Mimesis Aegis: A Mimicry Privacy Shield

A System's Approach to Data Privacy on Public Cloud

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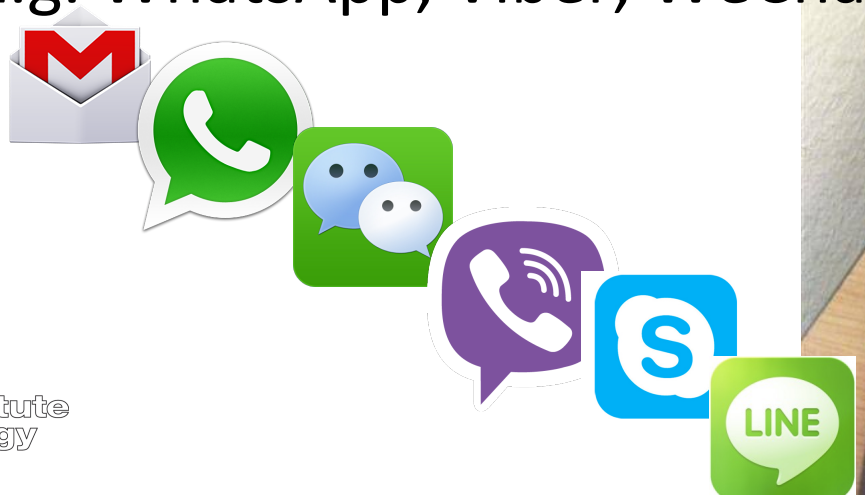
INTRODUCTION

Unsatisfactory Status Quo

- Users do not have control over their data that is communicated over public cloud
  - Rely on server to secure user's data
  - Conflict of interest for data privacy between users and public cloud service (PCS) providers
  - E.g. WhatsApp, Viber, WeChat, etc.



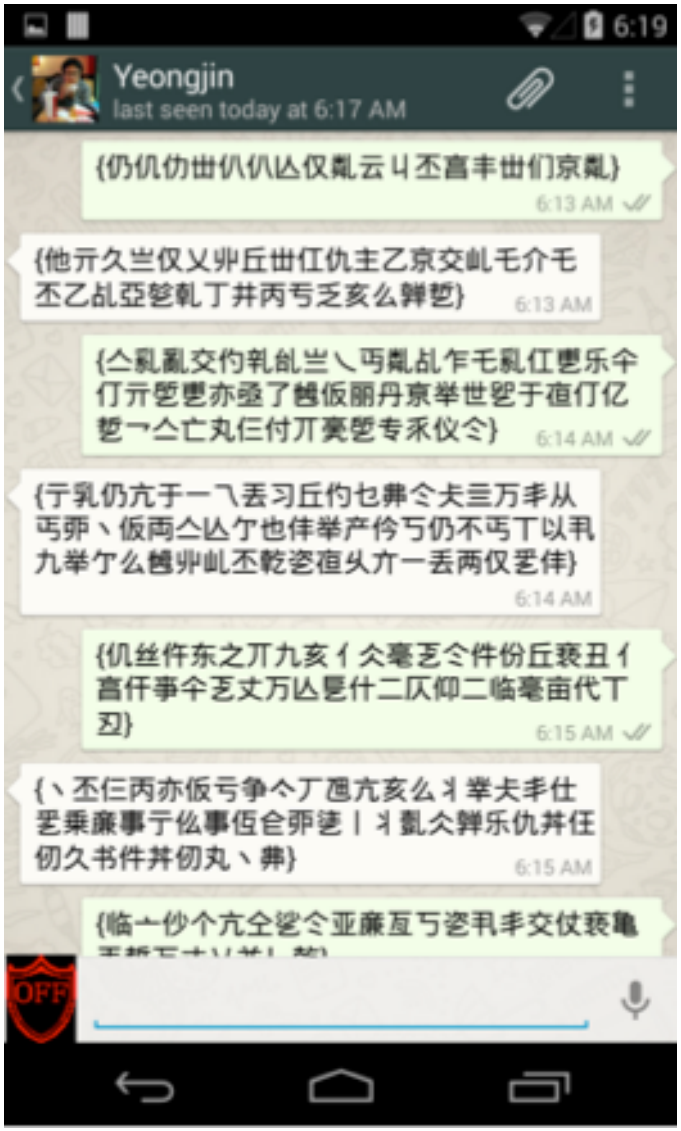
Changing the Status Quo

- Can be solved if users use end-to-end encryption
  - Hard to use in practice
- Existing solutions:
  - Requires user to be trained to use custom apps to perform safe communication
  - Have questionable data isolation model

Mimesis Aegis

- Applies end-to-end encryption to users' communication data while preserving user experience by:
  - Mimicking GUIs of app-of-interest
  - Interacting with app-of-interest on behalf of user
- Good isolation model
- Generalizable across different apps in the same category
- Resilient to app updates

Mimesis Aegis - WhatsApp



Mimesis Aegis - WhatsApp

RELATED WORK

Standalone Solutions

- Protect data confidentiality
- Good isolation from untrusted entities
- Examples: PGP, Gibberbot, TextSecure, SafeSlinger, FlyByNight, etc.
- Problem:
  - Requires open protocol
  - Do not preserve user experience

Browser Plugins/Extensions

- Provides transparent integration with applications of interest
- Examples:
  - Scramble!, TrustSplit, NOYB, SafeButton, etc.
- Problem: Only applicable to web applications.
  - How about mobile devices?

