RSAConference2015

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CHANGE

Challenge today's security thinking

SESSION ID: BR-W04

You are what you click: Using Decoys to Identify Mobile Device Attackers

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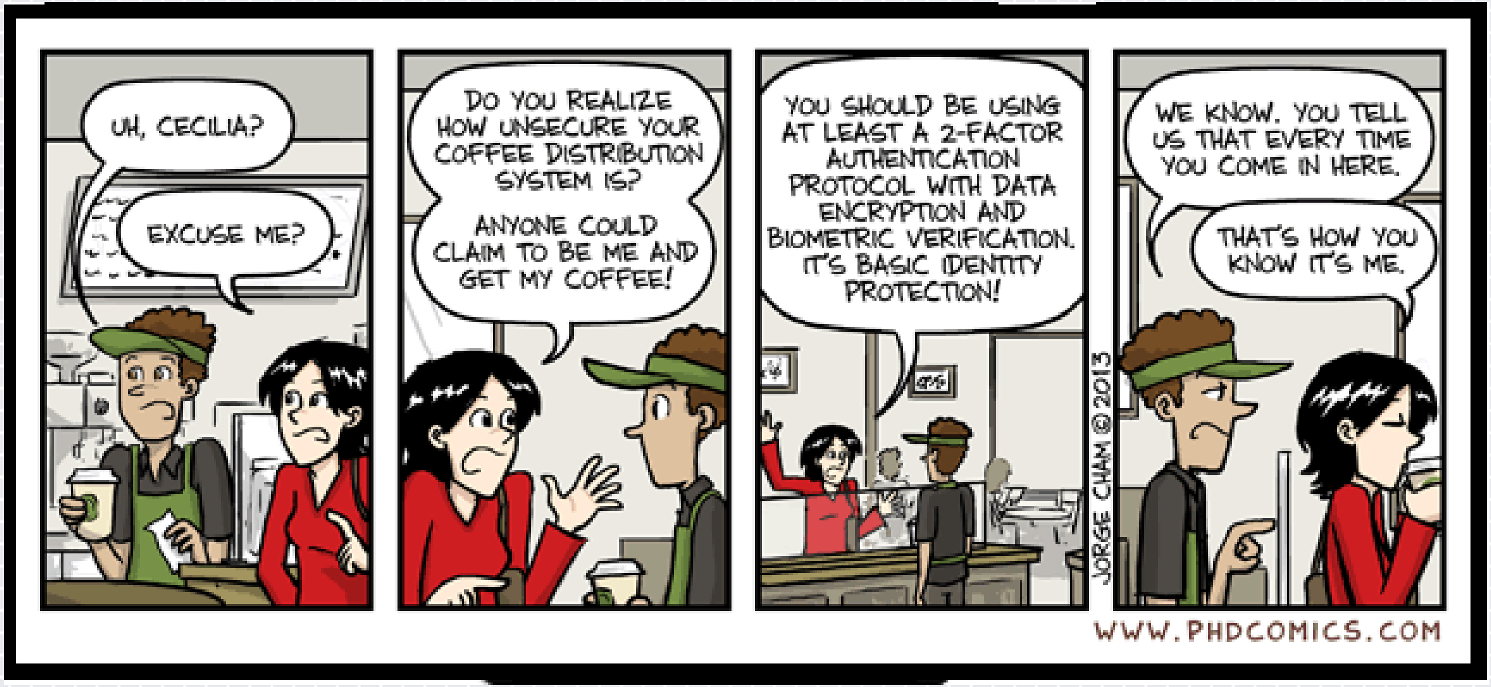
New York, NY

#RSAC

The old ways don't work….


UH, CECILIA?
EXCUSE ME?
DO YOU REALIZE HOW UNSECURE YOUR COFFEE DISTRIBUTION SYSTEM IS?
ANYONE COULD CLAIM TO BE ME AND GET MY COFFEE!
YOU SHOULD BE USING AT LEAST A 2-FACTOR AUTHENTICATION PROTOCOL WITH DATA ENCRYPTION AND BIOMETRIC VERIFICATION. IT'S BASIC IDENTITY PROTECTION!
JORGE CHAM © 2013
WE KNOW. YOU TELL US THAT EVERY TIME YOU COME IN HERE.
THAT'S HOW YOU KNOW IT'S ME.
WWW.PHDCOMICS.COM

It's not what you know (twice), it's what you do….

Age of Collaboration

“Anywhereization”

Rise in BYOD

- **2 billion** smartphone users projected for 2015
- **61%** of employees use smartphones for work

Enterprise is borderless…and vulnerable

- Devices carry sensitive corporate data:
  - 59% of employees using BYOD haven’t told their employers
- Lost or stolen:
  - 113 smart phones lost every minute
  - 1 laptop is stolen every 53 seconds
- Mobile security fails:
  - 34% of consumers fail to activate security mechanisms on their mobile devices

Security should be designed for the people who use it

- Easy to understand controls
- Transparent to the user
- Seamless and continuous authentication

Are you you?

- With patented machine-learning technology, RUU learns how you use your device and creates a personalized behavioral profile that continuously and seamlessly authenticates.

- If unusual behavior is detected, it's prompted to ask, "*Are you you?*"

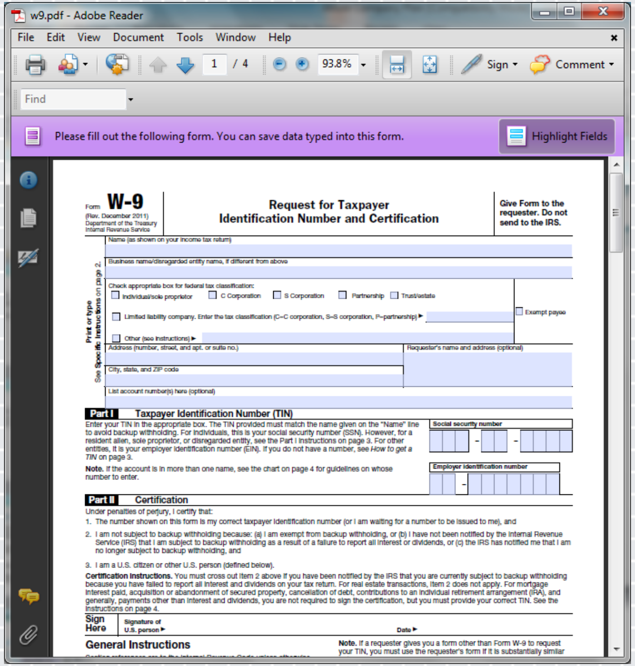
What are decoys?

Beacons

- Enticing, believable but bogus data, documents, files, and other types of fake bur realistic media
- Touch a decoy and send a beacon alert signal

Here’s how it works

What’s the difference?



Please fill out the following form. You can save data typed into this form.

Form **W-9**
(Rev. December 2011)
Department of the Treasury
Internal Revenue Service

Request for Taxpayer Identification Number and Certification

Give Form to the requester. Do not send to the IRS.

Print or type
See Specific Instructions on page 2.

Name (as shown on your income tax return)

Business name/disregarded entity name, if different from above

Check appropriate box for federal tax classification:
□ Individual/sole proprietor □ C Corporation □ S Corporation □ Partnership □ Trust/estate

□ Limited liability company. Enter the tax classification (C=C corporation, S=S corporation, P=partnership) ▶

□ Other (see instructions) ▶

□ Exempt payee

Address (number, street, and apt. or suite no.)

Requester’s name and address (optional)

City, state, and ZIP code

List account number(s) here (optional)

Part I **Taxpayer Identification Number (TIN)**

Enter your TIN in the appropriate box. The TIN provided must match the name given on the “Name” line to avoid backup withholding. For individuals, this is your social security number (SSN). However, for a resident alien, sole proprietor, or disregarded entity, see the Part I instructions on page 3. For other entities, it is your employer identification number (EIN). If you do not have a number, see *How to get a TIN* on page 3.

Social security number
□□□ - □□ - □□□□

Note. If the account is in more than one name, see the chart on page 4 for guidelines on whose number to enter.

Employer identification number
□□ - □□□□□□□

Part II **Certification**

Under penalties of perjury, I certify that:

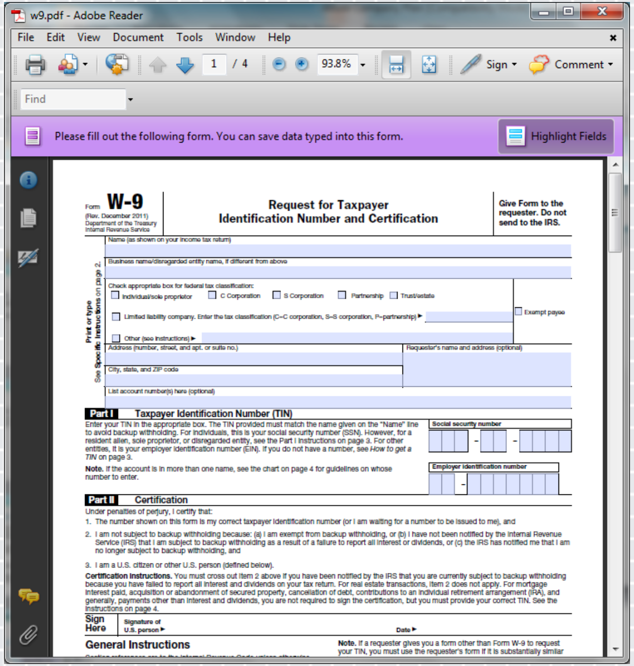
1. The number shown on this form is my correct taxpayer identification number (or I am waiting for a number to be issued to me), and
2. I am not subject to backup withholding because: (a) I am exempt from backup withholding, or (b) I have not been notified by the Internal Revenue Service (IRS) that I am subject to backup withholding as a result of a failure to report all interest or dividends, or (c) the IRS has notified me that I am no longer subject to backup withholding, and
3. I am a U.S. citizen or other U.S. person (defined below).

Certification instructions. You must cross out item 2 above if you have been notified by the IRS that you are currently subject to backup withholding because you have failed to report all interest and dividends on your tax return. For real estate transactions, item 2 does not apply. For mortgage interest paid, acquisition or abandonment of secured property, cancellation of debt, contributions to an individual retirement arrangement (IRA), and generally, payments other than interest and dividends, you are not required to sign the certification, but you must provide your correct TIN. See the instructions on page 4.

