
University of Pittsburgh
Insider Threats
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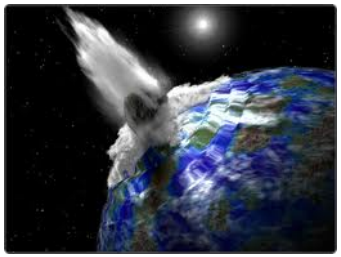
Announcements

- Crypto assignment:
  - Slide your printed solution under the door of room 410 on Friday 23rd **by 5pm**
  - Only submit the questions covered until last class (Dr. Joshi will send an email)
- The midterm will cover today's class
  - I'll post the slides in course web
- Today: two topics
  - Insider threats
  - Risk Management

Insider Attacks

- According to CERT insider attackers are defined as:
  - Currently or previously employed individuals, contractors or business partners that:
  1. are or were legitimately authorized to use some privileges,
  2. decide to exceed or *intentionally* use their privileges to negatively impact an organization

Insider Attacks' Impact



- Insider attacks accounted for **33% of the total incidents** reported
- Monetary losses ranged from $500 to **$10 million**
- 75% of the organizations had a negative impact on their operations, and 28% on their reputations

[Computer Crime and Security Survey 2010]

Insider Attacks' Impact

- Caused more monetary damage than attacks performed by outsiders

[Computer Crime and Security Survey 2011]

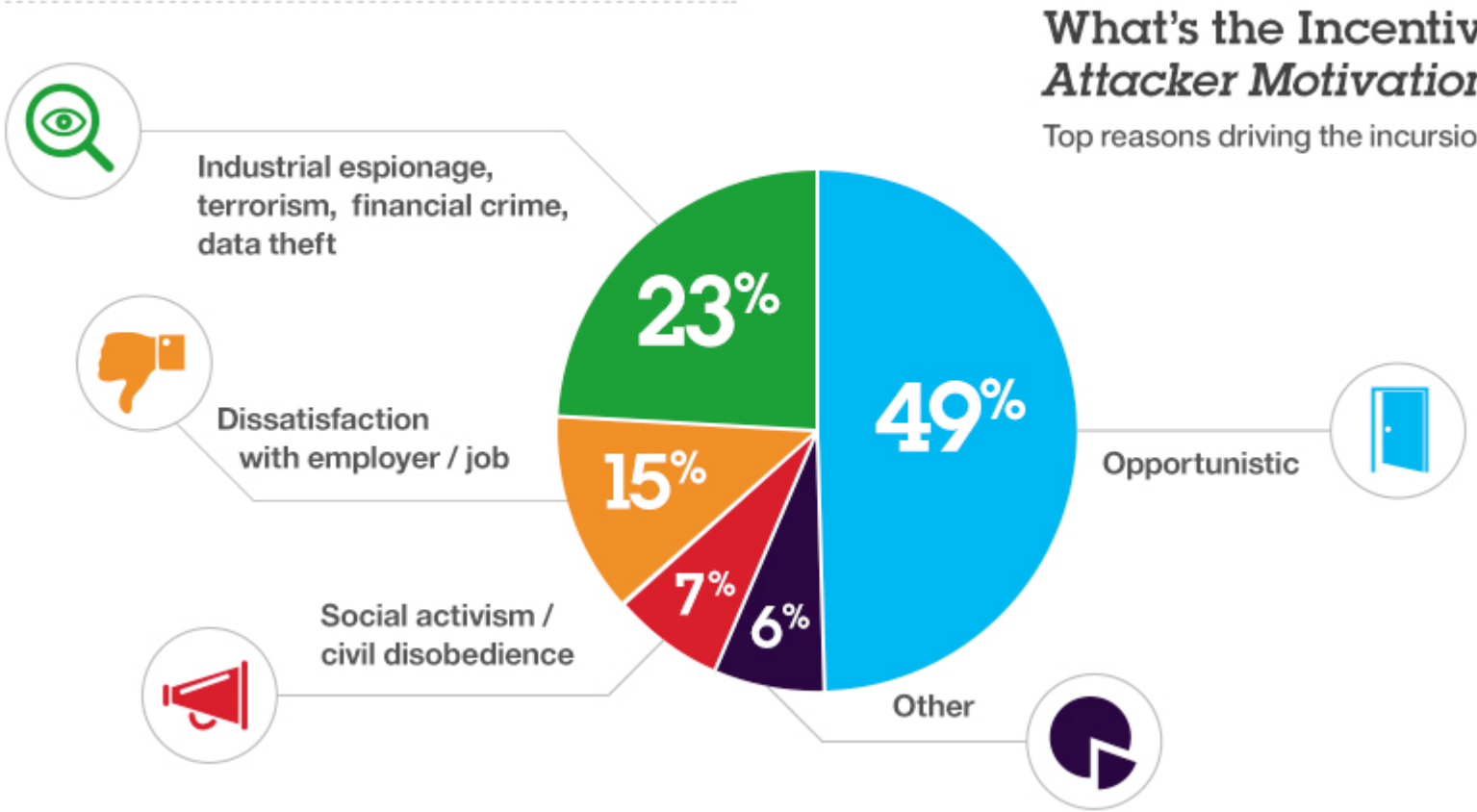
A closer look

Figure 2: The causes and consequences of cybercrime committed by insiders*

Taken from "US cybercrime: Rising risks, reduced readiness Key findings from the 2014 US State of Cybercrime Survey" *By PWC*

Why do we care about this information?

