Risk Scoring Engine to Detect Anomalous Service Accesses

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Motivation
- Growing use of online identity credentials
  - Passwords, certificates, SSN, etc.
  - Loss and theft due to phishing, malware, etc.
- Consequence of online identity theft
  - Impersonation
  - Disclosure of sensitive information
  - Financial loss for both users and service providers
- Many large companies rely on manual review.
  - Huge amount of log records
  - Non-real time processing

Goals
- Secure monitoring of login (service access) requests in an automated and real-time manner
- Computation of Risk Score based on suspiciousness of each access to help reduce burden on human experts
- Broad applicability by supporting general access log records

Challenges
- Limited amount of information in access logs
  - E.g., user ID, timestamp, IP address, etc.
- Limited types of events
  - Only a login event in an extreme case
- Real-time score calculation
- Reasonably high accuracy to reduce human effort

Anomaly-based Scoring
- Extract (categorical) profiling attributes from an individual log record
  - Timestamp (day-of-week etc.), IP address, etc.
- Construct a user profile as frequency distribution over categories of an profiling attribute
- Support multiple profiles per user
  - E.g., Day-of-week profile and hour-of-day profile etc.
- Implement data aging
  - Aiming at reducing the impact of older observations
  - Multiplying a decay factor with all frequency counts
- Calculate Base Score based on “unlikeness” of an observed attribute value
  - Base Score = -log (Relative Freq. of Attribute Value)
- Determine Weight based on “effectiveness” of the corresponding profiling attribute.
  - Use “distance” between the frequency distribution and uniform distribution
    - Bhattacharyya Distance etc.
    - Example of an “effective” profiling attribute

Sub Score = Base Score * Weight
- Aggregate Sub Scores to output Risk Score

Future Work
- Investigate other profiling attributes
  - Session duration, access frequency / interval, etc.
- Implement in production environment
  - White / Black list for score adjustment
  - Interaction with human operators
- Conduct detailed experiments and evaluation
- Integrate into other security mechanisms
  - Risk-based authentication systems
  - Other fraud / intrusion detection systems

Preliminary Experiments
- Data set 1: University portal site
  - Profiling attributes:
    - Week of month, day of week, and hour of day
  - Decay factor for data aging:
    - 0 (without data aging) and 0.5 (with data aging)
- Data set 2: E-commerce company portal
  - Profiling attributes:
    - Week of month, day of week, and hour of day
    - Country, region (state), city
    - Organization name / ISP name
  - Decay factor for data aging: 0.5
- Methodology
  - Scale scores in [0,100)
  - Pick the max of sub scores
  - Determine thresholds based on past scores
- False positive / True positive for Data set 1
- False positive rate distribution for Data set 2

Integration of Domain Knowledge
- Rule-based scoring module
  - Define scoring criteria tailored for each domain and setting, such as
    - Consecutive login failure
    - Simultaneous login with distant location
    - Speed contradiction
      - Access interval against distance moved
- Rule-based scores can be combined with anomaly-based scores.
  - Sum, max, weighted average etc.