App Rewriting/Repackaging

- Provides transparent integration with applications of interest
- Examples:
  - Aurasium, Dr. Android, etc.
- Problems:
  - Breaks app updates
  - The security of the reference monitor may be compromised as it resides in the same address space as the untrusted entity

SYSTEM DESIGN

Design Goals

- Offer good security
  - Strong isolation from untrusted entities
- Preserve user experience
  - Transparent interaction with existing apps
- Easy to maintain and scale
  - A sufficiently general-purpose approach

Threat Model

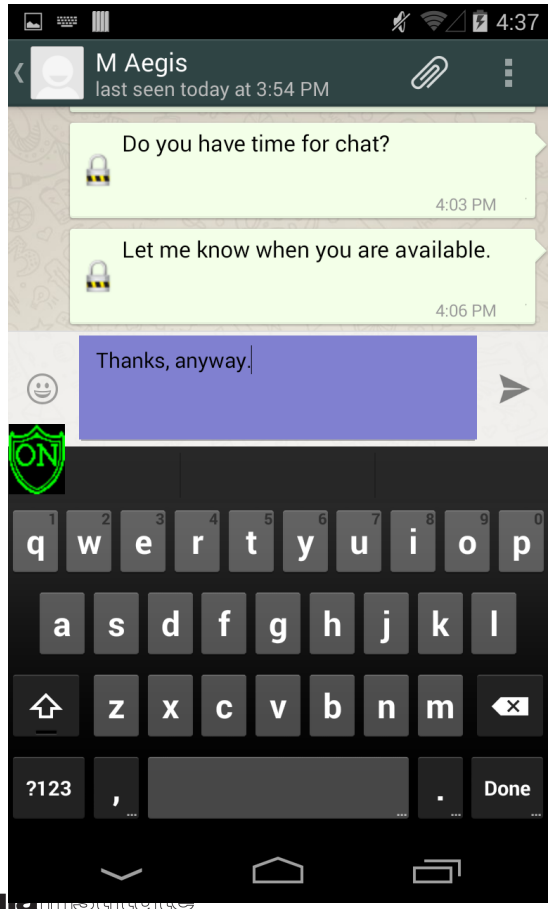
- Untrusted parties:
  - Public cloud service (PCS) providers
  - Client-side apps
  - Middle boxes between a PCS and client-side app

Threat Model

- Trusted components:
  - Hardware
  - Operating System (OS)
  - Soft keyboard
  - M-Aegis components
  - The user

M-Aegis Architecture

- Layer 7.5



M-Aegis Architecture

- UI Automation Manager (UIAM)
  - Gives M-Aegis the context of the screen
  - Provides information to correctly render mimic GUIs on L-7.5
  - Relays user input to the underlying app

M-Aegis Architecture

- Per-Target Client App (TCA) Logic
  - Processes UI tree to determine a TCA's current UI state
  - Makes sense out of the information gathered from UIAM
  - Decides suitable actions for different UI states

M-Aegis Architecture

- Cryptographic Module
  - Key Manager
  - Searchable Encryption Scheme
    - Easily-Deployable Efficiently-Searchable Symmetric Encryption Scheme (EDESE)

Easily-Deployable Efficiently-Searchable Symmetric Encryption Scheme (EDESE)