More numbers…



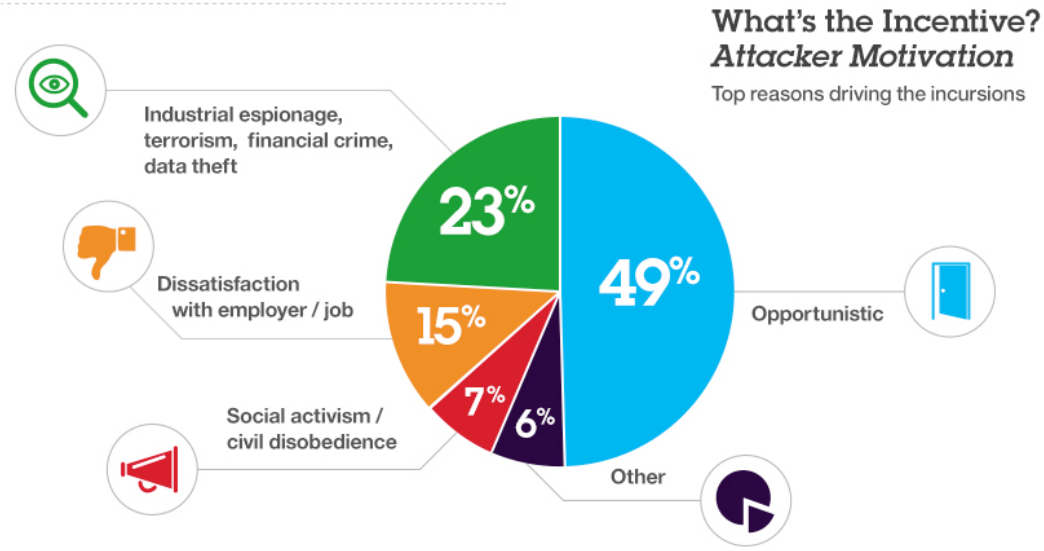
IBM Cyber Security Index
http://www-935.ibm.com/services/us/en/security/infographic/cybersecurityindex.html

Any incidents come to mind?

- Edward Snowden
  - Leakage of confidential information
- WikiLeaks
- Employee of an electric company
  - 911 service was out of reach for several minutes

Let's classify these attacks according to the attacker's motivation

- Edward Snowden
- Wiki-leaks
- Employee of an electric company
- Insider Trading
- Any examples of an opportunistic attack?



Classification of attacks

- IT sabotage
- Intellectual property theft
- Fraud
- Espionage
- Think about the cloud… Any new types?
  - Curious cloud administrators
  - Stalking
  - Blackmailing or embarrass others
  - Affect political events

According to the CERT

Insider Definition of a Malicious Insider

- "is a current or former employee, contractor, or other business partner who has or had authorized access to an organization's network, system, or data and **intentionally exceeded** or **misused** that access in a manner that negatively affected the **confidentiality, integrity**, or **availability** of the organization's information or information systems."
  - CERT, Insider Threat Technical Report

Are there unintentional insider attackers?

A world far from ideal…

- 60 % of respondents reported monetary losses caused by non-malicious insiders *
- Not wise to trust users blindly!

** [Computer Crime and Security Survey 2010/2011]*

Unintentional Insider: Fishing

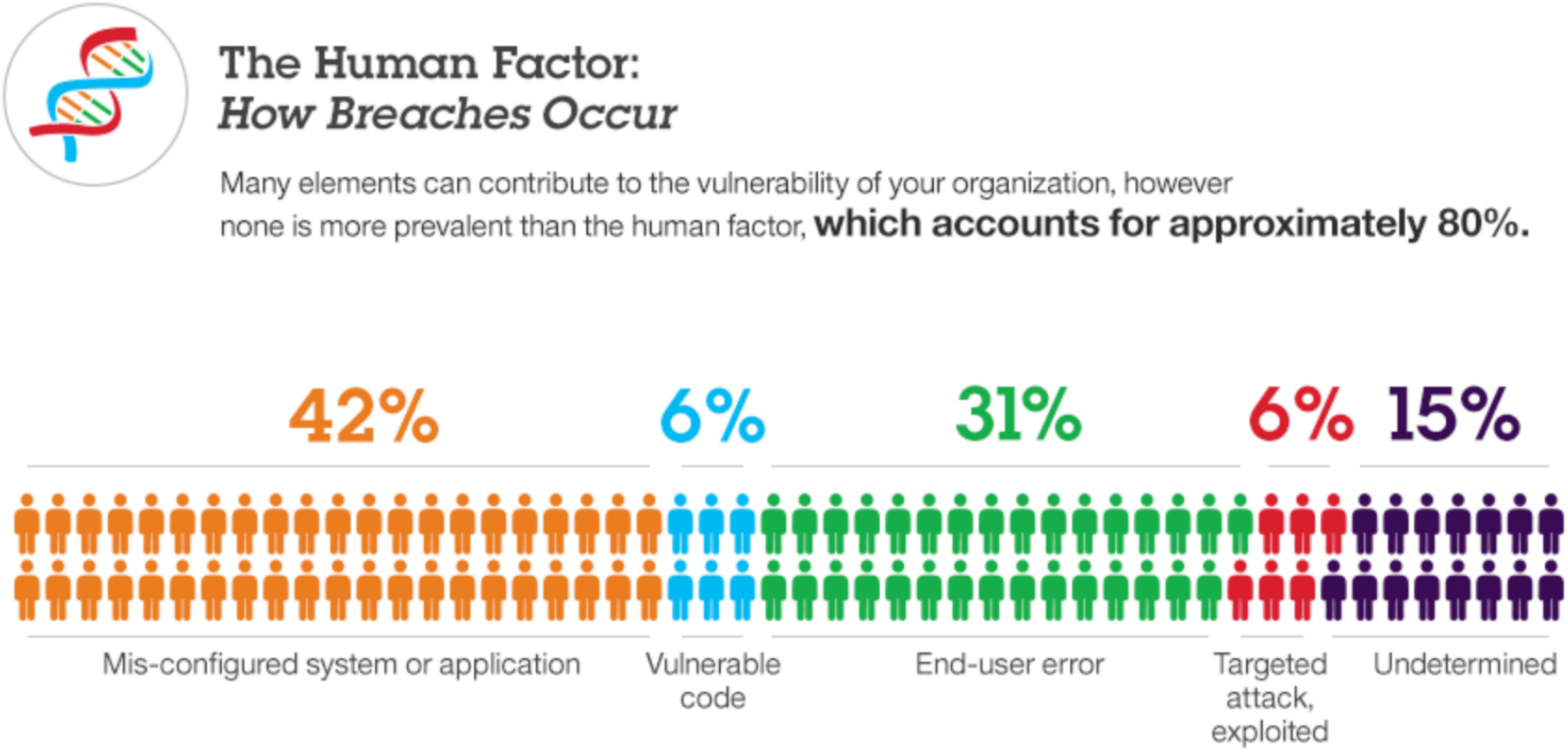
- Goals:
  - Obtain user-name and passwords
  - Other confidential information
  - Install virus or spyware