Sign Here Signature of U.S. person ▶ Date ▶

General Instructions

Note. If a requester gives you a form other than Form W-9 to request your TIN, you must use the requester’s form if it is substantially similar



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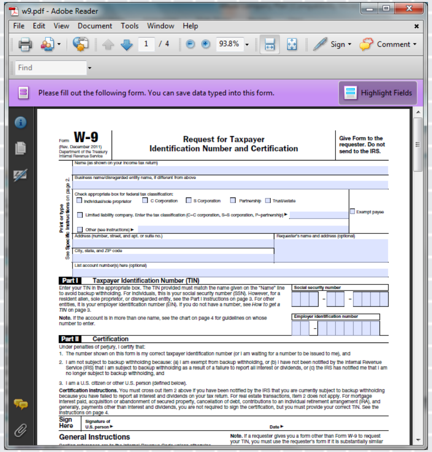
Document is *beaconized*

Beaconized Document → Data Loss → Data Loss Alert



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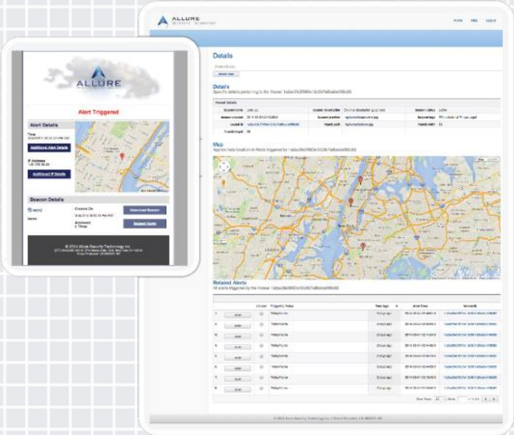
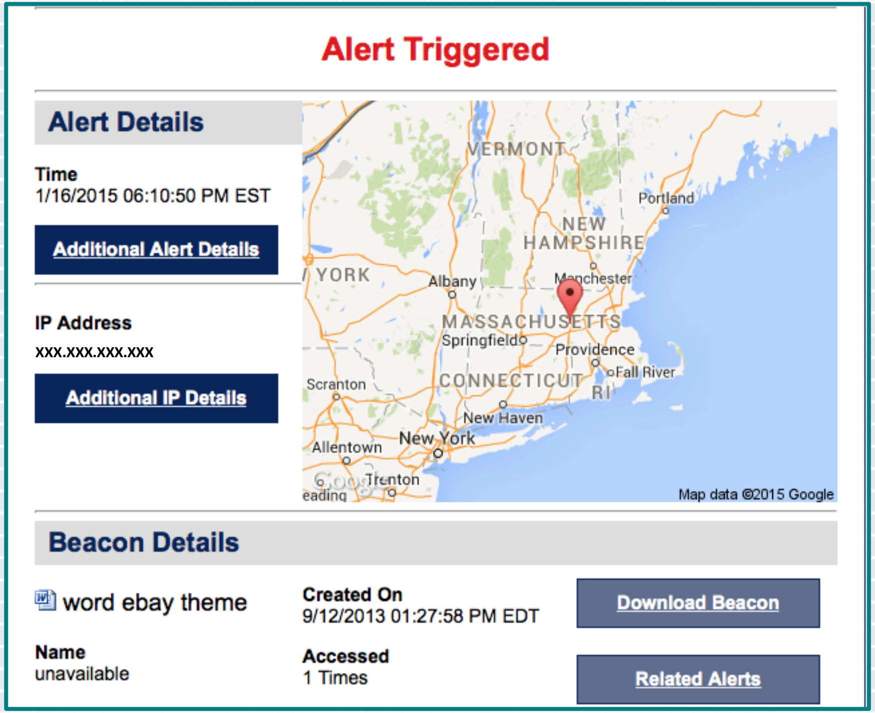


Touch a decoy file, a data loss alert is emailed



Alert Triggered

Alert Details

Time
1/16/2015 06:10:50 PM EST

Additional Alert Details

IP Address

xxx.xxx.xxx.xxx

Additional IP Details

Beacon Details

word ebay theme

Created On
9/12/2013 01:27:58 PM EDT

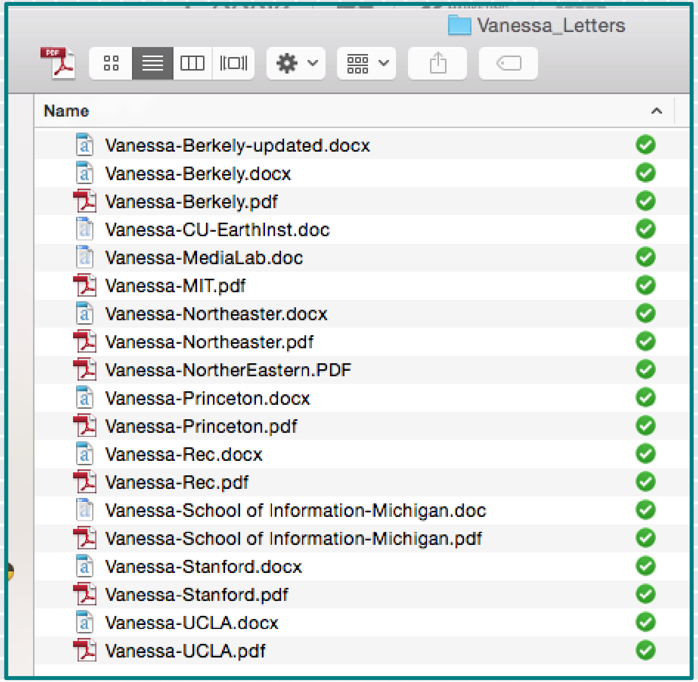
Download Beacon

Name
unavailable

Accessed
1 Times

Related Alerts

Enticing decoy files in the cloud, too!



Vanessa-Berkely-updated.docx ✓
Vanessa-Berkely.docx ✓
Vanessa-Berkely.pdf ✓
Vanessa-CU-EarthInst.doc ✓
Vanessa-MediaLab.doc ✓
Vanessa-MIT.pdf ✓
Vanessa-Northeaster.docx ✓
Vanessa-Northeaster.pdf ✓
Vanessa-NortherEastern.PDF ✓
Vanessa-Princeton.docx ✓
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Vanessa-Stanford.pdf ✓
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Vanessa-UCLA.pdf ✓

One is real, the others aren’t – Can YOU tell?

The Hypothesis

- We all search uniquely on our own machines….that is a user biometric captured by a behavior model computed by a machine learning algorithm.
- Decoys are a powerful tool to detect intruders who do not know the real content of a target victim’s file system.

The two together detect masqueraders and provide accurate

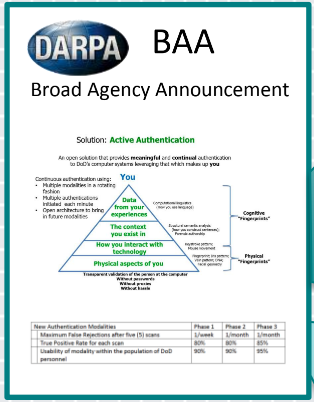
active and continuous authentication.

(Sidebar: Decoys can also be used to detect…)

- Hackers who hijack sessions from other legitimate users
- Embedded APT actors whose malware behaves abnormally
- But, let’s return our attention to Active and Continuous Authentication of users…

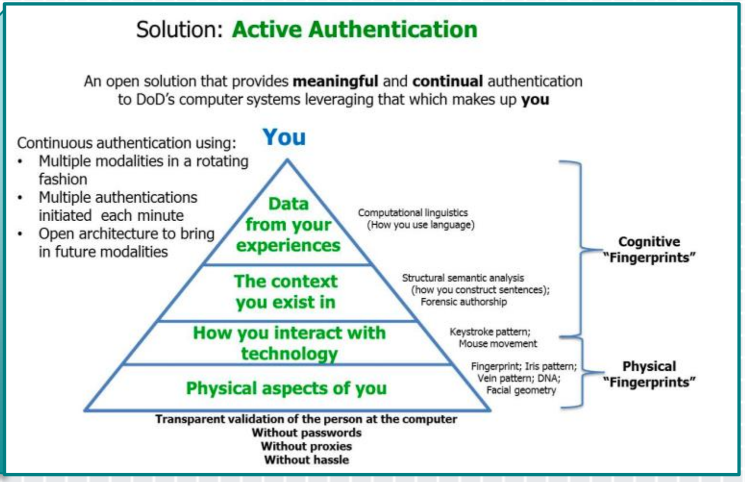
Phase 1
DARPA Active Authentication - Desktop

DARPA Phase 1 Goals



DARPA BAA

Broad Agency Announcement



Solution: **Active Authentication**

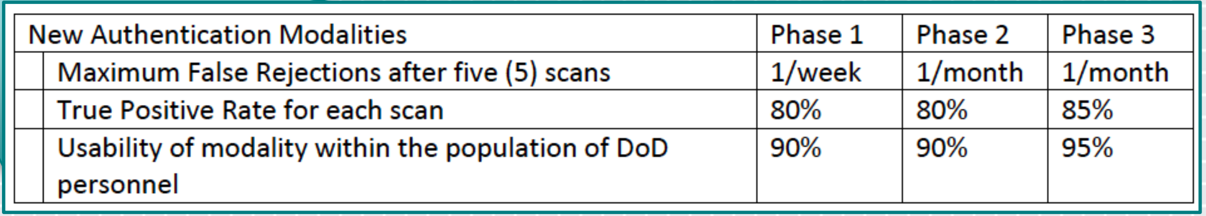
An open solution that provides **meaningful** and **continual** authentication to DoD's computer systems leveraging that which makes up **you**

Continuous authentication using:

- Multiple modalities in a rotating fashion
- Multiple authentications initiated each minute
- Open architecture to bring in future modalities

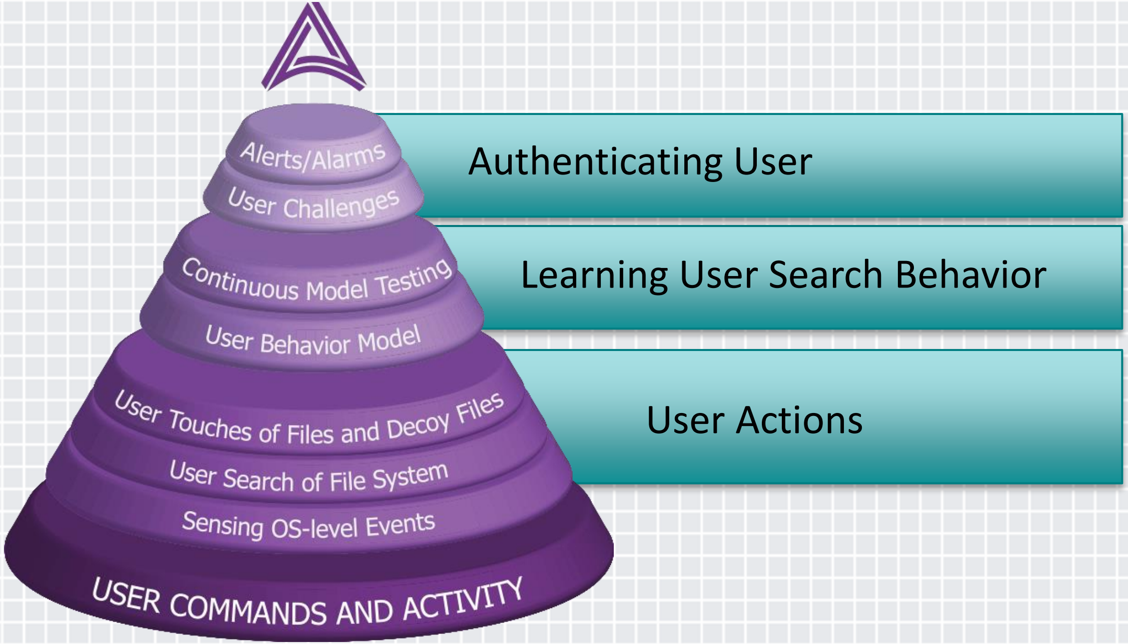
You
Data from your experiences
The context you exist in
How you interact with technology
Physical aspects of you
Computational linguistics (How you use language)
Structural semantic analysis (how you construct sentences); Forensic authorship
Keystroke pattern; Mouse movement
Fingerprint; Iris pattern; Vein pattern; DNA; Facial geometry
Cognitive "Fingerprints"
Physical "Fingerprints"