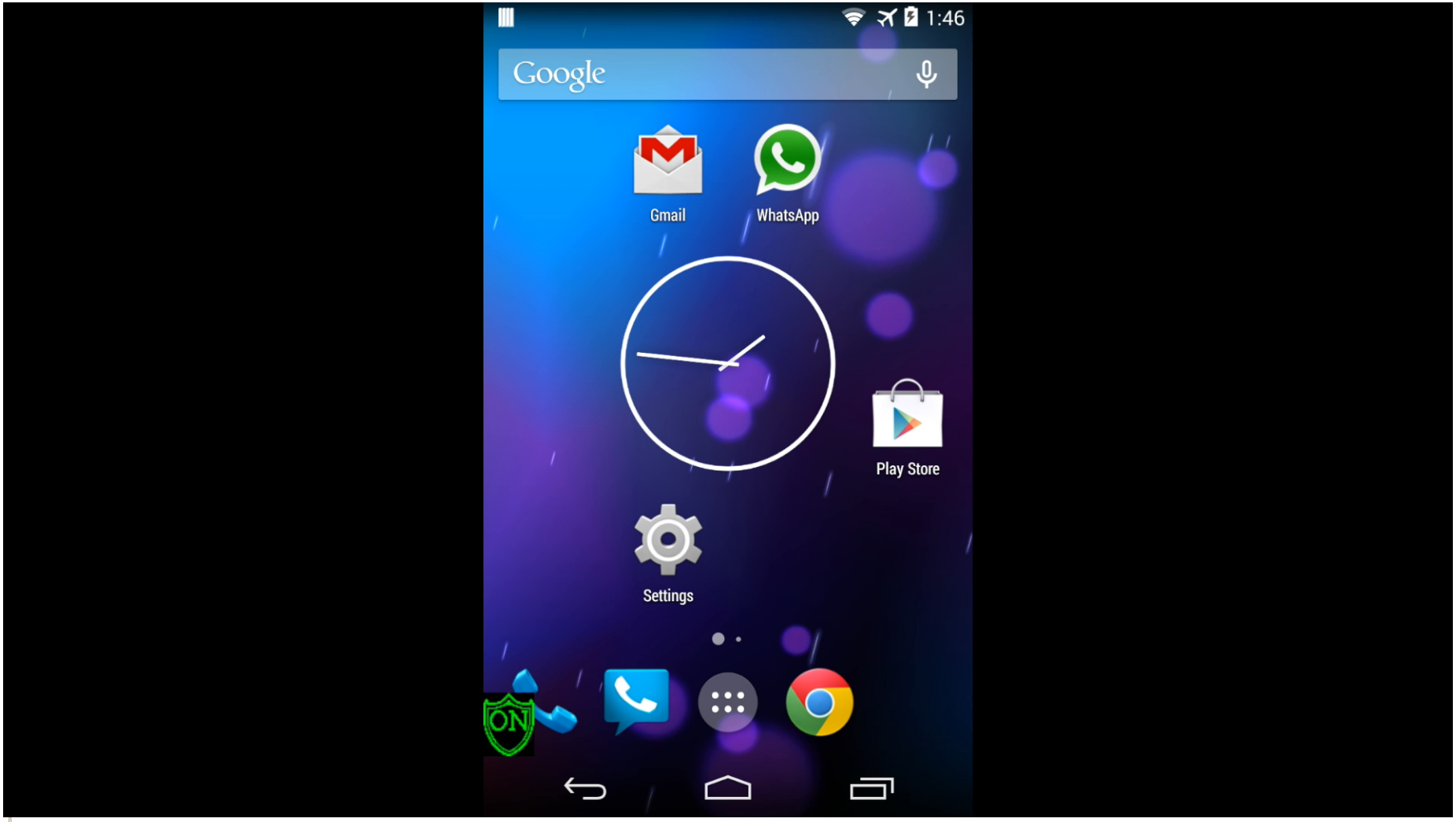
- Main idea – tag the encrypted text
  - Bad idea: leaving ciphertext of keywords in the open.
- Utilize bloom filter (BF) to "collect" keywords.
  - Problem: email providers don't support BF tests.
  - Solution: cleverly encode BF in such a way that it is searchable by simple string matching.

Easily-Deployable Efficiently-Searchable Symmetric Encryption Scheme (EDESE)

- Algorithm:
  - Determine the size of BF, *n* bits.
  - Determine the # of bits to be turned on in the BF, *k* bits.
  - For every unique keyword in the text:
    - Produce *k* keyed hash digest, m_i
    - Treat every *m* as a the position in the BF to be turned on.
  - Encode all the positions that are ON into text.
  - Append the encoded BF to the encrypted text.

USER WORKFLOW

Demo Video with WhatsApp



EVALUATIONS

Performance Evaluations

- Experimental Setup:
  - Stock Android phone (LG Nexus 4)
    - Android 4.4.2 (Kit Kat, API Level 19)
  - Each experiment is repeated 10 times and the average is taken

Performance Evaluations

- Preview Encrypted Email:
  - 76 ms to render plaintext on L-7.5
  - Well within expected response time (50 – 150 ms)
- Composing and Sending Encrypted Email:
  - Used Enron Email Dataset
  - With longest email:
    - 953 words, of which 362 are unique
    - 205 ms to encrypt, build the search index, and encode

Discussions

- Limitations:
  - Not robustly tested against social engineering attacks
  - Currently only handles text-based apps
  - Does not tolerate typographical error during search

CONCLUSIONS

Conclusions

- Users can now regain control over their private data using Mimesis Aegis, where:
  - Plaintext is never visible to client apps
  - Original user experience is preserved
  - Technique is generalizable to a large number of apps and is resilient to app updates

Questions?