Unintentional Insider: Social Engineering

Some examples of this type of attack

- Any other examples come to mind?

Other types of Unintentional Threats Caused by Insiders



Taken from **IBM Cyber Security Index**

Unintentional Insider Threat Definition

- *An unintentional insider threat is (1) a current or former employee, contractor, or business partner (2) who has or had authorized access to an organization's network, system, or data and who, (3) through action or inaction without malicious intent (4) **causes harm or substantially increases the probability** of future serious harm to the confidentiality, integrity, or availability of the organization's information or information systems."*

"Unintentional Insider Threats: A Foundational Study", CERT 2013

Can we prevent insider threats?

Can we predict these attacks?

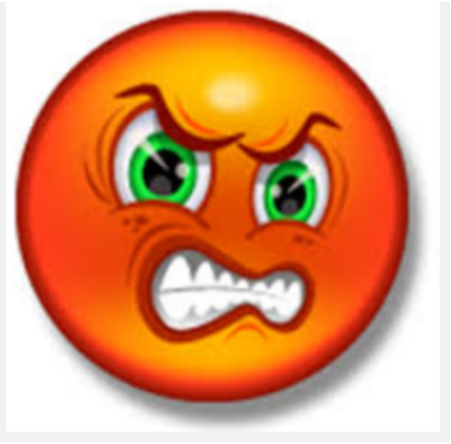
- Insider attacks are typically preceded by **technical** and **psychological precursors**

Technical precursors

- Download and use of hacker tools
- Unauthorized access to other users' or customer data
- Setup or use of backdoors
- Transmitting large files
- Etc.

Psychological precursors

- Disgruntlement
- Bad attitude
- Lack of dependability
- Absenteeism
- Etc.



[Greitzer et. al]

Where does this data come from?

Very Recent Research

- Identify narcissism personality traits in Twitter posts [1]
  - What for?
- Use graph connections to detect possible spies [2]

[1] M. Kandias, K. Galbogini, L. Mitrou, and D. Gritzalis. **"Insiders trapped in the mirror reveal themselves in social media"** 2013

[2] Kathleen Carley et. al **"*Insider Threat Mitigation Project: A Dynamic Network Approach"***
Poster: https://resources.sei.cmu.edu/asset_files/Poster/2014_020_001_435088.pdf

Now, let's switch sides!

- As an employee… Do you like to be scrutinized?

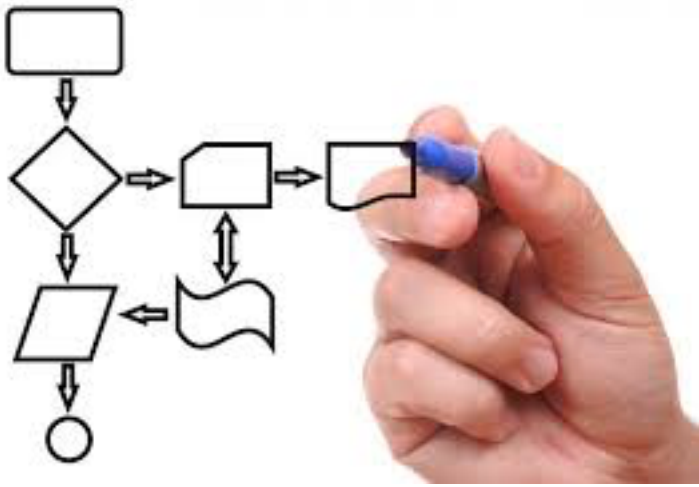
An important remark

- It is important to inform employees that they are being monitored!
  - Otherwise it may:
  - increase their disgruntlement levels and their likelihood of becoming an insider
  - reduce the trust employees have in the organization

