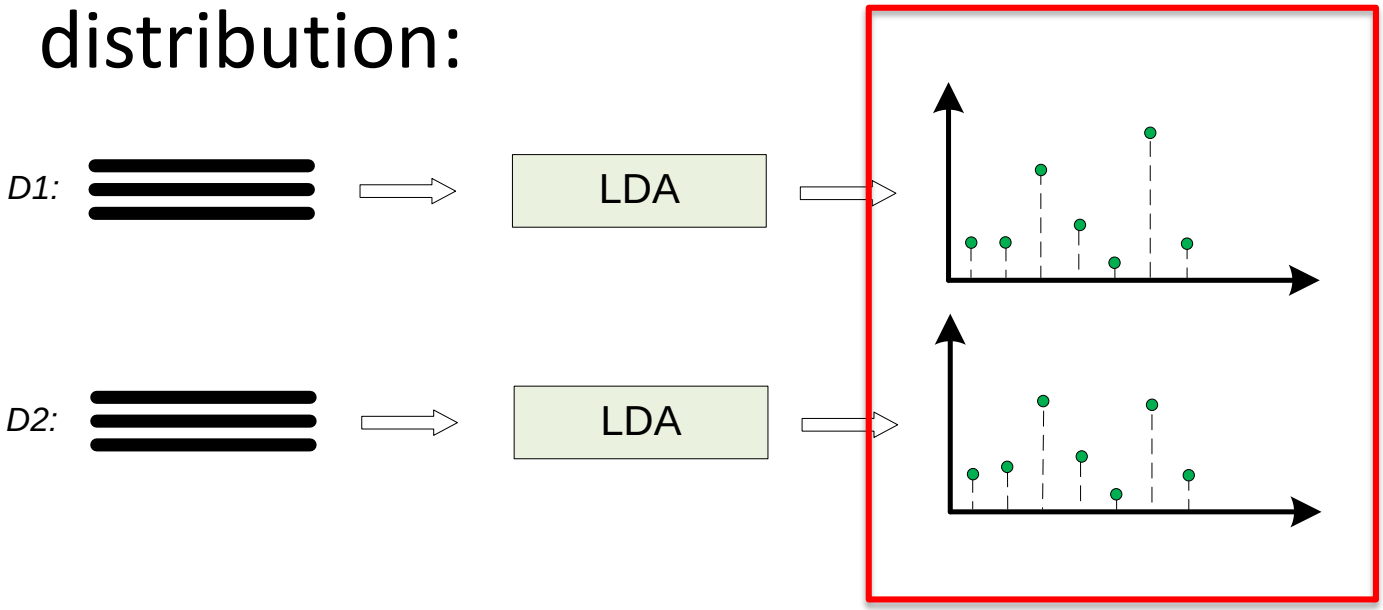
Type II Risk

- Model the similar textual content?
  - Using a topic modeling method
  - Latent Dirichlet Allocation (LDA): gives the probability distribution that a document is associated with a certain topic.



Modeling of Type II Risk

- Cosine similarity of two vectors of topic distribution:

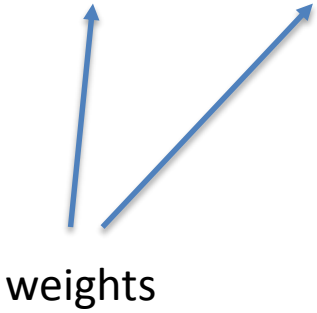


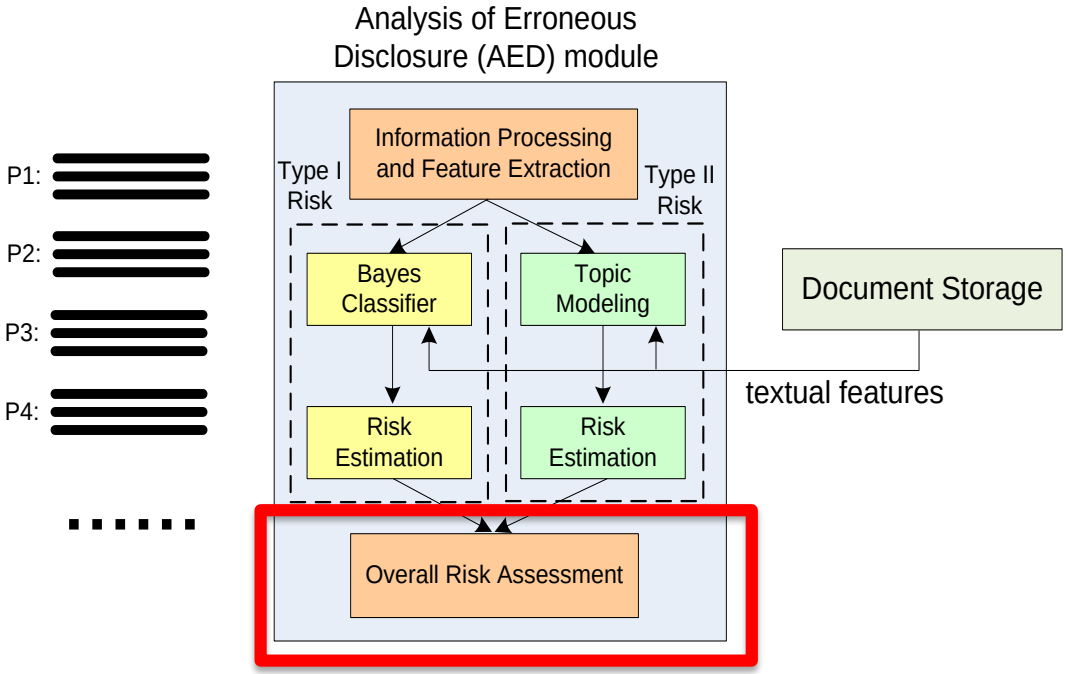
$$C(P_1, P_2) = \frac{\sum_{i=1}^{T} |X_1(i)X_2(i)|}{\sqrt{\sum_{i=1}^{T} X_1(i)^2}\sqrt{\sum_{i=1}^{T} X_2(i)^2}},$$

Overall Risk Assessment

- Combing Type I and Type II:

$$R_o(P_{\text{in}}) = w_1 R_I(P_{\text{in}}) + w_2 R_{II}(P_{\text{in}}),$$





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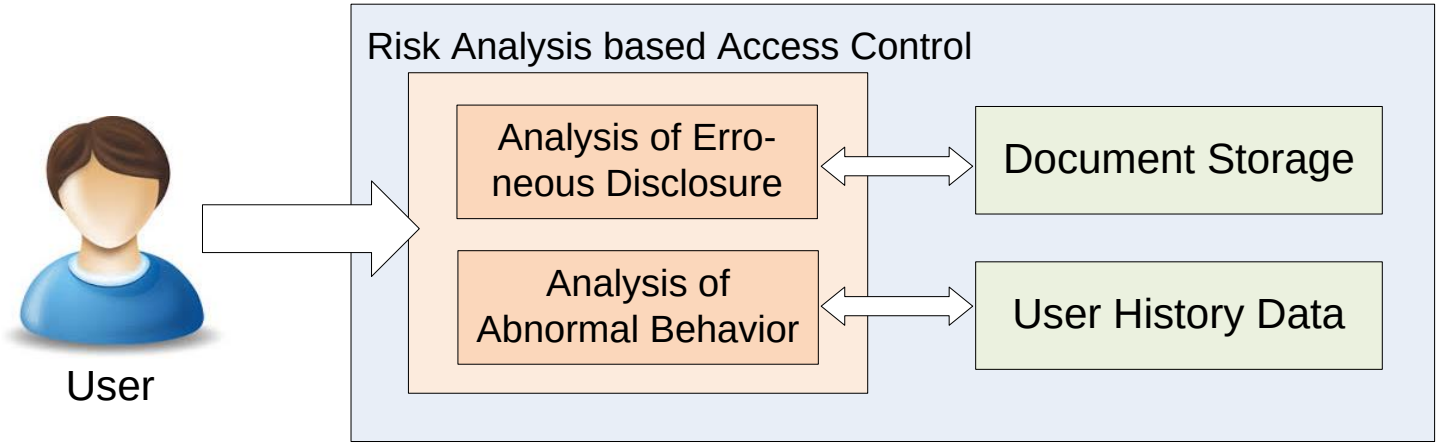
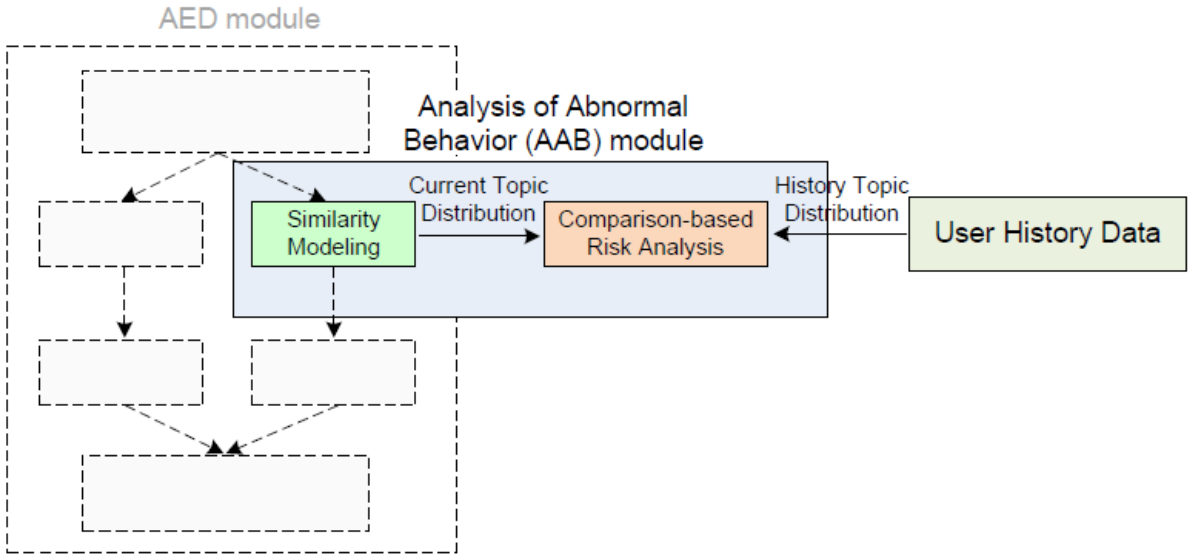