Transparent validation of the person at the computer
Without passwords
Without proxies
Without hassle



New Authentication Modalities	Phase 1	Phase 2	Phase 3
Maximum False Rejections after five (5) scans	1/week	1/month	1/month
True Positive Rate for each scan	80%	80%	85%
Usability of modality within the population of DoD personnel	90%	90%	95%

RUU Baseline Architecture



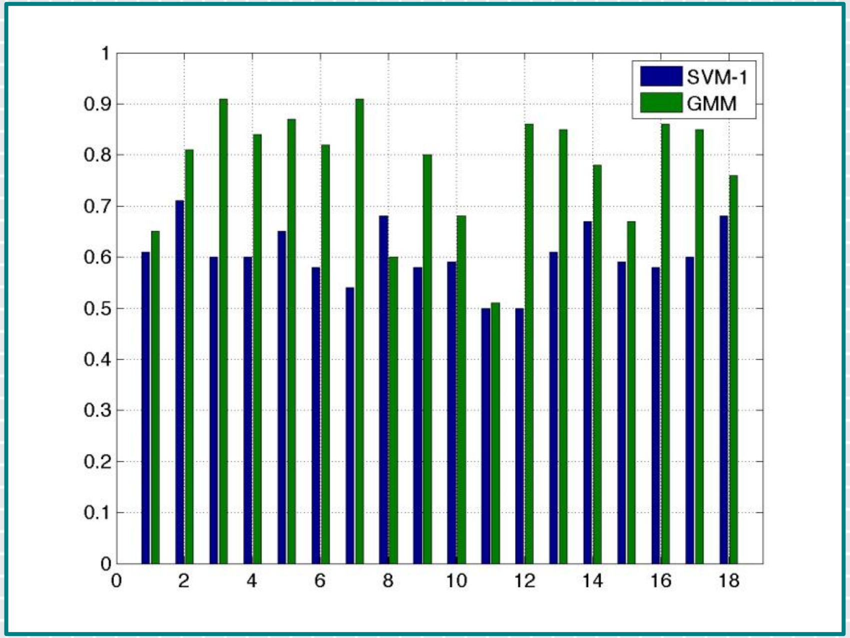
Initial baseline scientific user study of accuracy of modeling user behavior

- Model baseline Volunteer Human Subject behavior; detect deviations from normal use. Generative model: inference, prediction, clustering, sampling, etc.
- Behavior biometrics: set of measurements on interactions between the Volunteer Human Subject and the system.
- Biometrics measurements based on OS events caused by Volunteer Human Subject action:
  - Process creation, deletion, manipulation.
  - File creation, deletion, renaming, etc.
  - Process window touches.
  - Registry key creation, manipulation, deletion.
- Four minute sliding window of measurement used.
- RUU1 dataset: 18 Volunteer Human Subjects at Columbia University, measured over the course of five weeks. Captured in 2011. RUU2 and RUU200 datasets delivered Sept 2013.

Fisher Linear Discriminant Analysis

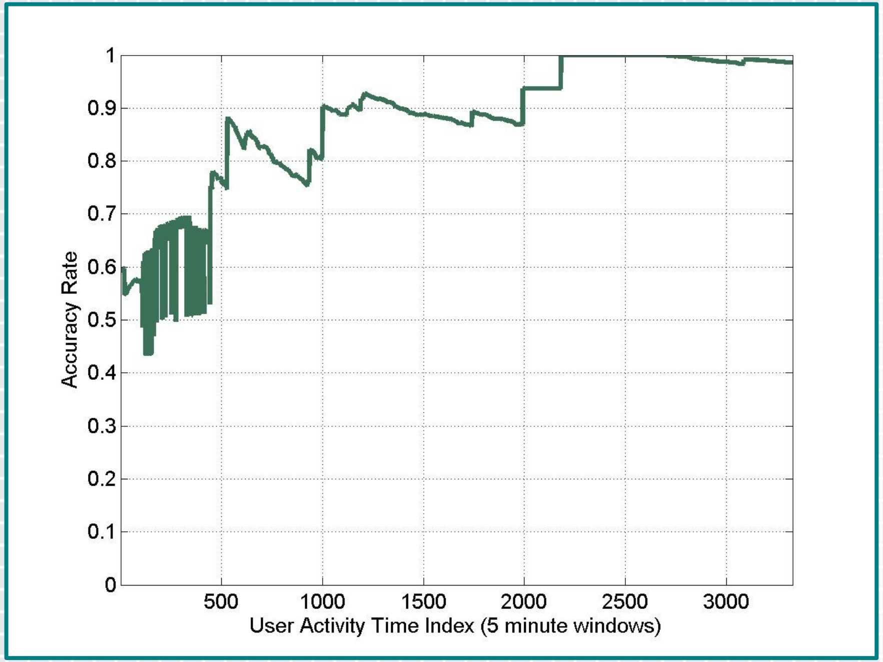
Feature	FLD Score
Number of unique processes	0.0359
Number of delete key actions	0.0018
Number of processes created	0.0015
Number of files touched	0.0013
Number of registry flush key actions	0.0012
Number of user touches	0.0011
Number of registry key queries	0.0011
Number of registry value queries	0.0010
Number of processes destroyed	0.0010
Number of open key actions	0.0010
Number of manual search actions	0.0009

Accuracy Improvements … choose wisely



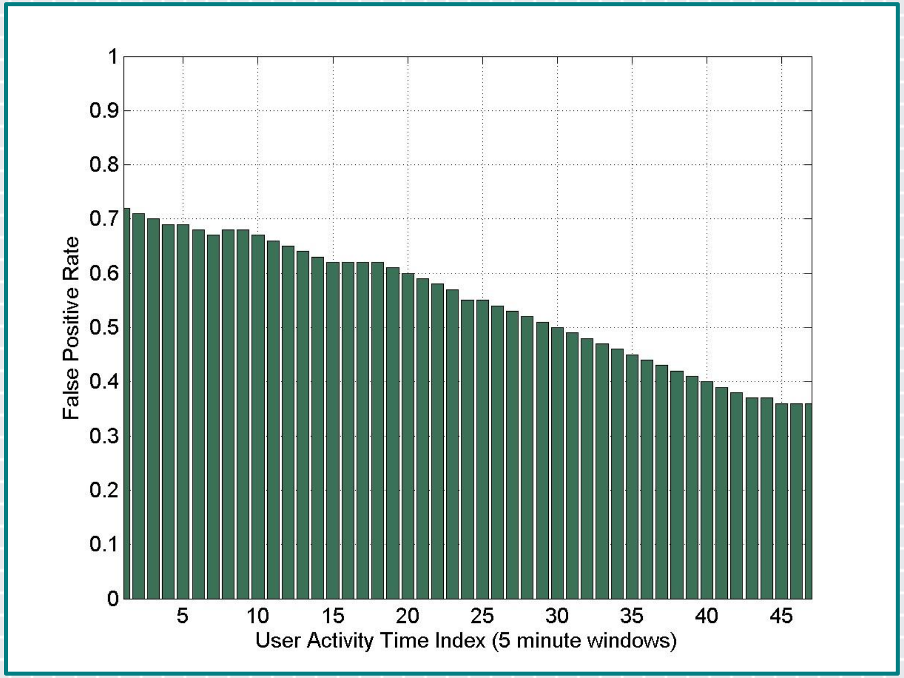
Accuracy over the initial RUU dataset. GMM model with Fisher features, improved accuracy and faster.

True Positive Rate increases with training



Accuracy improves over time. As more data is observed, the accuracy of the user's model improves. And…

False Positive Rate Decays, too…



Maintaining and improving model performance over time is an important goal. Continuous learning methods work well.

Phase 2 – Desktop

- Sensor Improvements
- Automatic Decoy Placement
- Larger formal user study to detect masqueraders

RUU Host Sensors

Phase 1

- Volunteer Human Subject data acquisition uploaded to server for analytics and performance bundled with Decoy Document Distribution
  - Identify most discriminating features
  - Measure decoy touch behavior

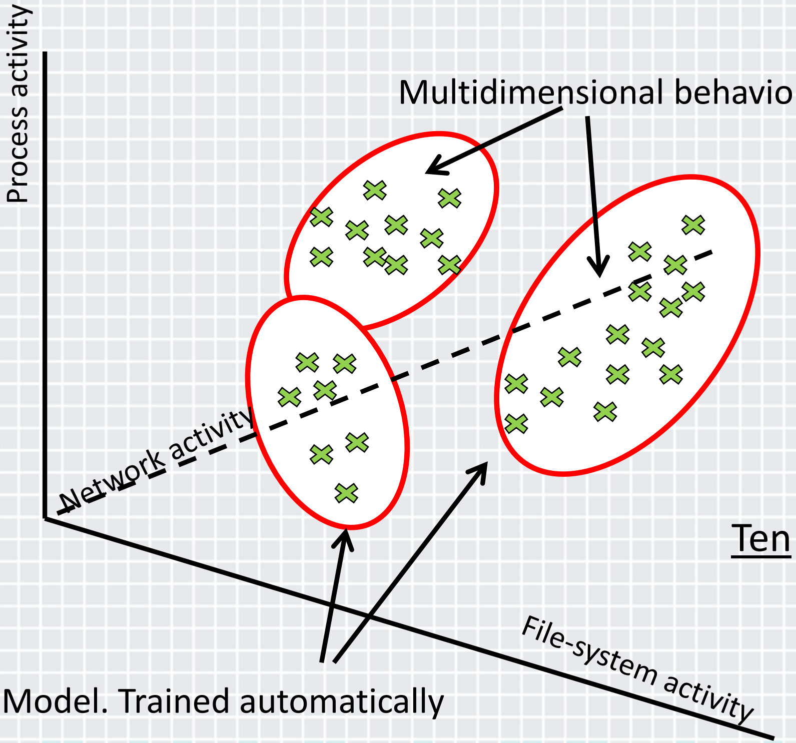
Phase 2

- Volunteer Human Subject data acquisition on local host for automatic analysis and active authentication with mitigation strategy, also bundled with Decoy Document Distribution
  - Continuous learning
  - Automate Decoy Placement
  - Self-measurement of performance
  - Re-authentication strategies