Some Approaches to Deter Insider Threats

Try to reduce the risk exposure

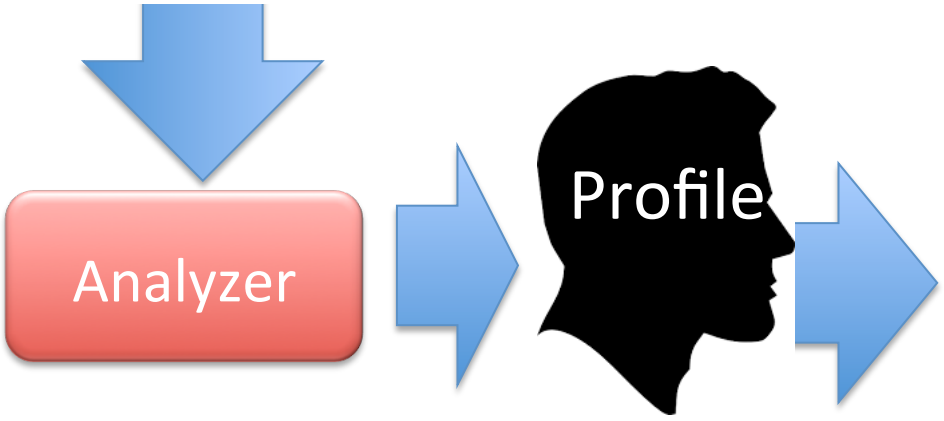
- Have in place appropriate procedures
- Design adequate access control policies
- Try to predict possible attacks
- Adapt to negative changes in behavior



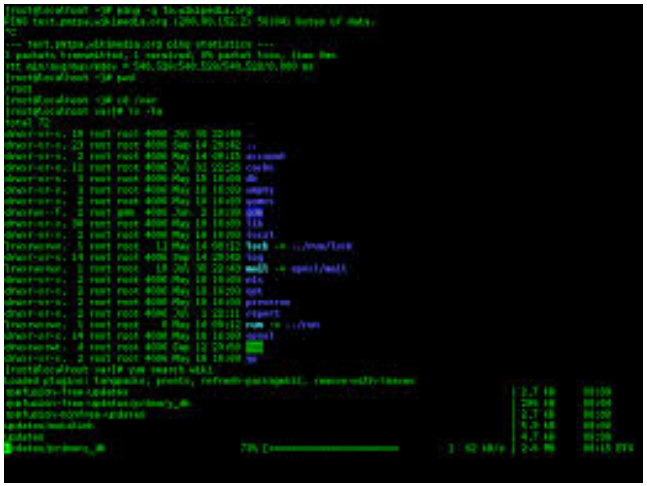
- We will see some examples!

Example Mitigation 1: Monitor emails, Internet traffic, file transfers, etc.

- Flag suspicious behavior and show an alert to the system administrator



Alerts



Example Mitigation 1 (cont.)

- Any problems?
  - May not be effective against **stealth attackers**
    - This is a problem for all anomaly detection systems
  - May not work if multiple adversaries are **colluding**
    - Much more difficult to flag suspicious behavior if malicious activity is carried out by multiple users
  - **Not automatic**, administrator may miss important alert!

TARGET

Example Mitigation 2: Use Decoys

- Use file search behavior to identify user's normal search patterns
- Monitor how user is searching his files
- If the current behavior does not match the expected one, **decoy** files are served to the user
- Is this a good solution?

Solution proposed by Salem et. al

Combining a baiting and a user **search** profiling techniques for masquerade detection

Example Mitigation 2 (cont.)

- Hypothesis of the solution:
  - If an opportunistic malicious colleague is accessing another's user computer, the search behavior would be different
  - In theory, the real user would distinguish fake files vs. real files
- Do you see any problems with this hypothesis?

Example Mitigation 3: Non-technical mitigation strategies

- Educate users
  - Avoid unattended terminals
  - Prevent fishing
  - Prevent social engineering attacks
  - Increase awareness of possible relevant problems e.g., SQL injections in a SW engineering company

- Create a good working environment ☺
  - Disgruntle employees are more likely to become insider attackers
  - Recall that 15% of attacks are committed by unhappy employees

Example Mitigation 4: Implement an Access Control System

- This is a MUST!
- Restrict the access enforcing
  - Separation of duty
  - Least privilege enforcement

- Challenge: Employees need the privileges, but we need to prevent the abuse those permissions

Current Access Control Approaches

- Access control systems are highly static
  - As long as users have the required credentials, they can access the system
  - What about their behavior?
- Require manual verification and input
  - Manual verification of alerts
  - Input of psychological precursors is slow and subjective

Current approaches (*cont.*)

- Do not minimize risk exposure *continuously*, *automatically* and *optimally*
  - Risk methodologies are performed sporadically (e.g., NIST, Octave, etc.)

Our Proposed Research

- Two concepts:
  - **Trust:** expectation of future behavior based on the history
  - **Risk:** likelihood of a hazardous situation and its consequences if it occurs

- We include **risk** and **trust** in access control systems to adapt to anomalous and suspicious changes in users' behavior

We identify an opportunity to control risk very frequently (for each access request) and automatically ☺