Analysis of Abnormal Behavior (AAB)

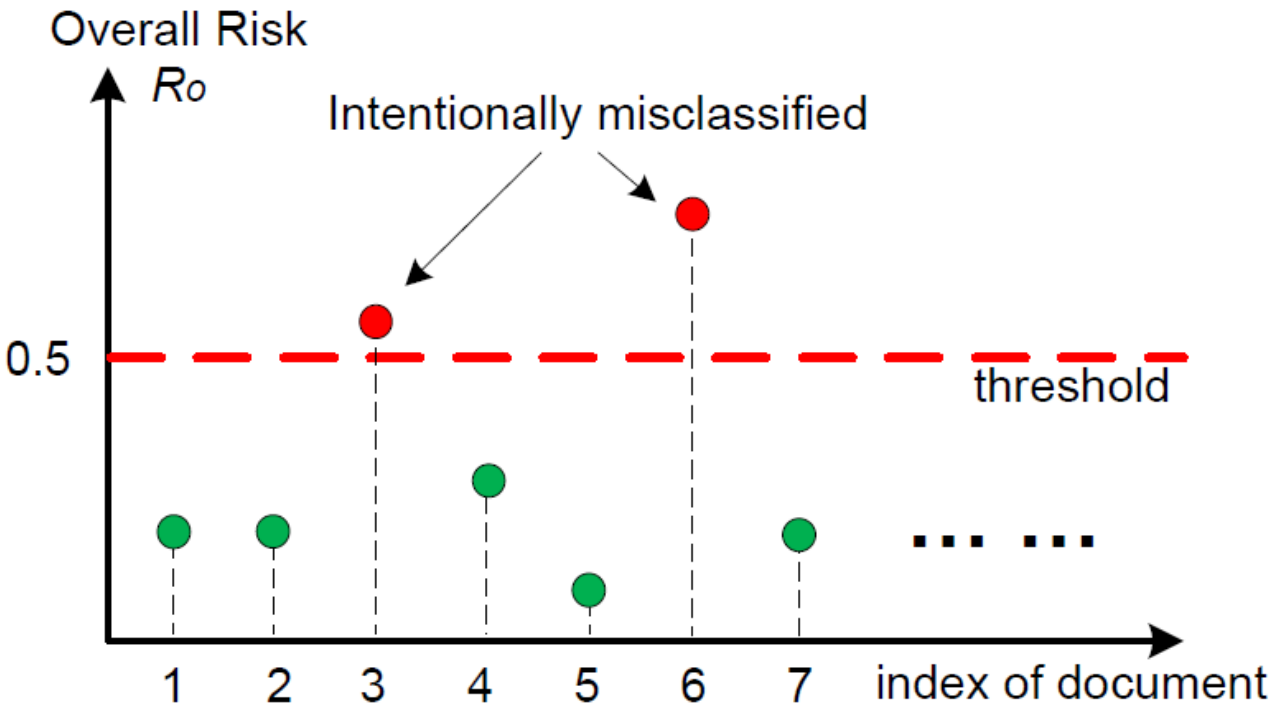
- Intuition: Due to the nature of a user's job, the documents that the user requests should have similar, if not the same, topics in routine operations.
- Hacking: the hacker uses a user's account to download all possible documents that the account has the access to, which should exhibit quite distinct topic