RUU?
ARE YOU YOU

RUU Sensor Identity Engine – 10 Dimensions works well

Learns User Search Behavior and OS-level Behavior Modeling



Multidimensional behavior measurements

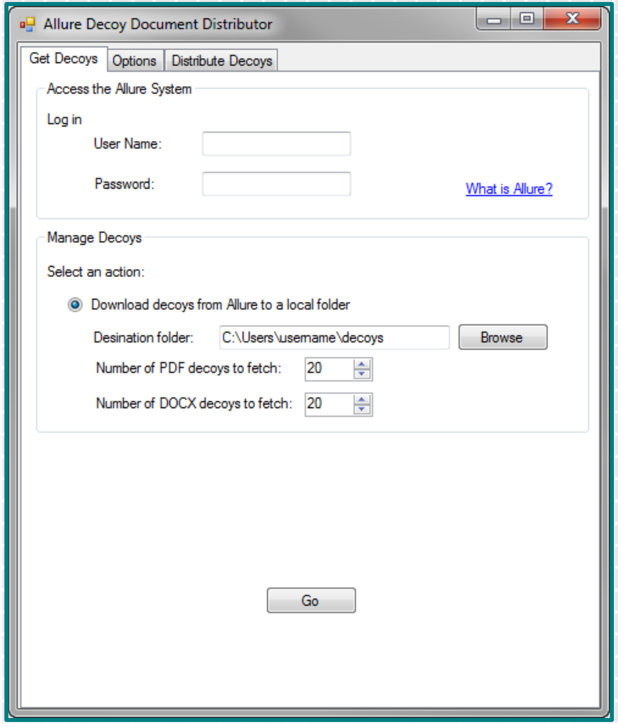
Ten dimensions in real model

Gaussian Mixture Model. Trained automatically

RUU Decoy Distribution

- How to deploy decoys in scale throughout an organization?
- Manual placement
  - Tedious
  - Requires survey of Volunteer Human Subject habits
- Alternative approach
  - Distribute via an automated application
  - Decoy Document Distributor (DDT)

Decoy Document Distributor (DDT)



Allure Decoy Document Distributor

Access the Allure System

Log in

User Name:

Password:

Manage Decoys

Select an action:

● Download decoys from Allure to a local folder

Desination folder: C:\Users\username\decoys

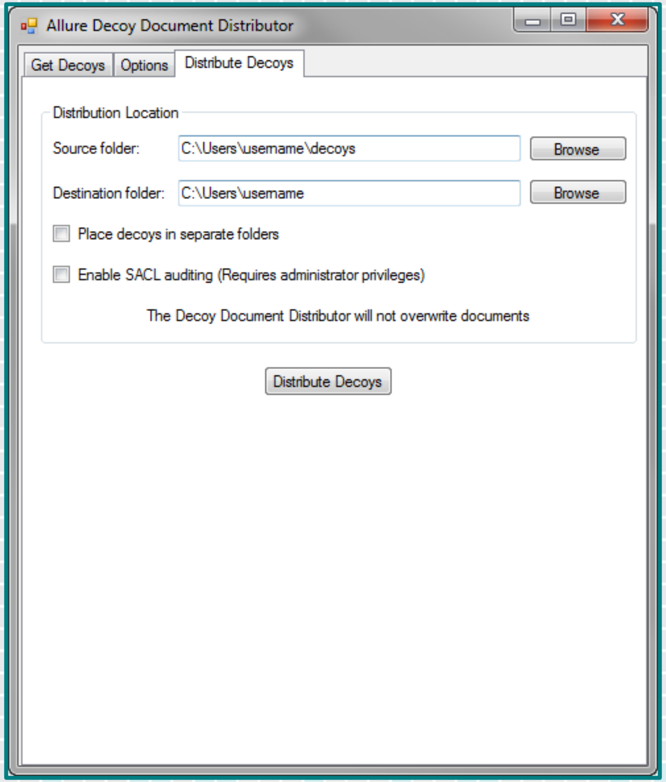
Number of PDF decoys to fetch: 20

Number of DOCX decoys to fetch: 20

- Fetches decoys from server

DDT Analyzes User's file system

- Automatic deployment of decoys to strategic file locations



Distribution Location

Source folder: C:\Users\username\decoys

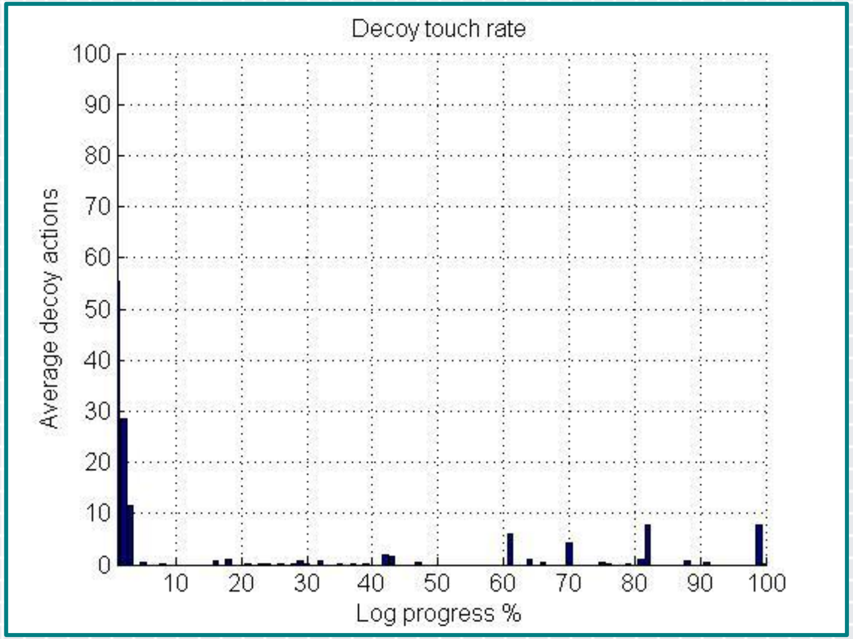
Destination folder: C:\Users\username

□ Place decoys in separate folders

□ Enable SACL auditing (Requires administrator privileges)

The Decoy Document Distributor will not overwrite documents

RUU Average Decoy Touch Rate of real user

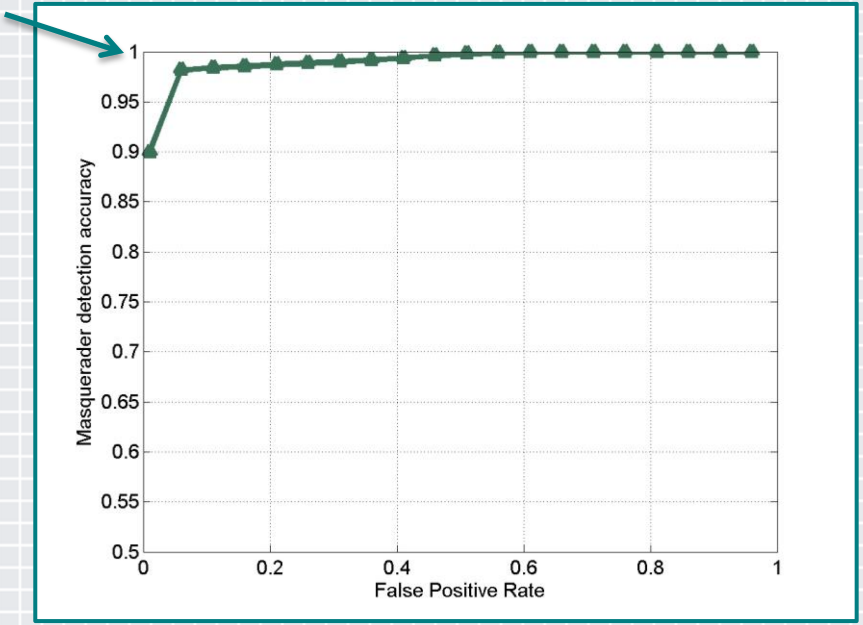


- Most decoy touches are caused by initial deployment.
- Curiosity decays rapidly!

Masquerader Detection Accuracy with user models and decoys: Average ROC

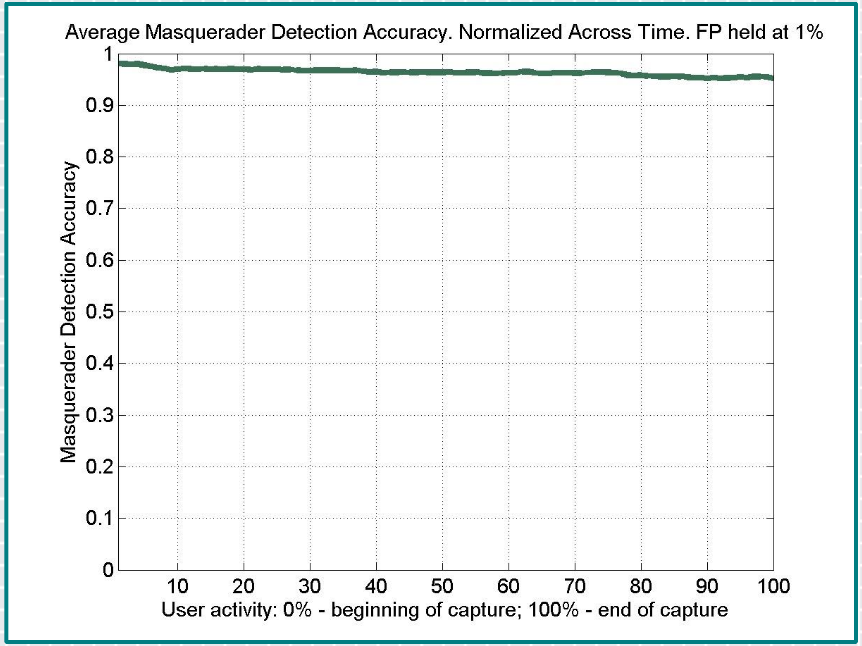
RUU models vs. *masquerader* data. Influential factors: masqueraders used “smash and grab.” (They didn’t play games.)