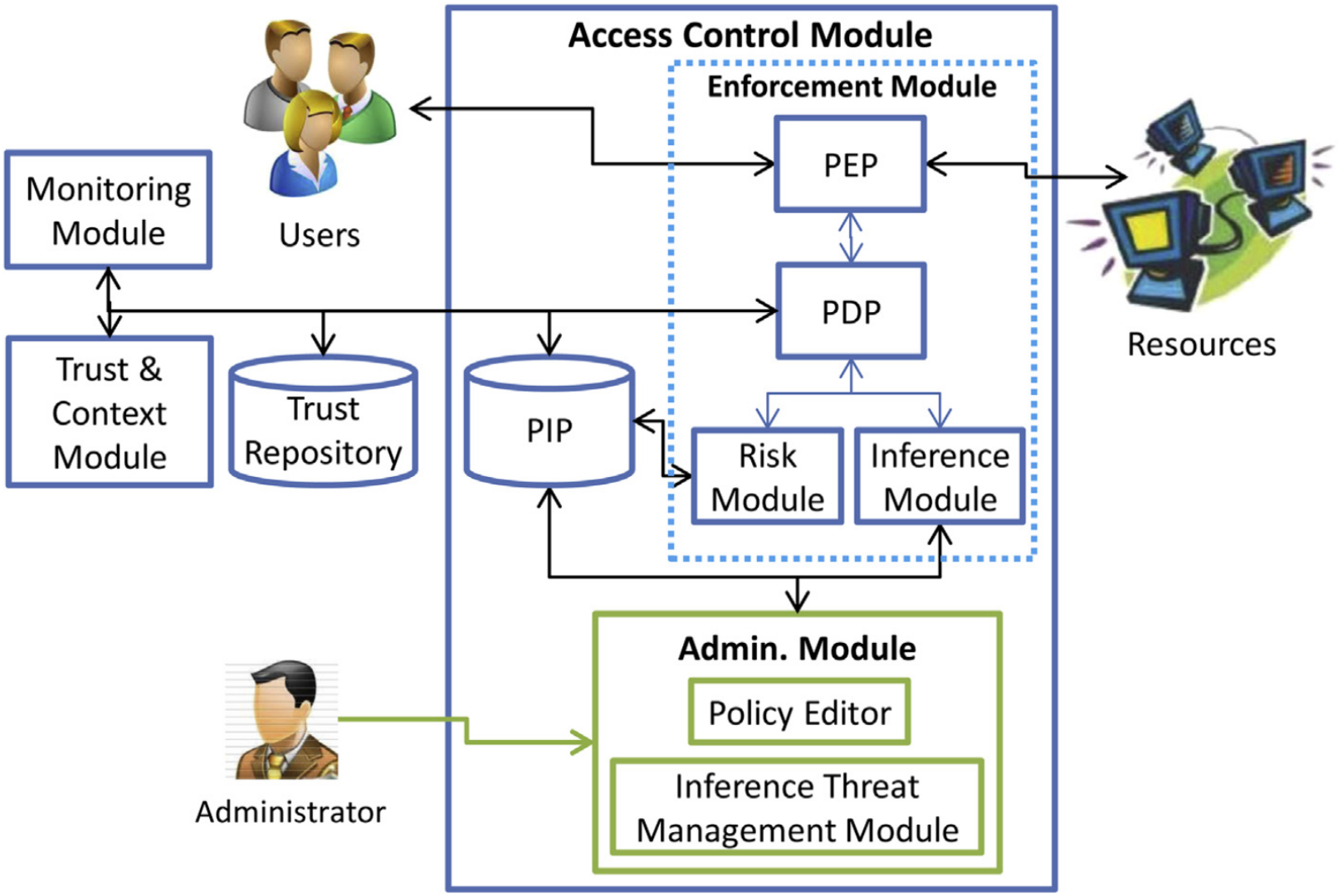
Requirements of Our Adaptive System

1. Enforce separation of duties (SoD) and cardinality constraints
2. Detect suspicious activities, and establish a trust level for each user
   - Different trust values for users depending on the *context*

Requirements (*cont.*)

3. Different permissions may have different risks associated with them
   - Adapt to suspicious changes in behavior of users by restricting permissions depending on risk values
4. Risk exposure should be **automatically** reduced, minimizing the impact of possible attacks

Framework Overview



"An adaptive risk management and access control framework to mitigate insider threats", Nathalie Baracaldo and James Joshi, 2013 Paper available: http://www.pitt.edu/~nab62/baracaldo_cose_2013.pdf

In a nutshell…

role

permission

trust_threshold(role)

authorized(*u*,role) & trust(u,c)≥trust_threshold(role)

Trust value of users

- Each user u is assigned a trust value:
  - $0 \leq trust(u,c) \leq 1$ → reflects his **behavior**
  - Where *c* is the context, and *u* is the user
- Some works exist to calculate this value based on user's behavior

Assigning risk to permissions

- Each permission is assigned a risk value according to:
  - The *context*
  - The likelihood of misuse
  - The cost of misuse

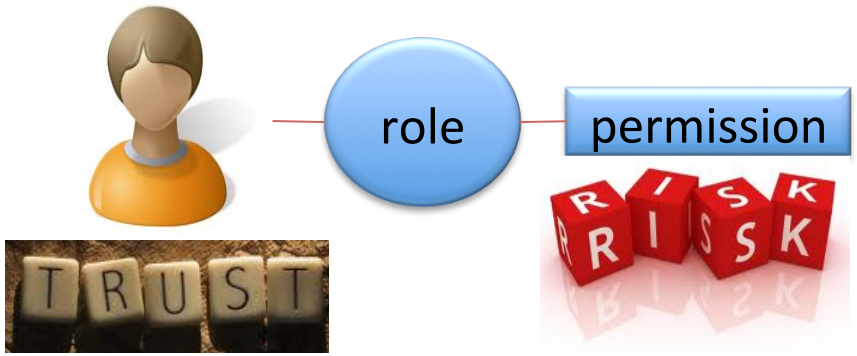
DEFINITION 1. *The risk of permission* $p = \langle obj, act \rangle \in P$ *in context* $c \in C$, *written as* $rs(p, c)$, *is defined as follows:*