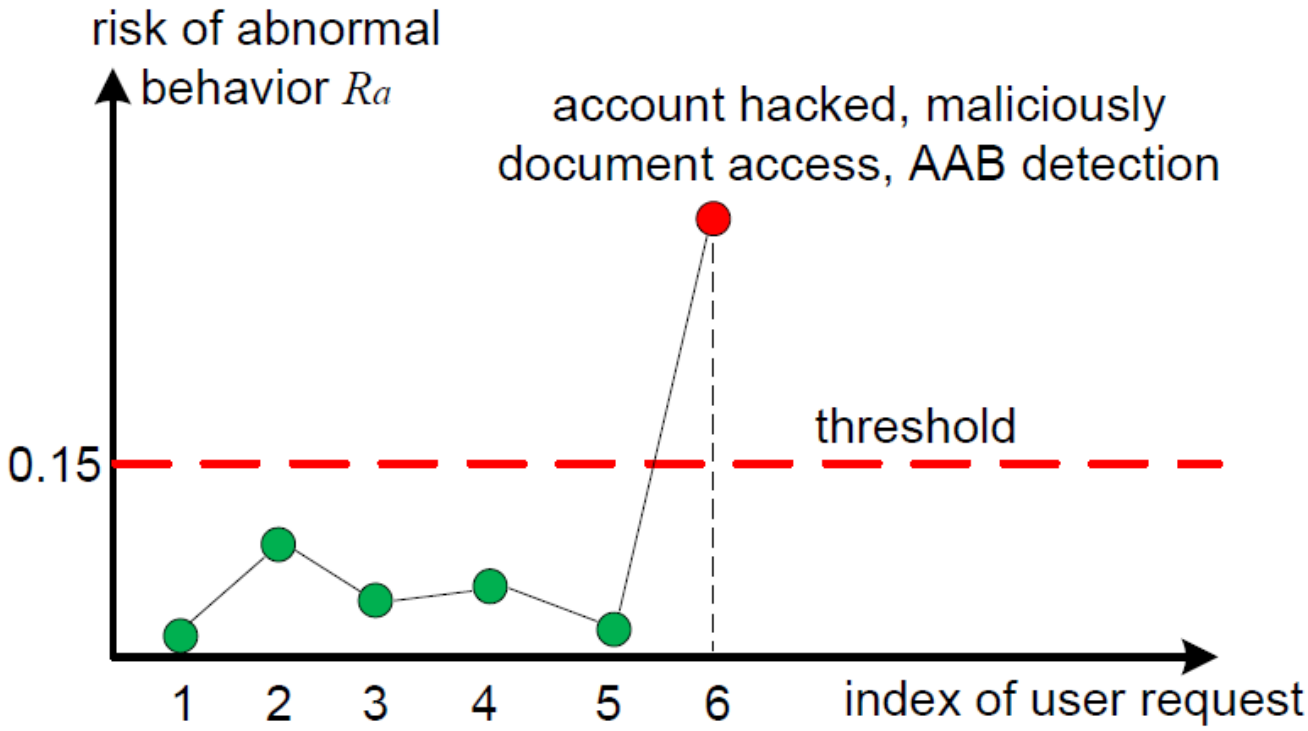
Evaluation

- 100 documents from the Internet
  - Treated as notional ‘classified’ documents.
  - classified into levels: A(lowest), B, C, D (highest).
  - Intentionally misclassified some documents

Analysis of Erroneous Disclosure (AED) Evaluation



Analysis of Abnormal Behavior (AAB) Evaluation



Conclusions

- We proposed an access control mechanism:
  - Two relatively independent AED and AAB modules
  - Text analysis and behavior analysis to quantify the risk of access to certain documents
  - grant the user access only if the risk is assessed low with respect to the user's credentials.
- Rudimentary evaluation results
  - More comprehensive tests
  - better testing using public declassified documents.

Thank you!

Q/A?