Optimal

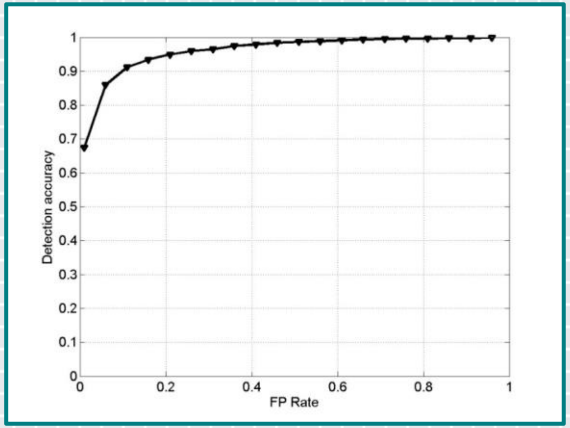


Accuracy of detecting masqueraders over time is consistently high

Human subject activities are scaled as a percentage of capture progress (0%-100%). Average performance across all users.



Accuracy translated to detection latency – users emit observables at different rates



Experiment

- Overall Average Attacker Detection Across All Users
- 160 Users
- 1 week average capture period

Time until detection (TTD) given evaluation frequency for a 40-hour work week.

Frequency	Total Samples	FP Req.	Acc.	Evals	TTD
1m	2400	0.042%	49.55%	5	5m
2m	1200	0.083%	50.29%	5	10m
3m	800	0.125%	51.46%	5	15m
4m	600	0.167%	53.11%	4	16m
5m	480	0.208%	54.00%	4	20m

- Evaluation interval: 3 minutes
- Active authentication corresponds to Bernoulli trial: Probability that masquerader evades detection in 5 consecutive evaluations is less than 5%.
- Detection within 15 minutes with 95% confidence

Experiment Results

- 95% detection accuracy at 1% false positive rate
- Constraint: 1 FP per 40 hour work week
  - Fifteen minutes until detection with 95% confidence

Discussion – user model alone works, too

Masquerader ID and number of decoy touches by masquerader

- Masqueraders had higher than normal volumes of activity; exhibited “smash and grab“ behavior
- 10 decoys were distributed randomly on the test environment
- Nearly every masquerader touched several decoys, didn’t matter where they were placed
- Some touched no decoys, but were still detected

		✓																✓		
ID	1	2	3	4	5	6	7	9	10	12	13	14	15	16	18	19	20	21	22	23
#	7	0	4	3	5	8	10	5	7	3	2	3	5	4	6	5	14	0	3	10

Masquerader detection even without decoy touches!

What about mitigation?

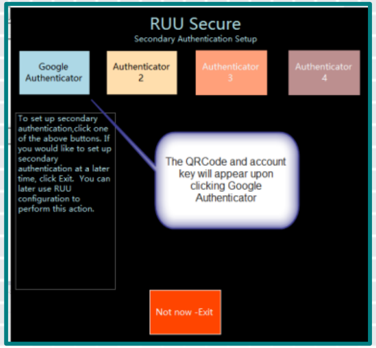
What do you do when you detect a masquerader?

- De-authenticate and challenge the user to re-authenticate
  - This also provides an opportunity to update and improve the user model, ground truth is revealed
- Several possible re-authentication strategies, here's one…

RUU Secondary Authentication: When Desktop Locks

Secondary Authentication

- Time-based One-time Password Algorithm for secondary authentication (RFC 6238)



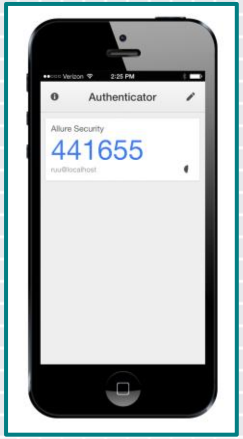
RUU Secure

Secondary Authentication Setup

To set up secondary authentication,click one of the above buttons. If you would like to set up secondary authentication at a later time, click Exit. You can later use RUU configuration to perform this action.

The QRCode and account key will appear upon clicking Google Authenticator

When installing RUU the user is prompted to enable secondary authentication

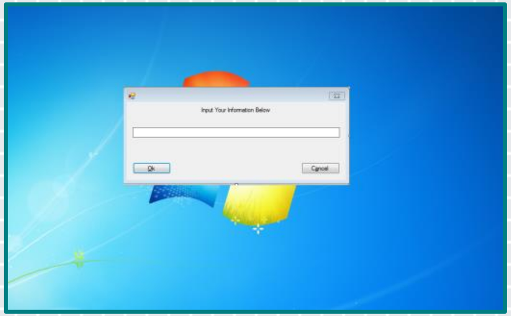


Allure Security

441655

ruu@localhost

Google Authentication running on an iPhone as the authentication agent

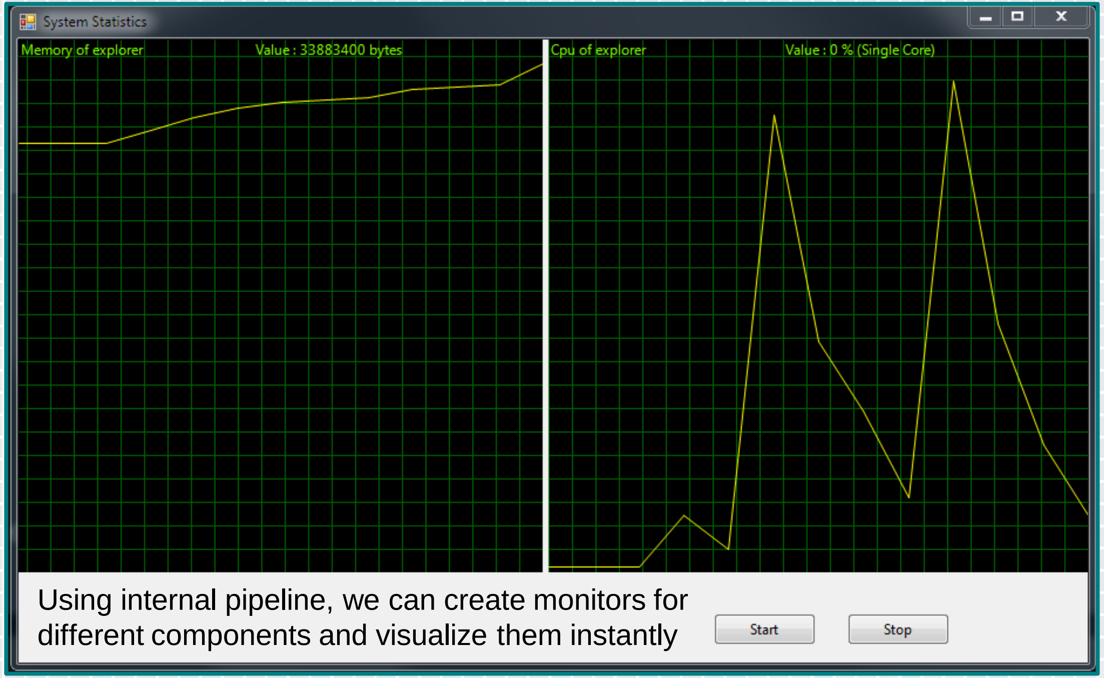


Input Your Information Below

When RUU locks and the user re-authenticates the secondary authentication is requested

Monitoring and displaying RUU Sensor Performance: System Monitoring in scale for BYOB Management

Monitoring Allure System Performance



Using internal pipeline, we can create monitors for different components and visualize them instantly

mRUU – Mobile Phones

Decoy Apps

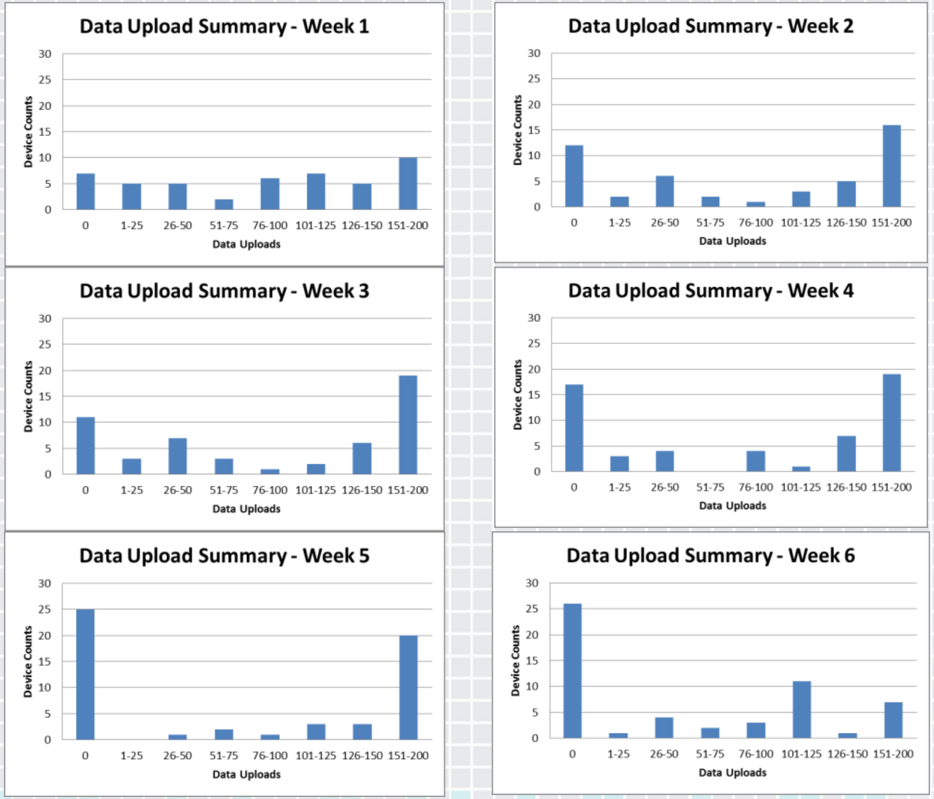
Decoy Clouds

mRUU Study

IRB-Approved User Studies

- January 2014: Pilot study
  - Preliminary Activity Collector
  - Users gathered from Accenture and Columbia University
  - Used to inform modeling approach
- July-August 2014: Full scale user study with 53 Accenture users
  - Fully developed activity collector
    - More efficient
    - Collection of auxiliary activity data
  - Used for final Identity Engine design and accuracy analysis