$$rs(p, c) = \sum_{x_p \in MaliciousUsage} Pr[x_p |\ c\ ] * \mathcal{C}(x_p)$$

Probability of misuse given the current context * Cost of misuse

Risk of roles

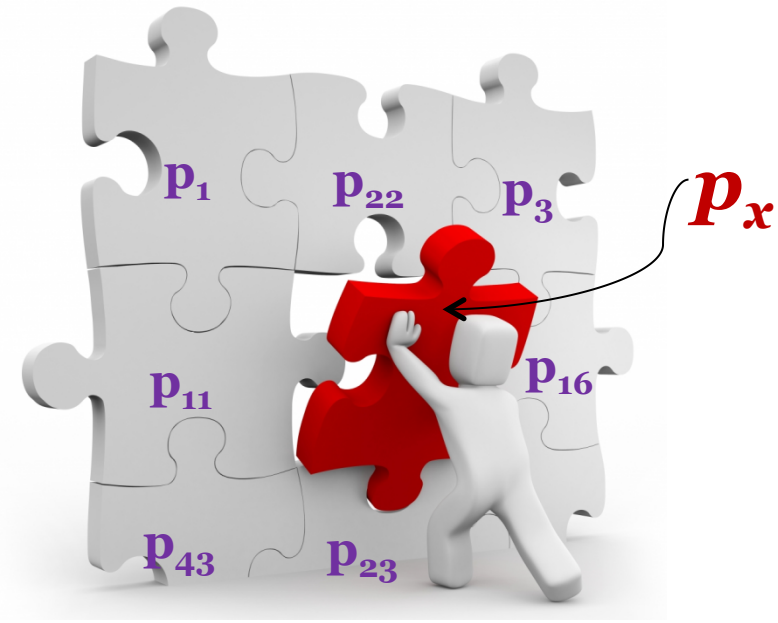
- The risk of activating a set of roles depends on:
  - Context
  - The user that is going to activate the roles
  - Authorized permissions & their risk
  - Inference risk



Inference risk

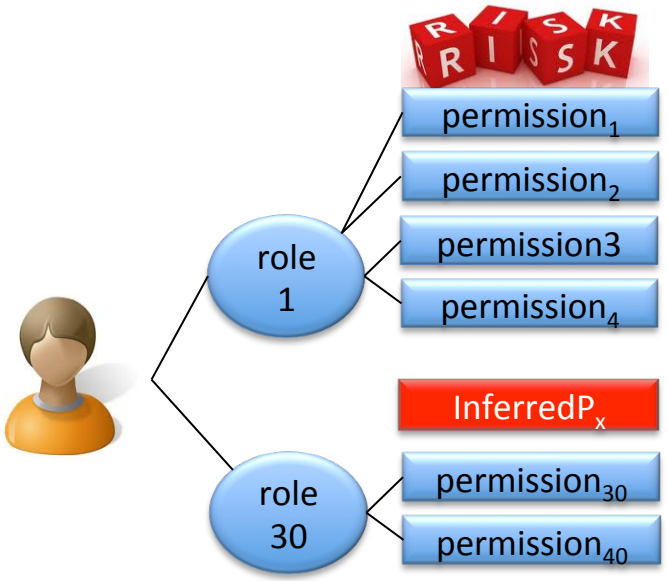
- *Inference Threat:* exists when a user is able to infer unauthorized sensitive information through what seems to be innocuous data he is authorized for
- *Inference tuple:*
  <*PS*, p_x>

  Shows the minimum information needed (*PS*) to infer p_x



Risk of roles

- Risk exposure of activating a set of roles



- For a set of roles *RS*, the **trust threshold** is the normalized version of their risk
- $0 \leq trust\_threshold(RS, c, u) \leq 1$

Automatically reduce the risk exposure

- **Select roles** with **minimum risk** that also respect the policy constraints & provide the requested permissions

Don't need to know this formulation by heart for the midterm!

DEFINITION 3. *The Trust-and-Risk Aware Role Activation Optimization Problem for a query* $q = \langle u, PS, c \rangle$, *consists of finding a solution,* R_q, *such that:*

$$\min_{R_q \subseteq authorized(u)} rs(R_q, c, u)$$

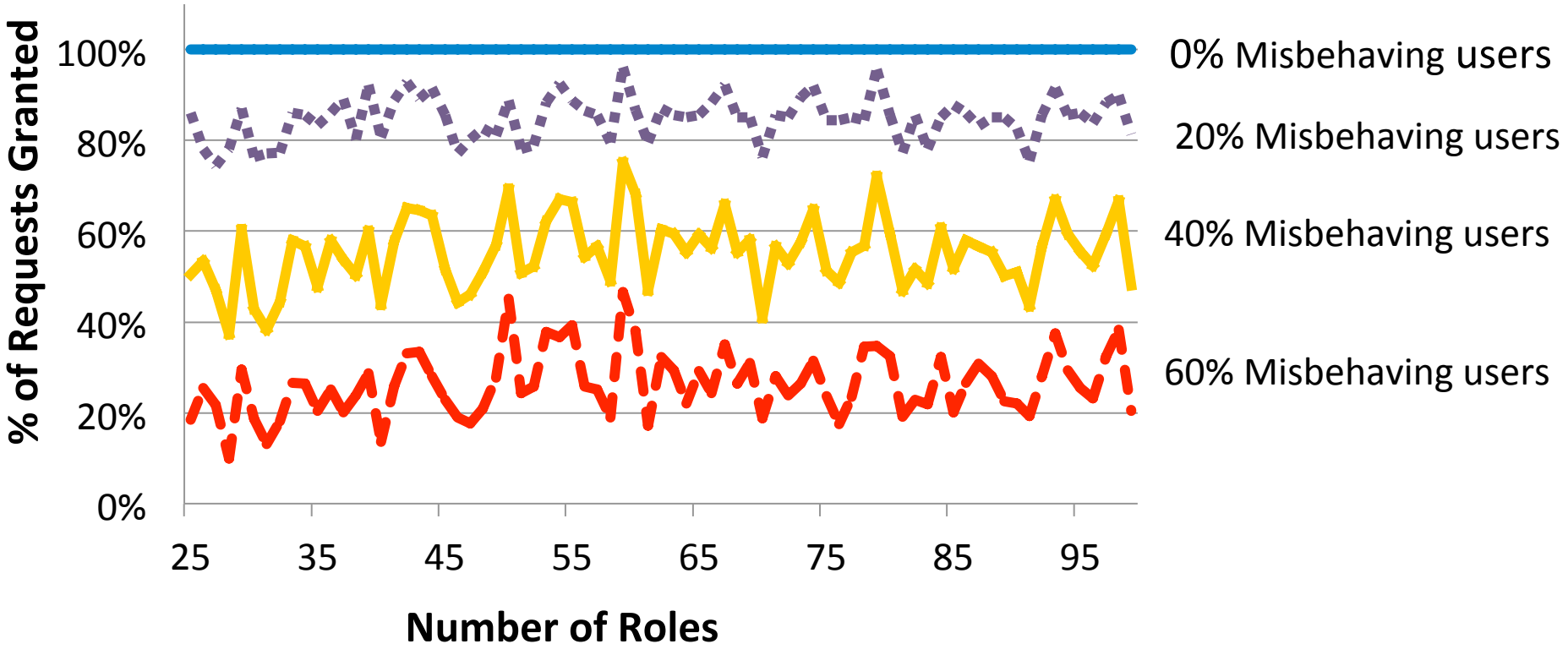
$$\textbf{s.t.} \ \forall\ dsod(RS_i, k_i) \in DSoD \ : |R_q \cap RS_i| < k_i$$

$$\forall\ card(r_c, k) \in CARD \wedge r_c \in R_q : activated(r_c) + 1 \leq k - 1$$

$$trust(u, c) \geq \tau(R_q, c, u)$$

$$P_{au}(R_q) \supseteq PS$$

Granted requests for different percentage of misbehaving users



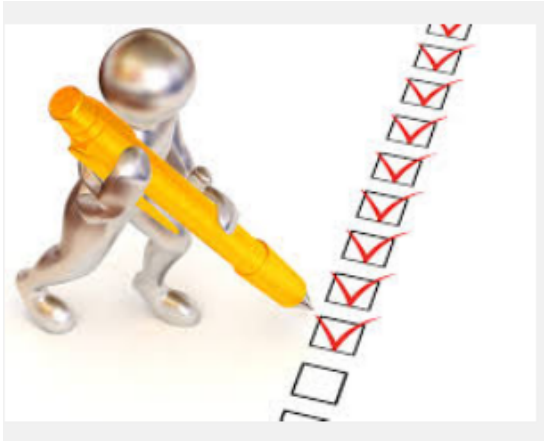
How should we mitigate insider threats?

- Mitigation strategies depend on the type of organization
- A **risk assessment analysis** should be performed to define the policies, mechanisms and overall investment
- Remember that multiple technical and **non-technical components** need to be aligned to create a comprehensive solution
- It is also important to have recovery strategies!

Conclusions

So what should we do?

- Be prepared! It is necessary to have a plan to manage insider attacks
  - Decide what mitigation mechanisms are appropriate
  - Have a plan to react in case an insider attack occurs
  - Create the plan before any incident occurs!
- Guidelines: "*Common Sense Guide to Mitigating Insider Threats*", 4th Edition CERT



Conclusions

- We overviewed **inside threats** and their impacts
- We also explored **unintentional insider threats** and their impact
- We overviewed some solutions to deter insider threats
- This is a challenging threat!

Conclusions (cont.)