mRUU Study Results

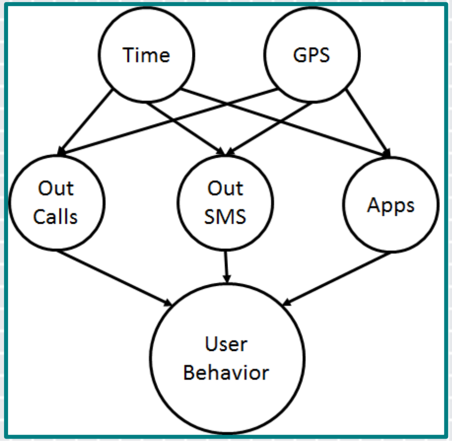


Participant Upload Distributions

mRUU Update

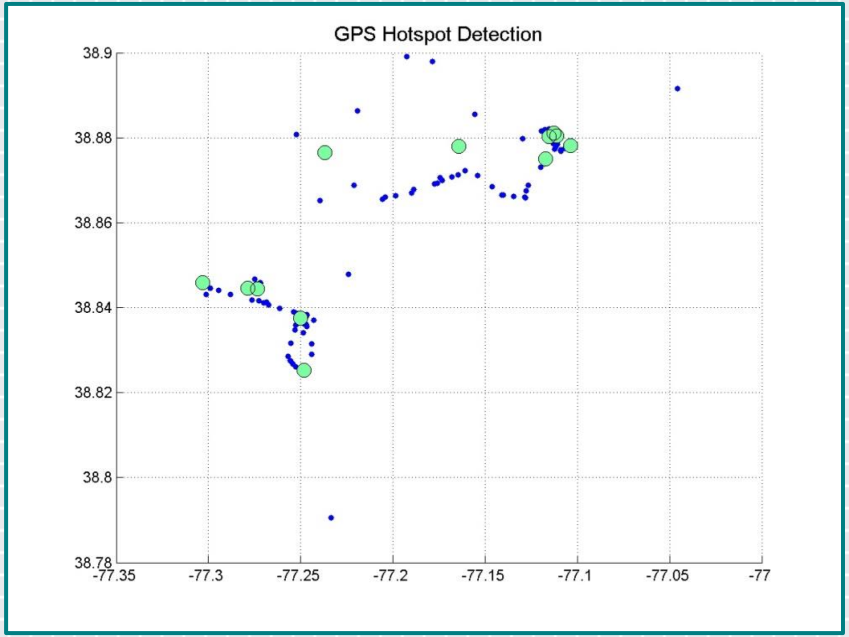
Sensor Updates

- Implemented Identity Engine using adapted modeling technique which incorporates:
  - Activity hotspots
  - Temporal information
  - Location information



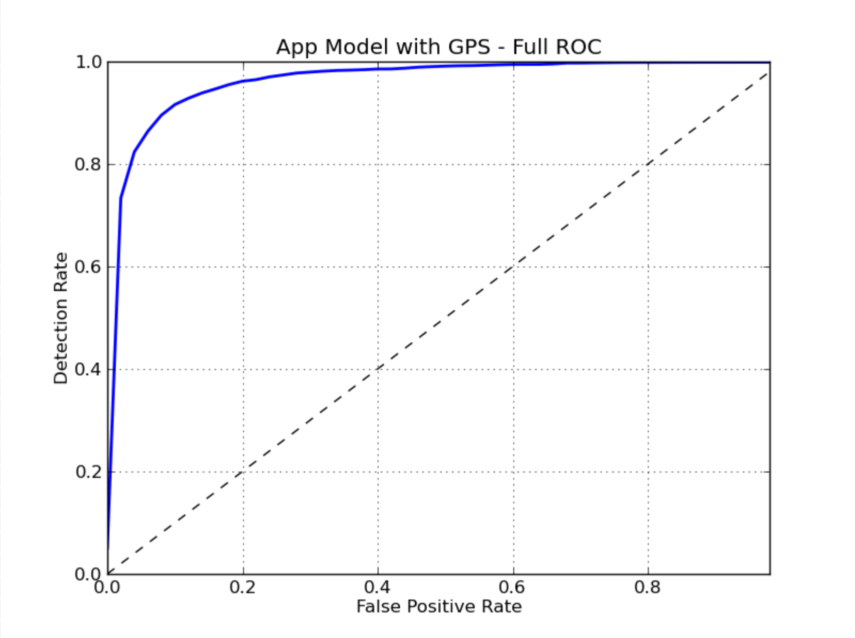
mRUU Location Based Modeling of User App Behavior

Location Based Sub-Modeling



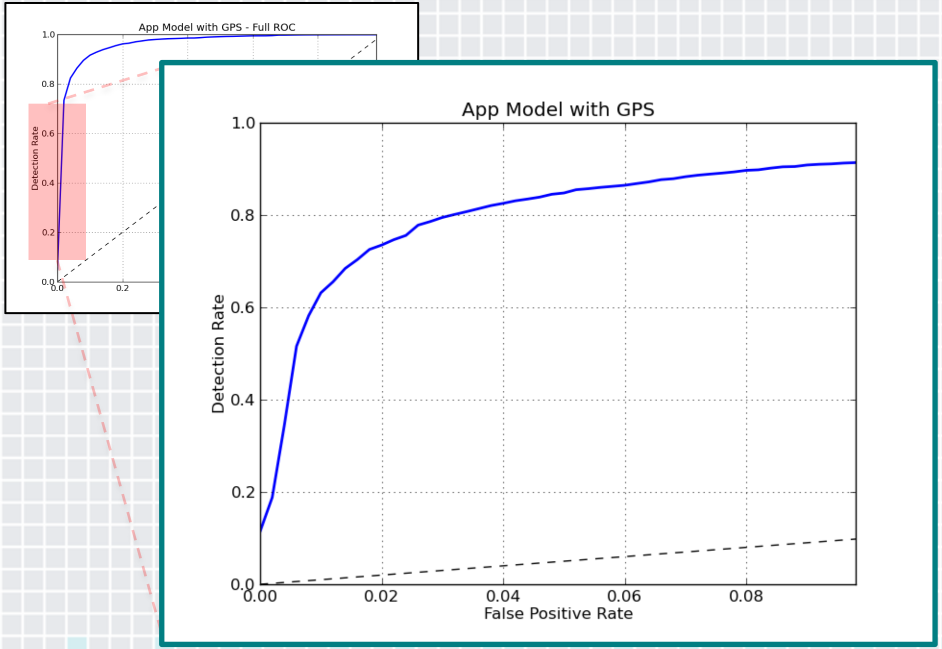
Accurate Modeling of user app behavior

Modeling where you use Apps is very accurate



mRUU Study Results- classification accuracy with no FP

Application Usage Model Accuracy



- Behavior eval every 2 min
- 4 hours total = 120 Evals/day
- Goal: 1 FP/day = 0.00833

False-Positives per day	Percent of Foreign behavior identified
1	62%
2	70%
3	78%
4	80%

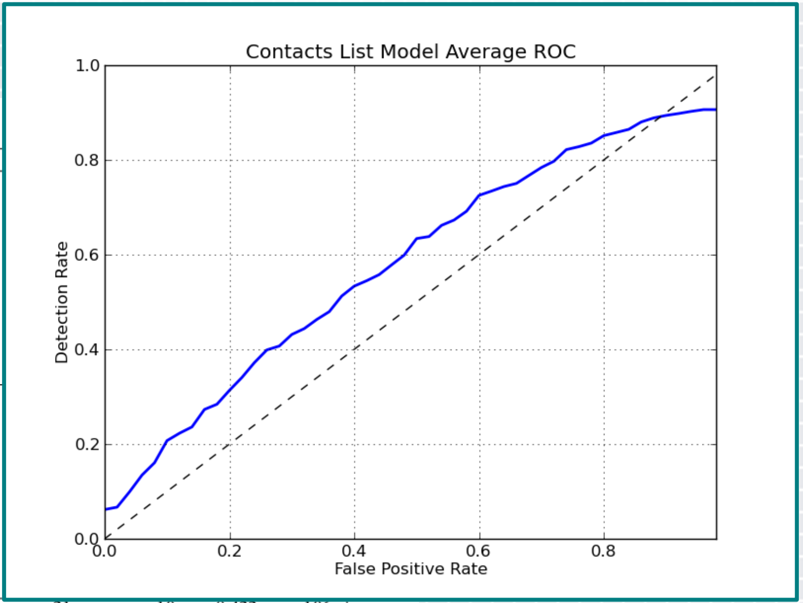
mRUU Study Results

Contact List Accuracy

When contacts list accessed

Ineffective – too few samples

User	Days	Hours	Apps	Contact List	GPS	Phone				
1	6 days	11:20:00	2,718,911	3,728	2,051	12				
2	22 days	20:12:00	3,490,217	143	7,940	107				
3	24 days	0:41:00	15,425,996	2,861	13,938	151				
4	3 days	3:19:00	3,767,563	83	1,870	10				
5	27 days	17:44:00	9,415,586	412	16,235	249				
6	20 days	5:49:00	3,142,314	10	3,506	0				
7	27 days	12:00:00	5,628,189	2,353	7,082	368				
8	10 days	11:06:00	9,311,562	119	6,255	53				
9	90 days	0:07:00	9,793,582	16,261	8,840	197				
10	46 days	21:27:00	14,548,709	717	8,965	176				
11	14 days	21:13:00	4,659,372	72	2,871	7				
12	27 days	13:28:00	35,406,045	131	16,170	27				
13	26 days	22:09:00	27,127,850	1,081	15,252	369				
14	16 days	21:31:00	7,335,354	863	7,829	109				
15	24 days	19:32:00	5,216,493	77	12,157	0				
16	24 days	1:54:00	17,703,599	4,189	13,290	265				
17	3 days	10:38:00	2,739,994	103	2,029	26				
18	19 days	21:54:00	12,941,415	318	8,095	34				
19	8 days	21:22:00	8,623,558	131	5,239	49				
20	24 days	6:08:00	9,884,105	518	14,189	376				
21	27 days	13:41:00	14,385,298	99	15,899	7	21	10	8,422	106
22	26 days	6:33:00	23,098,123	835	14,694	480	243	76	7,872	319



mRUU User Study

Conclusions

- Users’ mobile application usage habits can successfully be used to derive behavioral biometric identifiers
- The discriminative power of application usage patterns can be augmented using temporal and geographic information
- Additional usage data (eg contacts, etc.) provides poor discriminative measurements

Introducing Decoy Apps and Decoy Clouds

- The mobile RUU app automatically creates decoy apps from unused apps or downloads strategic decoy apps
- Masqueraders are herded to pre-positioned decoy file system and decoy cloud services when they fail to re-authenticate