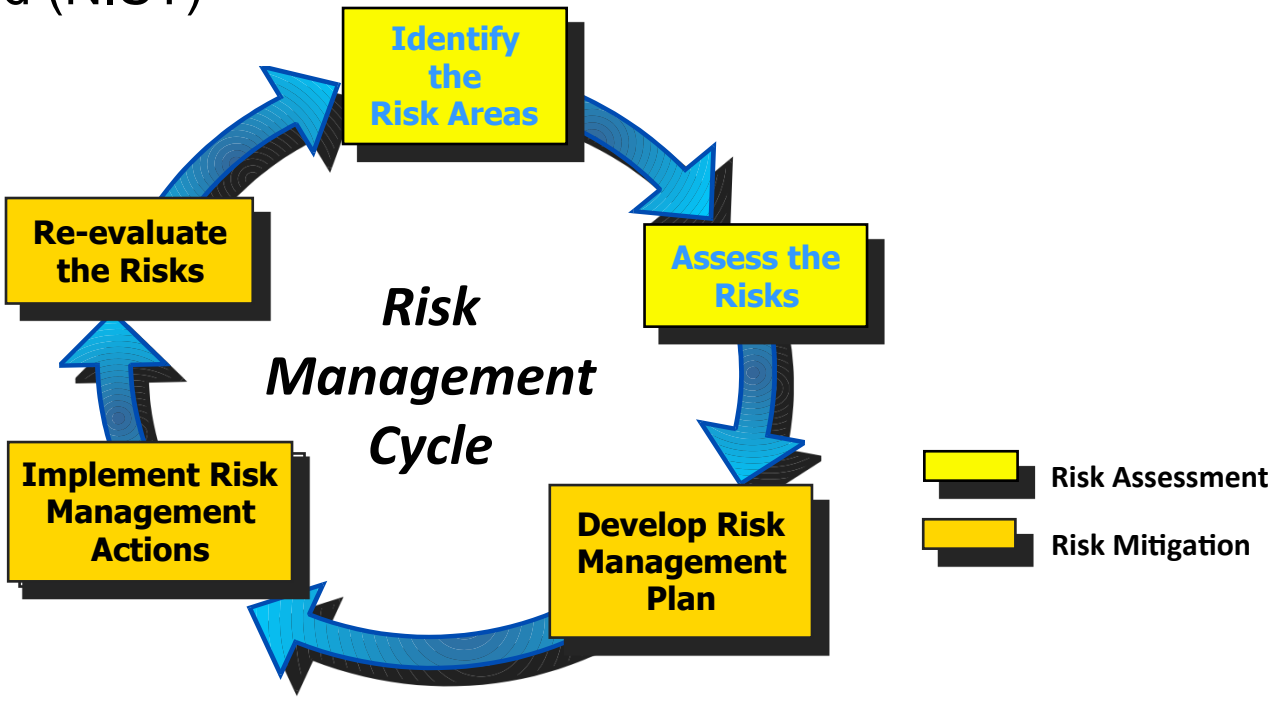
- Want to know more?
  - Insider threats
    - The CERT Guide to Insider Threats
      http://resources.sei.cmu.edu/library/asset-view.cfm?assetID=30310
    - Common Sense Guide to Mitigating Insider Threats, 4th Edition
      http://resources.sei.cmu.edu/library/asset-view.cfm?assetID=34017
    - General publication list:
      http://www.cert.org/insider-threat/publications/index.cfm
  - Unintentional insider threat:
    http://www.sei.cmu.edu/reports/13tn022.pdf
  - Use of decoys to deter insider threats:
    - Baiting inside attackers using **decoy** documents
    - Combining a baiting and a user **search** profiling techniques for masquerade detection
  - Adaptive access control systems to deter insider threats:
    http://www.pitt.edu/~nab62/research.html (check papers related to insider threat)

Risk Analysis

Don’t adopt the ostrich strategy!

Risk Management

- The process concerned with identification, measurement, control and minimization of security risks in information systems to a level commensurate with the value of the assets protected (NIST)



Risk

- The *likelihood* that a particular *threat* using a specific *attack*, will exploit a particular *vulnerability* of a system that results in an undesirable *consequence* (NIST)
  - *Likelihood* of the threat occurring is the estimation of the probability that a threat will succeed in achieving an undesirable event

Risk Assessment/Analysis

- A process of analyzing *threats* to and *vulnerabilities* of an information system and the *potential impact* the loss of information or capabilities of a system would have
  - List the threats and vulnerabilities
  - List possible control and their cost
  - Do cost-benefit analysis
    - Is cost of control more than the expected cost of loss?
- The resulting analysis is used as a basis for identifying appropriate and cost-effective counter-measures
  - Leads to proper security plan

Risk Assessment steps

- Identify assets
  - Hardware, software, data, people, supplies
- Determine vulnerabilities
  - Intentional errors, malicious attacks, natural disasters
- Estimate likelihood of exploitation
  - Considerations include
    - Presence of threats
    - Tenacity/strength of threats
    - Effectiveness of safeguards
  - Delphi approach
    - Raters provide estimates that are distributed and re-estimated

I personally like Octave and Octave Lite methodologies.

Risk Assessment steps (2)

- Compute expected annual loss
  - Physical assets can be estimated
  - Data protection for legal reasons
- Survey applicable (new) controls
  - If the risks of unauthorized access is too high, access control hardware, software and procedures need to be re-evaluated
- Project annual savings of control

Example 1

- Risks:
  - disclosure of company confidential information,
  - computation based on incorrect data
- Cost to correct data: $1,000,000
  - @10% liklihood per year: $100,000
  - Effectiveness of access control sw:60%: -$60,000
  - Cost of access control software: +$25,000
  - Expected annual costs due to loss and controls:
    $100,000 - $60,000 + $25,000 = $65,000
  - Savings:
    $100,000 - $65,000 = $35,000

What decision should we take?

Implement controls or accept the risk?

Example 2

- Risk:
  - Access to unauthorized data and programs
    - 100,000 @ 2% likelihood per year: $2,000
  - Unauthorized use of computing facility
    - 100,000 @ 4% likelihood per year: $4,000
  - So, expected annual loss: $6,000
- Effectiveness of network control: 100%

-$6,000

Example 2 (2)

- Control cost
  - Hardware +$10,000
  - Software +$4,000
  - Support personnel +$40,000
  - Annual cost: +$54,000
  - Expected annual cost
    - (6000-6000+54000) +$54,000
  - Savings
    - (6000 – 54,000) -$48,000

What decision should we take?
Implement controls or accept the risk?

Conclusion