Under the Hood

- Bad Behavior or Touching of decoy apps

  de-authenticates the user

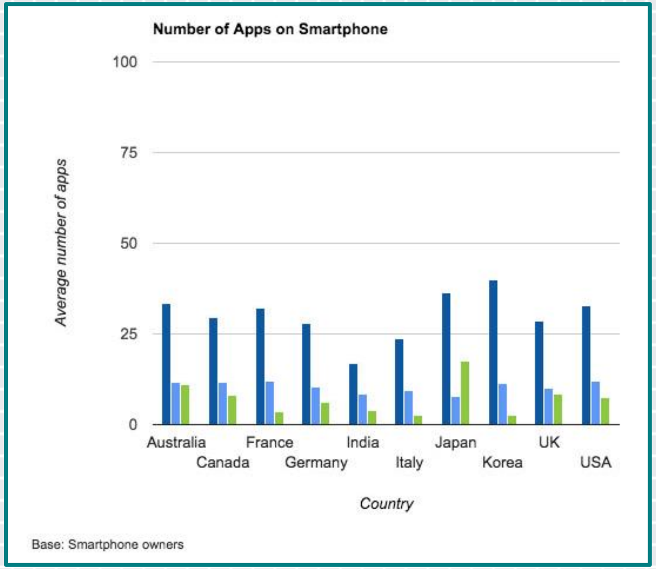
  - Locks the device
  - Captures a picture of the current user and records background ambient sound
  - Sends an alert out of band to the user
  - Re-authenticates by a second factor
    - Failure: Load Decoy Clouds and Decoy file system
    - Capture data on attacker

Decoy Apps are intuitive

- Authentic looking apps that hold fake but enticing information to the adversary
- An attacker does not know what is a Decoy App and what is a Real App
- They are simple to use
- They are simple to understand
- They do not increase resource use

Bloatware is turned into a Security Feature

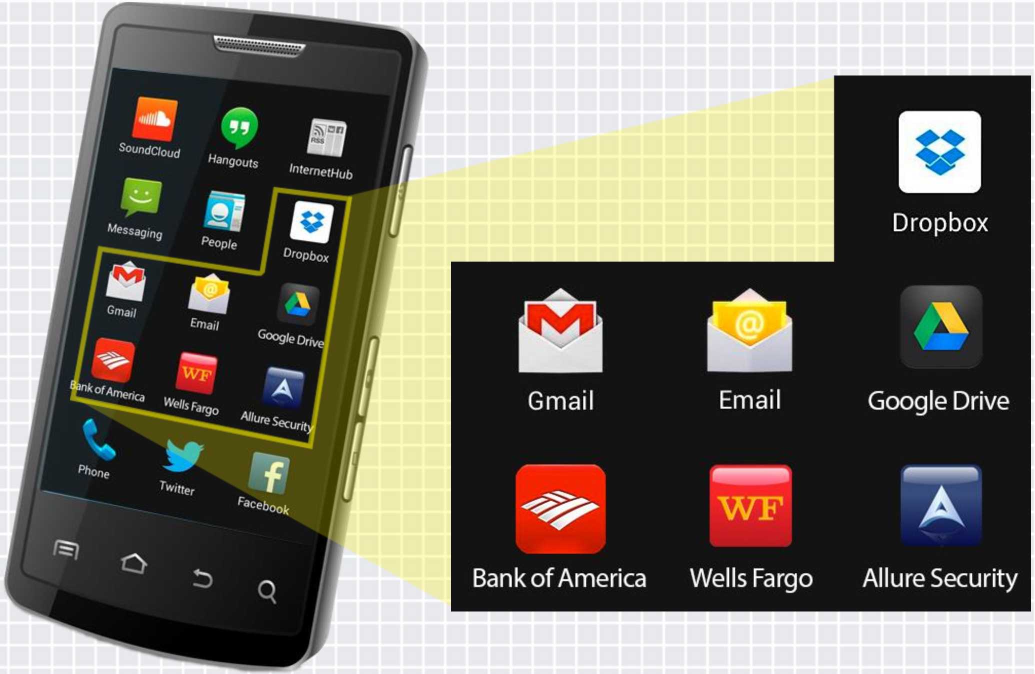
Numerous Unused Apps available as decoys



Base: Smartphone owners

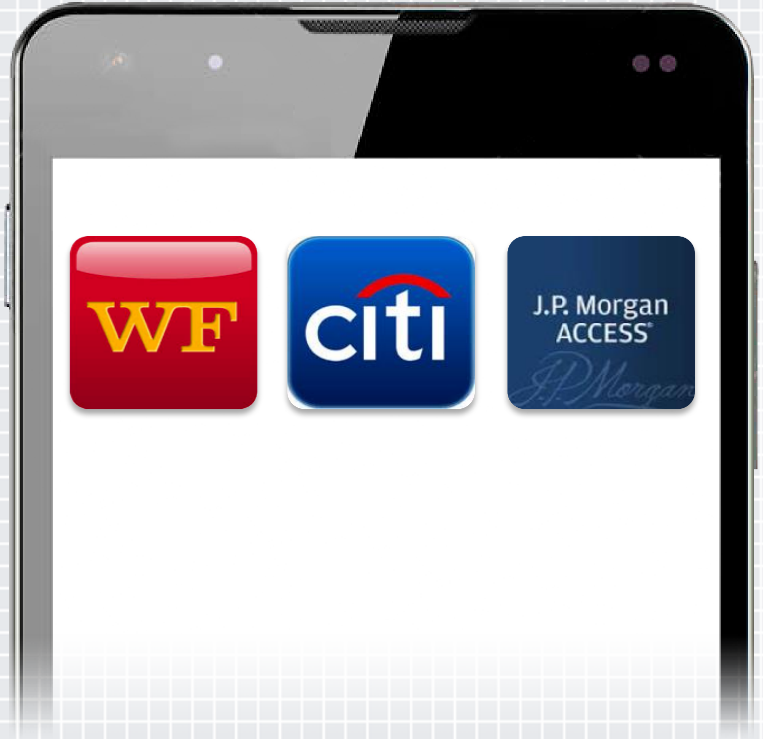
- ■ Number of Apps on Smartphone
- 🟦 Number of actively used Apps (last 30 days)
- 🟩 Number of paid Apps

Onboard unused apps become decoys or strategic decoy apps are installed



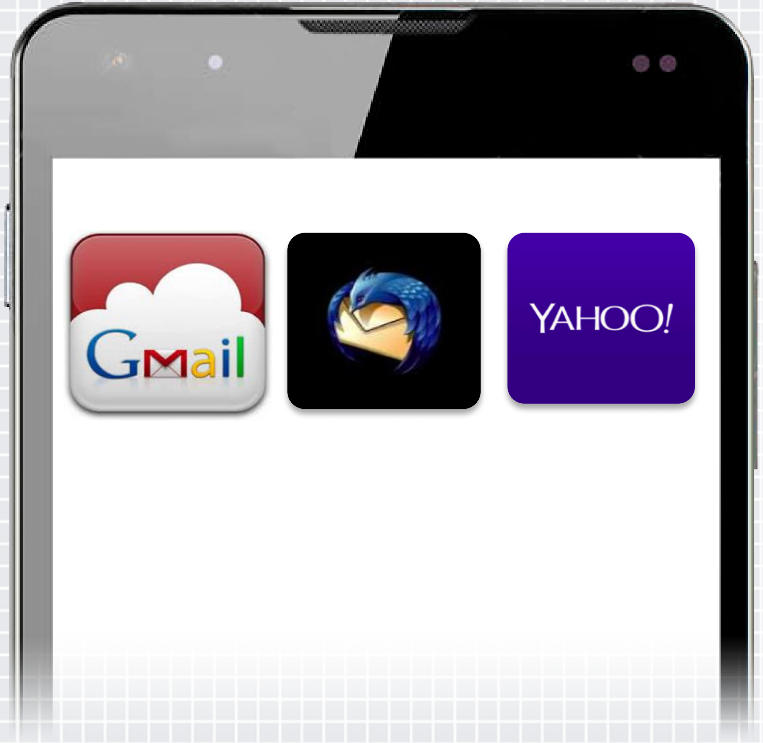
Who do you really bank with?

One is real, the others aren’t – Can YOU tell?



Which is your real email client?

One is real, the others aren't – Can YOU tell?



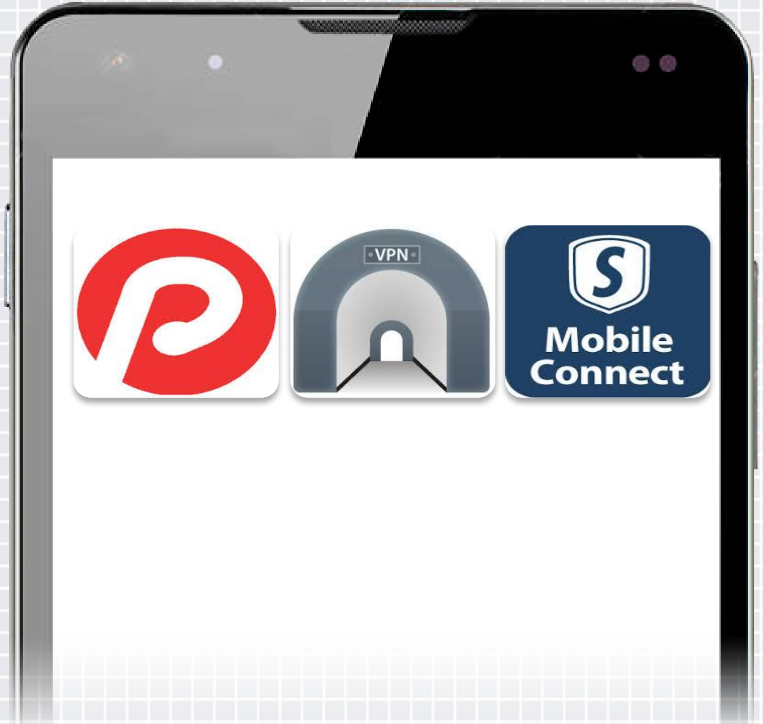
Who is Your Cloud Provider?

One is real, the others aren’t – Can YOU tell?

box
Google Sheets
Write. Edit. Share
Google Docs
Write. Edit. Share

Which is your real corporate VPN?

One is real, the others aren't – Can YOU tell?

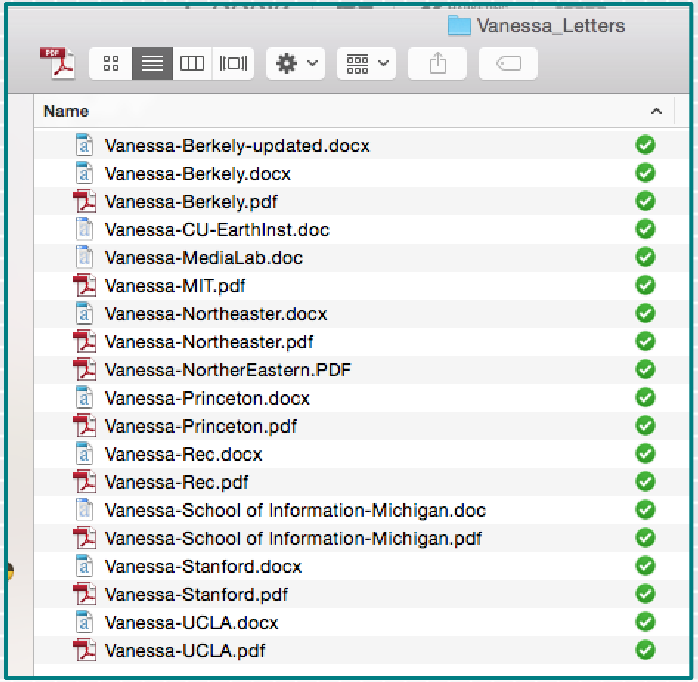


Which is your real Facebook?

One is real, the others aren’t – Can YOU tell?

Note: 2-D Passcode!

Recall, enticing decoy files in the cloud, too!



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Vanessa-Berkely.pdf ✓
Vanessa-CU-EarthInst.doc ✓
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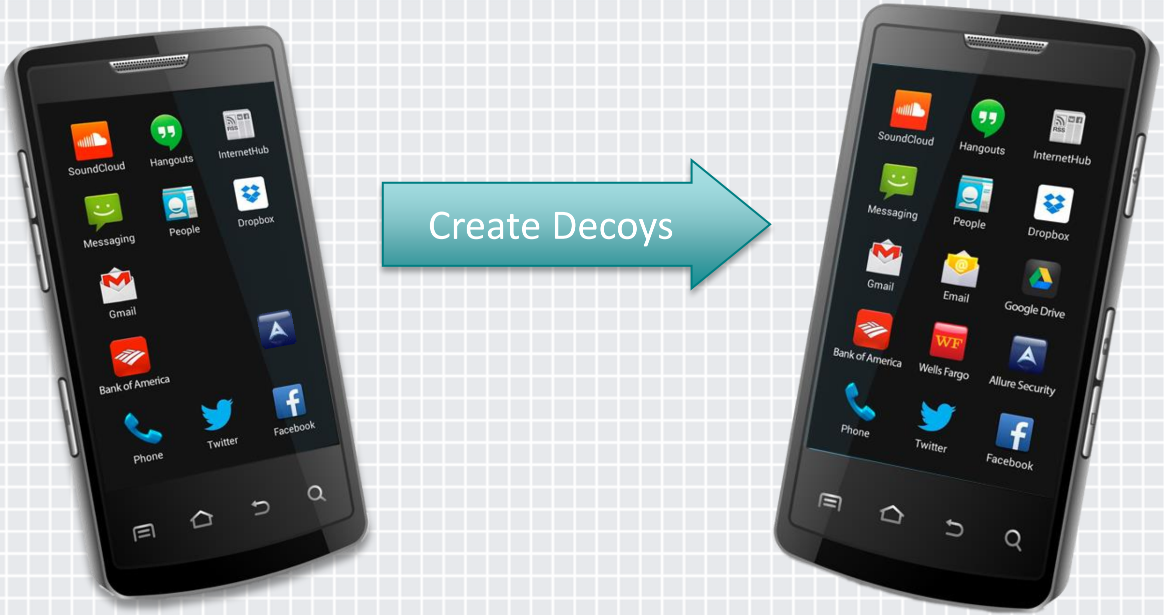
One is real, the others aren’t – Can YOU tell?

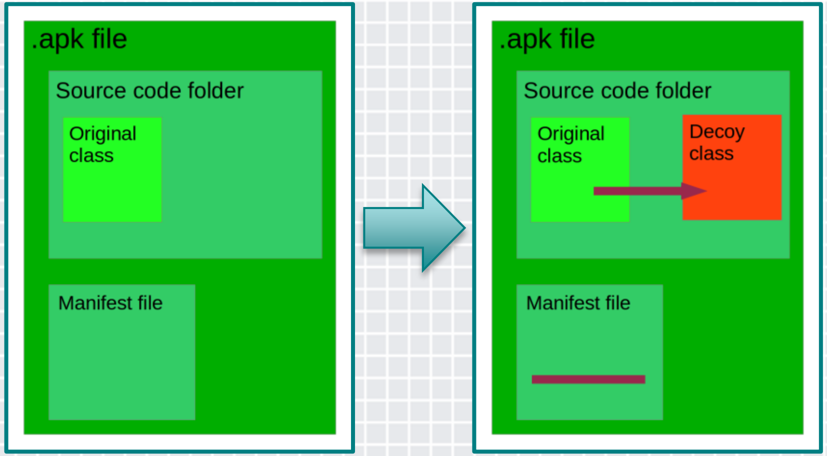
How do we do it?



Create Decoys

Any app is easily converted into a decoy

1. Unpack and disassemble .apk file.
2. Copy decoy functionality classes into assembly code folder
3. Insert code into original classes to run decoy functionality
4. Insert permissions for decoy functionality into manifest file
5. Reassemble and repack .apk file.

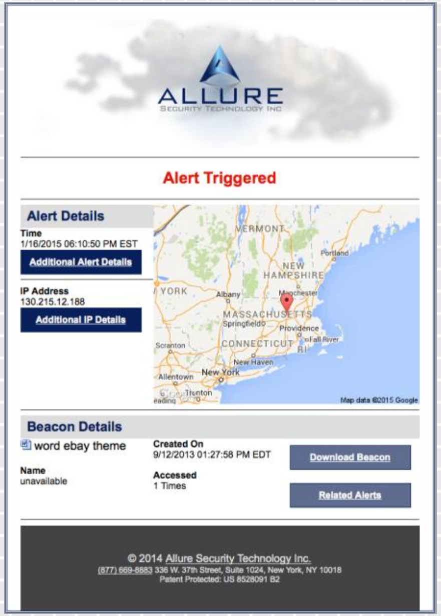


Touch a decoy app, the phone locks and alerts

SoundCloud
Hangouts
InternetHub
Messaging
People
Dropbox
Gmail
Bank of America
Phone
Twitter
Facebook

Lock & Alert

…includes location, picture & recording



Alert Triggered

Alert Details

Time
1/16/2015 06:10:50 PM EST

IP Address
130.215.12.188

Beacon Details

word ebay theme

Name
unavailable

Created On
9/12/2013 01:27:58 PM EDT

Accessed
1 Times

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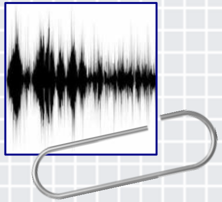
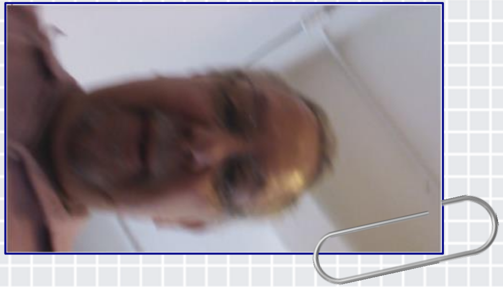
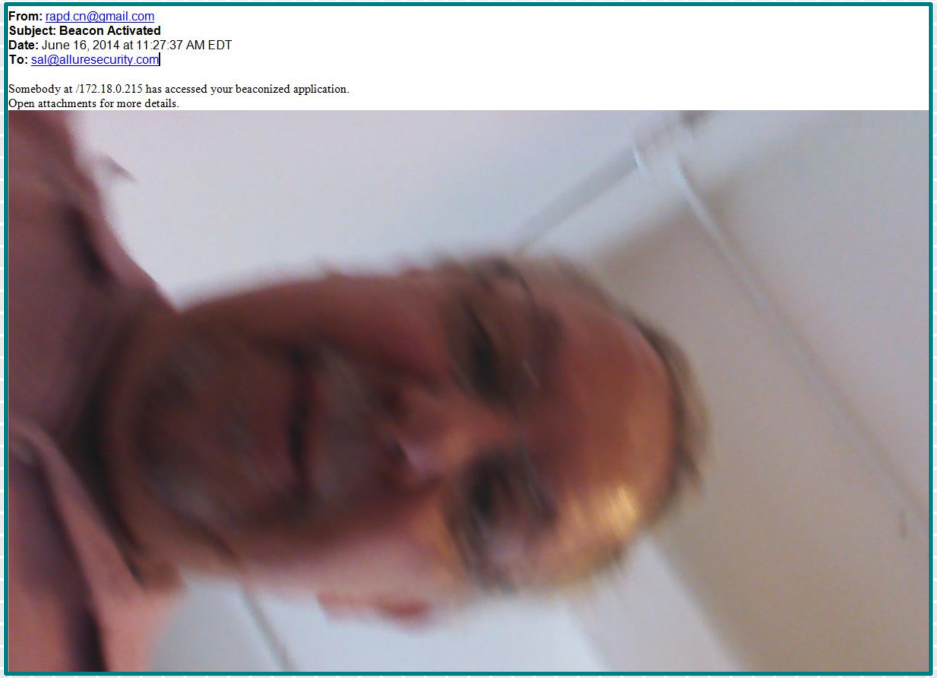
Patent Protected: US 8528091 B2





Sample Decoy App email alert



From: rapd.cn@gmail.com
Subject: Beacon Activated
Date: June 16, 2014 at 11:27:37 AM EDT
To: sal@alluresecurity.com

Somebody at /172.18.0.215 has accessed your beaconized application.
Open attachments for more details.

Have we offered sufficient gifts to the demo gods?

Demonstration

Alternative Unlock strategy, challenge the user, the phone knows your most recent behavior

With whom did you last chat?

□ John Public

□ Jane Doe

□ Bill Jones

□ None of the Above

Answer wrong, try once more

What city did you last visit?

□ Philadelphia

□ New York

□ Menlo Park

□ None of the Above

Answer wrong again…

Configurable mitigation strategies

- □ Brick the phone
- □ Upload tracking data
- □ Unlock and Load a decoy file system
- □ Alert Security Personnel

DARPA Sponsorship

- DARPA ADAMS – Anomaly Detection at Multiple Scales
  - Insider threat
- DARPA Active Authentication
  - Masquerader/Impersonator threat
- $10 Million of research support, transitioned from Columbia University IDS Lab to Allure Security Technology

The Research Team

Sal Stolfo

Malek Ben Salem

Jon Voris

Yingbo Song

Joel Peterson

Shlomo Hershkop

Apply What You Have Learned Today

- Next week you should:
  - Review corporate security policy for BYOD
  - Identify the number of employee phones stolen or compromised
  - Measure how many employees have no security controls on their devices
- In the first three months following this presentation you should:
  - Measure employee mobile access to critical corporate infrastructure
  - Evaluate corporate access and authentication controls
  - Explore a deployment strategy for advanced mobile authentication
- Within six months you should:
  - Identify and deploy solutions to protect employee mobile devices

Thank you…

- Resources and contact
  - www.cs.columbia.edu/ids
  - www.alluresecurity.com

http://www.channelpronetwork.com/article/Mobile-Device-Security-Startling-Statistics-on-Data-Loss-and-Data-Brea

http://transition.fcc.gov/bureaus/oet/tac/tacdocs/meeting12414/TAC-MDTP-Report-v1.0-FINAL-TAC-version.pdf

http://mashable.com/2012/11/08/smartphone-theft-city/